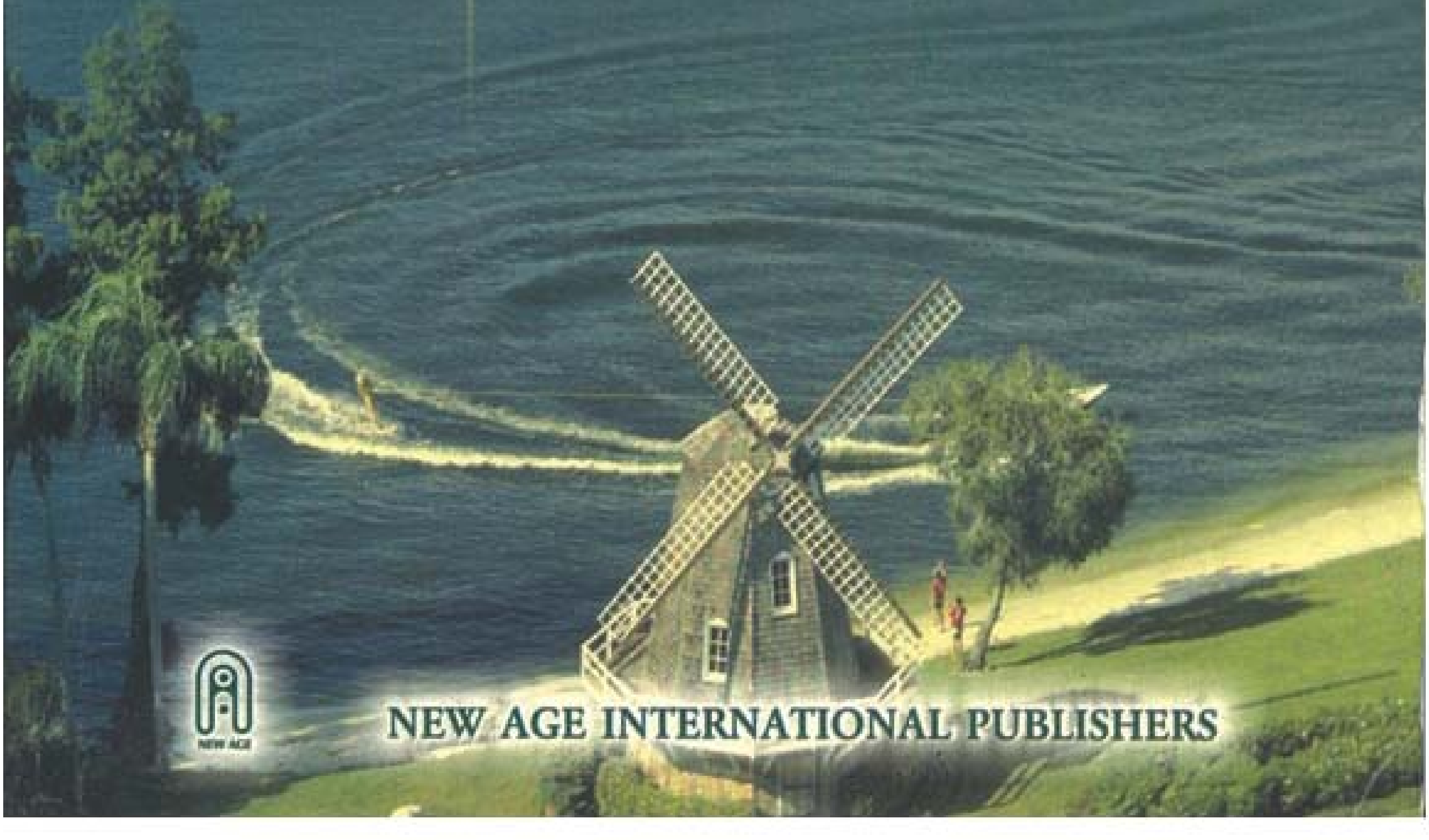
Principles of

Environmental Science & Technology

K. Saravanan
S. Ramachandran
R. Baskar



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NEW AGE

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PREFACE

This book is meant to be an introductory text on the Fundamentals of Environmental Science and Engineering. Today, knowledge of Environmental Science is essential for students as well as practicing engineers and scientists of all disciplines. Here an attempt has been made to provide precise and upto date information on the fundamental aspects of Environmental Science and Engineering without going much in-depth in to specific areas, so as to be useful for a cross section of fields of study. Indian technical universities are making the study of Environmental Science and Engineering mandatory for all courses and hence a comprehensive textbook covering all domains of this field (including the policy aspects and management practices) is the need of the hour.

The book adopts a simple narrative style keeping in mind both the knowledge requirements and the examination needs of university students. The authors wish to profusely thank all those who have supported them in their effort viz. the Management, the Principal, teachers, professors and students of our institution Kongu Engineering College, Perundurai, Erode. The authors also thank M/s New Age International (P) Ltd. for having accepted to publish the work and the wonderful way they have brought out this book in such a short time.

Feedback and corrective action is the only way to progress. As students of science the authors most humbly seek feed back from the readers of this book. The authors can be reached in any of the following e- mail addresses —

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CONTENTS

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INTRODUCTION

The objective of this book is to promote an understating among Engineers of different disciplines the concept and principles of environmental science and Engineering. Earth is a member of the solar system orbiting the Sun. The Sun is one of the millions of stars in the Milky Way. When the Earth was formed there was no life in it. Mixtures of methane, ammonia, water vapour and hydrogen were converted into life generating compounds by electrical discharge. Thus life came in to the Earth. With the passage of time the evolution of life and Ecosystems took place. The planet as we see today is the result of millions of years of evolution. The modern man with his high level of intellect became the most dominant animal in the entire planet.

SOME FACTS ABOUT THE EARTH

The earth is the third planet from the Sun at a distance of about 150 million kilometers, which is called an "astronomic unit". The earth is 12760 kilometers in diameter. It is not an ideal globe. At the equator there are little bumps and at the poles it is flatter than it is at the rest of the world. The southern part has more bumps than the northern part. The Earth's circumference is 40070 kilometers. Some basic facts about our planet is detailed below :

Average Diameter	12760 kms
Average Circumference	40070 kms
Surface Area	510 Million sq.kms
Land Area	149 Million sq.kms (29.2%)
Ocean Area	361 Million sq.kms (70.8 %)
Mass	5973 trillion tons
Human Population	Around 7 Billion
Average surface temperature	14.3 deg C
Age	4.6 billion years

The surface temperatures on our planet fluctuate between –88 degrees Celsius (in Siberia) and + 58 degrees Celsius (in Death Valley, California, USA). The temperature in the Earth's core is about 10000–12000 degrees Celsius at a pressure of about 3 millions times our air pressure at sea level. About 70% of the Earth's surface consists of the ocean's water and hence Earth is called "the blue planet". The oceans contain about 97% of all the water on our planet. The oceans have high salt content. The Earth is the only planet in our solar system that has an atmosphere consisting of 21% oxygen and 78% nitrogen. The Earth rotates at a speed of 30 kilometers per second around the Sun. This rotation is made in an elliptical form.

MAN EARTH INTERFACE

Man's quest for improvement and progress is eternal. In order to meet his natural and acquired needs he started utilizing the planet's resources indiscriminately. The stress of these efforts increased phenomenally due to the increase in population and industrial revolution. The environmental damage that we have done in the last 200 years is much more than the total damage done in the entire period of human existence in this planet. The stress on the resources became so acute that nature started reacting in an adverse fashion. The world population woke up to this scenario and started systematizing and controlling the indiscriminate use of natural resources. It is hence the study, research and application in Environmental Science and Engineering has become overwhelmingly relevant especially for engineering professionals.

1

COMPONENTS AND SUBCOMPONENTS OF ENVIRONMENT

1.1 CLASSIFICATION OF ENVIRONMENT

The term Environment can be broadly defined as one's surroundings. To be more specific we can say that it is the physical and biological habitat that surrounds us, which can be felt by our physical faculties (seen, heard, touched, smelled and tasted.)

The two major classifications of environment are :

(A) **Physical Environment:** External physical factors like Air, Water, and Land etc. This is also called the **Abiotic Environment.**

(B) **Living Environment:** All living organisms around us viz. plants, animals, and microorganisms. This is also called the **Biotic Environment.**

Earth's environment can be further subdivided into the following four segments:

(1) Lithosphere

(2) Hydrosphere

(3) Atmosphere

(4) Biosphere.

LITHOSPHERE

The earth's crust consisting of the soil and rocks is the lithosphere. The soil is made up of inorganic and organic matter and water. The main mineral constituents are compounds or mixtures derived from the elements of Si, Ca, K, Al, Fe, Mn, Ti, O etc. (Oxides, Silicates, and Carbonates). The organic constituents are mainly polysaccharides, organo compounds of N, P and S. The organic constituents even though form only around 4% – 6% of the lithosphere, they are responsible for the fertility of the soil and hence its productivity.

HYDROSPHERE

This comprises all water resources both surface and ground water. The world's water is found in oceans and seas, lakes and reservoirs, rivers and streams, glaciers and snowcaps in the Polar Regions in addition to ground water below the land areas. The distribution of water among these resources is as under Table 1.1

Table 1.1

Oceans and Seas	96–97 %
Glaciers and polar icecaps	2–3 %
Fresh water	< 1%

The water locked up in the Oceans and Seas are too salty and cannot be used directly for human consumption, domestic, agriculture or Industrial purposes. Only less than 1% of water resources are available for human exploitation. Water is considered to be a common compound with uncommon properties. These uncommon properties (e.g. anomalous expansion of water) are mainly responsible for supporting terrestrial and aquatic life on earth.

BIOSPHERE

The biosphere is a capsule encircling the earth's surface wherein all the living things exist. This portion extends from 10000 m below sea level to 6000 m above sea level. Life forms do not exist outside this zone. The biosphere covers parts of other segments of the environment viz. Lithosphere, Hydrosphere and Atmosphere. Life sustaining resources like food, water and oxygen present in the biosphere are being withdrawn and waste products in increasing quantities are being dumped. The biosphere has been absorbing this and assimilating them. However the rate of waste dumping has gone beyond the assimilating capability of the biosphere and signals of this stress is becoming evident.

ATMOSPHERE

It is the gaseous envelope surrounding the earth and extends upto 500 kms above the earth's surface. The composition of the atmosphere is given in Table 1.2

Table 1.2

Constituent	Volume %
Nitrogen	78.1
Oxygen	20.9
Water vapour	0.1–5
Argon	0.9
Carbon dioxide	0.03
Trace constituents*	Balance

*The trace constituents include Helium, Neon, Krypton, xenon, SO_2, NO_2, Ammonia, Ozone, and Carbon monoxide etc.

The atmosphere, which is a gaseous cover, protects the earth from cosmic radiations and provides life sustaining Oxygen, the macronutrient Nitrogen and Carbon dioxide needed for photosynthesis. The atmosphere screens the dangerous UV radiations from the sun and allows only radiations in the range of 300 nm – 2500 nm (near UV to near IR) and radio waves. The atmosphere plays a major role in maintaining the heat balance of the earth by absorbing the re-emitted radiation from the earth. In addition the atmosphere is the medium of carriage of water from the oceans to the land in the hydrological cycle.

The Structure of the Atmosphere

The atmosphere is broadly divided into four major zones viz. Troposphere, Stratosphere, Mesosphere and Thermosphere. Characteristics of these zones are pictorially represented below in Fig. 1.1

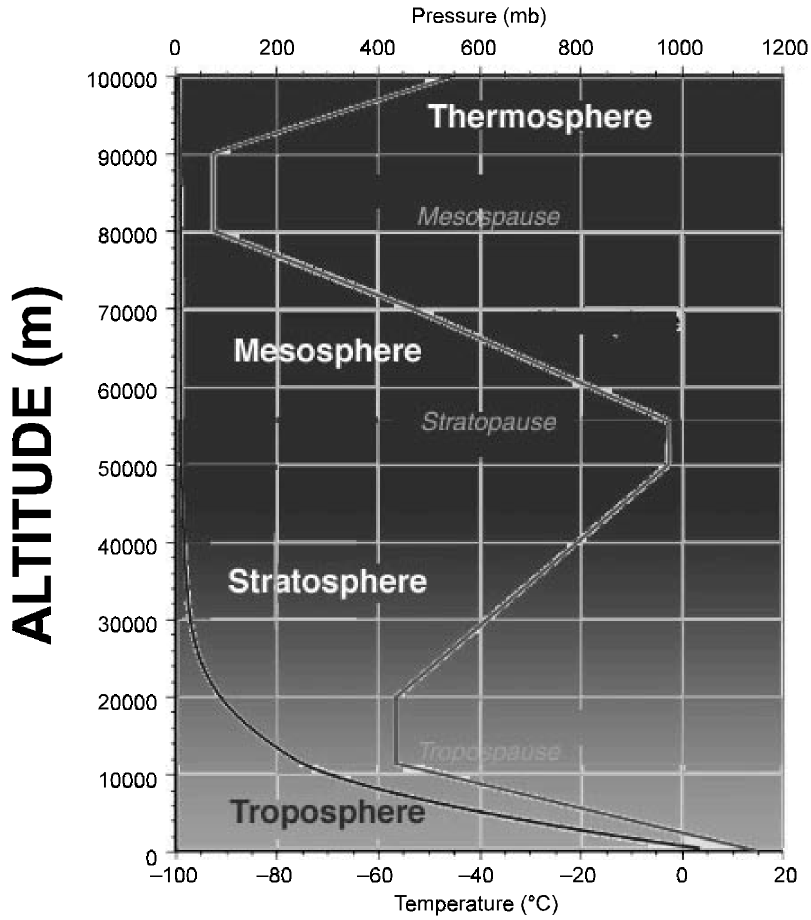


Figure 1.1

TROPOSPHERE

Troposphere is the layer of air nearest to the ground. Temperature decreases with height. The average temperature drops from 15ºC at sea level to –56.5ºC at 11,000 m above sea level. Mixing of the air molecules due to their constant movement (winds) keeps the composition of the gases more or less same throughout the troposphere. An exception to this is water vapor. Most water vapor evaporates from the surface of the Earth and is found in the lower troposphere. Most of the weather occurs in the troposphere. Tropopause is the top of the troposphere, which is a transition layer between Troposphere and Stratosphere

STRATOSPHERE

Stratosphere is the layer of air above the troposphere where temperature increases with height. The average temperature rises to –2.5ºC at 50,000 m above sea level. Ozone is found in higher concentrations between 20 and 30 km above the surface. Hence sometimes this layer is referred to as the "ozone layer". Ozone absorbs radiant energy from the sun and hence warmer temperatures are encountered in the stratosphere. Stratopause is the top of the stratosphere, which is a transition layer between Stratosphere and Mesosphere.

MESOSPHERE

Mesosphere is the layer of air above the stratosphere where temperature decreases with height. The average temperature decreases to –90°C at 90,000 m. This is the coldest layer of the atmosphere. Mesopause is the top of the mesosphere, which is a transition layer between Mesosphere and Thermosphere.

THERMOSPHERE

Thermosphere is the layer of air above the mesosphere. The temperatures in the thermosphere increase with increasing height, but there are not many molecules in this layer. The air becomes less and less dense as we reach space.

1.2 INTER-RELATIONSHIP BETWEEN THE COMPONENTS AND SUBCOMPONENTS

Matter (chemicals) as well as living beings on earth are distributed among the four major Environmental Components viz. Lithosphere, Hydrosphere, Atmosphere and Biosphere. While for the purpose of studying and understanding the Global Environment this division may be convenient, constant interaction by way of mass and energy transfer between these components and subcomponents is constantly taking place. This is pictorially indicated in Fig. 1.2

Every sphere has a flow of matter and energy to every other sphere, which is a two-way linkage as shown in the figure. Such two-way interactions are also taking place within individual spheres. This indicates movement of matter/energy from one location to another without exiting the sphere. Environmental problems are hence not confined only to the component/system where they arise but spread to other components as well. A clear example of this is the Acid Rain. Emissions of air pollutants like oxides of Sulfur and Nitrogen are transported over long distances where they are brought down to land and fresh water bodies by rain, creating damage to crops, lands, fresh water resources including ground water, properties and aquatic life. Another classical example is the buildup of gases like Carbon dioxide in the atmosphere. The emissions may be localized but the impact is massive and global in nature leading to global warming which has far reaching consequences in terms of both area and time.

1.3 STRUCTURE AND FUNCTIONAL COMPONENTS OF THE ECO SYSTEM

1.3.1 Ecology and Ecosystem

The study and understanding of Ecology is an integral part of Environment Science learning. Every living being however small or big depends on the environment for its existence and also competes with others for essentials in life. For survival, living beings form groups and different groups compete with each other for survival. The study of interrelationships between organisms and group of organisms is called the science of Ecology. The word Ecology has its roots from two Greek words “ikos” meaning a house or dwelling or place of living or habitat and “logos” meaning study. Ecology is hence the study of interrelationship among plants and animals and their interactions with the physical environment.

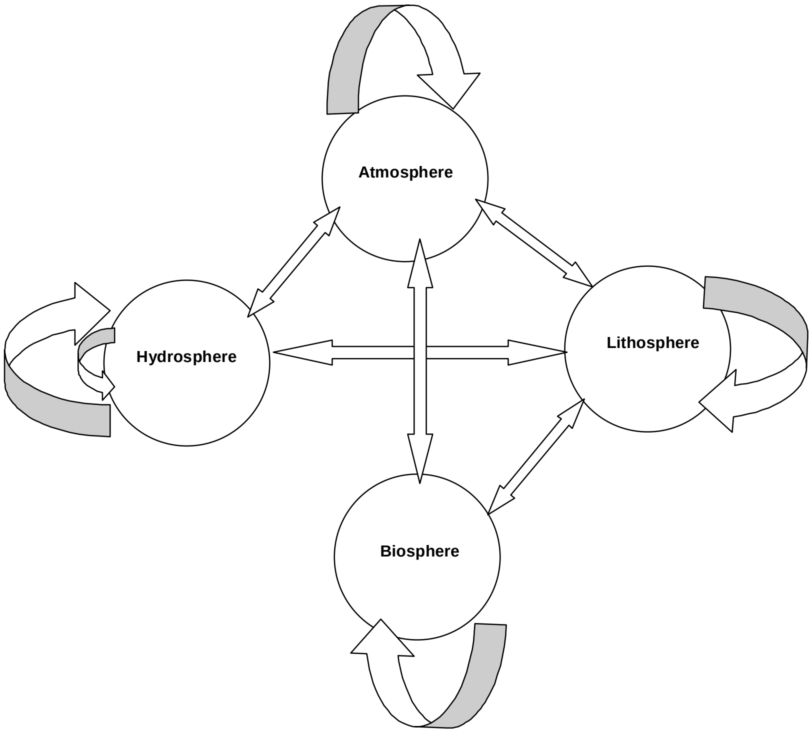


Figure 1.2

There are two important divisions of Ecology. They are :

(1) **Autoecology or Species Ecology:** This is the study of an individual species. i.e. behavior, adaptation and interaction of a particular species in its environment.

(2) **Synecology or Ecology of Communities:** This is the study of Communities and their interaction with the environment.

An Ecosystem is defined as a group of plants, animals or living organisms living together and interacting with the physical environment in which they live. An Eco system has a more or less a closed boundary and the flow of mass in and out of the system is very less as compared to the internal movement of mass. Ecosystems can be large or small. Examples of large eco systems are rain forests, deserts, salt marshes, coral reefs, lakes and ponds, open ocean, grass lands etc.

1.3.2 STRUCTURE AND FUNCTIONAL COMPONENTS OF ECOSYSTEM

Any Ecosystem consists of both living (biotic) and nonliving (abiotic) components, which are called Environmental or ecological factors. A factor is hence an ecological status, which directly or indirectly affects the life of an organism.

Abiotic Components

The physical factors of the environment (which are nonliving) have a major influence on the life of organisms. The abiotic components are of two types. They are :

(a) Climatic factors

(b) Edaphic factors

(a) Climatic factors consist of Temperature, rainfall and snow, wind, light, humidity etc. The climate of an area is the result of several factors such as latitude, elevation, nearness to the sea, and monsoon activities and ocean currents.

Temperature influences the rates of biochemical reactions in plants, with the reaction rates approximately doubling with every 10°C increase. Plant species require a range of temperature to survive. Below a minimum temperature they are inactive, and above a maximum temperature biochemical reactions stop. Normally in many plants growth is possible above 6°C. In areas with extremes of temperature, such as the tundra and tropical deserts the plants have mechanisms to adapt to such conditions.

Light levels decide the magnitude of photosynthesis reactions. Different plants have their characteristic light requirements in respect of light intensity, duration and wavelength. Some plants, termed heliphytes, require high levels, whereas sciophytes can grow in shady, low light conditions.

Water is an essential factor for biochemical plant processes, including photosynthesis. Plants growing on lands obtain their water requirements from the soil through their roots by the osmosis process. Plants called Hydrophytes grow in fresh water and they cannot withstand drought. Xerophytes survive long periods of drought, and halophytes are able to survive in saline water. Mesophytes require moderate conditions (neither waterlogged nor drought) and are found mainly in temperate areas.

(b) Edaphic factors or soil factors are pH, mineral and organic matter in soil and texture of soil.

Soil is the major source of nutrients and moisture in almost all the land ecosystems. Soil is formed when a rock weathers .The rocks brake down into a collection of different inorganic or mineral particles. The climate influences the type and rate of the weathering of the rocks as well as the nature of the vegetation growing on it. Nutrients are recycled in the soil by the plants and animals in their life cycles of growth, death and decomposition. Thus humus material essential to soil fertility is produced.

Soil mineral matter is derived from the weathering of rock material. These consist of two types viz. stable primary materials like quartz and various secondary materials like clays and oxides of Al and Fe.

Soil texture is the different size range of mineral particles varying from fine clay to coarse gravel. The varying percentages of each size range produce soils with different characteristics.

Soil organic matter is called humus that is formed by the decomposition of plant and animal matter. The rate of decay depends upon the nature of the material and the climate. The humus produced and incorporated into the soil, is known as clay-humus complexes, which are important soil nutrients.

Soil organisms carry out following three main groups of processes. Decomposition of organic material, such as plant and animal parts by bacteria, fungi, actinomycetes and earthworms. Bacteria and fungi also breakdown soil mineral matter generating nutrients.

Transformation and fixation of Nitrogen (which is an essential plant nutrient) obtained through rainwater or from nitrogen gas in the air. Bacteria like Azobacter and Rhizobium in the root nodules of leguminous plants, fix nitrogen from the air. Some types of bacteria have the ability to transform pesticides and herbicides into less toxic compounds.

Structural processes are carried out by atinomycetes and fungi. Mineral particles are bound together forming larger structures by these organisms. Earthworms, insects and burrowing mammals, such as moles, assist in the improvement of soil porosity resulting in better aeration and water holding ability.

Soil Nutrients are obtained from the weathering of rock material, rainwater, fixing of gases by soil and the decomposition of plant and animal matter. They are available to plants in solution and in clay humus complexes.

Soil pH indicates the level acidity or alkalinity of the soil. pH is the concentration of hydrogen ions in the soil. It is measured on a scale from 0 to 14, with 7 being neutral. A pH value of >7 indicates alkalinity while a value <7 indicates acidity.

Soil profile is the vertical sectional view of the soil. Soil consists of a series of layers, or horizons, produced by the vertical movement of soil materials. Generally soil profile consists of four horizons.

Biotic Components

The live component of an ecosystem comprises plants, animals, and microorganisms (Bacteria and Fungi). They carry out different functions and based on their role they are classified into three main groups. They are:

(1) Producers

(2) Consumers

(3) Decomposers

Producers are mainly green plants having chlorophyll. They produce carbohydrates by photosynthesis process. In effect the plants convert solar energy into chemical energy using water and carbon di oxide. These are called Autotrophs (self feeder) since they produce their own food. Part of the food produced by the autotrophs are utilized for their own consumption for survival and growth while the remaining is stored in the plant parts for future consumption. This becomes the food for other biotic components in the environment.

Consumers are living things, which do not have chlorophyll, and hence they are unable to produce their own food. They rely on the producers for their food requirements. Consumers are called Heterotrophs. Consumers are classified into four categories. They are

Primary Consumers or Herbivores: They are also called first order consumers. They eat the producers or plants. Examples are cattle like cow and goat, deer, rabbit etc.

Secondary Consumers or Primary Carnivores: They are also called second order consumers. They eat herbivores Examples are snakes, cats foxes etc.

Tertiary Consumers: They are also called third order consumers. They feed on secondary consumers. They are large Carnivores. Example is Wolf.

Quaternary Consumers: They are also called fourth order consumers. They feed on secondary consumers. They are very large Carnivores and feed on tertiary consumers and are not consumed by other animals. Examples are lions and tigers.

Decomposers called, as Sapotrophs are mainly microorganisms like Bacteria and Fungi. The dead organic materials of producers and consumers are their food. They break down the organic matter into simple compounds during their metabolic process. These simple compounds are nutrients, which are absorbed by the producers thus completing a cyclic exchange matter between the biotic and abiotic components of the ecosystem.

1.4 DEVELOPMENT AND EVOLUTION OF ECOSYSTEM

When the earth was formed around 4.6 billion years ago there were no life on it since the surroundings were inhospitable to living organisms. Earth was formed from solidified cloud of dust and gases left over from the creation of the Sun. For around 500 million years, the interior of Earth stayed solid and relatively cool, at around 2000°F. The main ingredients were iron and silicates, with small amounts of other elements, some of them radioactive. As millions of years passed, energy released by radioactive decay-mostly of uranium, thorium, and potassium-gradually heated Earth, melting some of its constituents. The iron melted before the silicates, and, being heavier sank toward the center. This forced up the silicates. After many years, the iron reached the center and began to accumulate. Exploding volcanoes, and flowing lava covering almost everything. Finally, the iron in the center accumulated as the core. Around it, a thin but fairly stable crust of solid rock formed as Earth cooled. Depressions in the crust were natural basins in which water, rising from the interior of the planet through volcanoes and fissures, collected to form the oceans. Slowly, Earth acquired its present appearance.

One billion years later there were with prokaryotic life forms, which are considered to be ancestors to all present living things. The last common ancestor of all presently living organisms must have characteristics, which are now present in the organisms. The common characteristics of living species can be enumerated as:

(1) All life is cellular in nature.

(2) All living things are made of 50 to 90% water, the source of protons, hydrogen and oxygen in photosynthesis and the solvent of biomolecules.

(3) The major elements in all living beings are carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur.

(4) There is a set of molecules (i.e. sugars, amino acids, nucleotides, fatty acids, phospholipids, vitamins and coenzymes. proteins, lipids, carbohydrates and nucleic acids) universally found in all living organisms.

(5) There is a universal type of membrane structure (i.e. the lipid bilayer).

The early earth is possibly provided all the elements and chemicals needed for life to begin. The **Miller-Urey experiments** showed that inorganic processes under primitive earth conditions could form organic molecules. By discharging electric sparks in a large flask containing boiling water, methane, hydrogen and ammonia, conditions presumed to be similar to those of the early earth, they produced amino acids and other organic molecules experimentally. Using variations of their technique, most of the major building blocks of life have been produced: amino acids, sugars, nucleic acid bases and lipids. Another source of amino acids and other organic molecule is meteorites

The first organisms presumably consumed these molecules both as building blocks and as sources of energy. The first forms of photosynthesis were probably non-oxygenic using inorganic molecules as a source of electrons to reduce carbon dioxide. However, when these sources were exhausted, oxygen-generating photosynthesis was developed using water as the electron source. The generation of oxygen had a most dramatic effect on future evolution.

Formation of **closed, membrane vesicles** was an early event in cellular evolution. Lipid molecules spontaneously form membrane vesicles or liposomes.

An ecosystem is made up of organisms, which established themselves in the given area and have continued to survive and has not become extinct. The species hence possess genes, which fit the environment and are tolerant to disturbances like flood, fire, drought; and a reproductive rate that balances the natural catastrophes. The birth rate of organisms will have to be optimum to avoid overpopulation and hence starvation. The human population is a good example. As technological evolution brings down our normal death rate, social evolution lowers the birth rate to strike a balance. Biological evolution is however much slower than social or technological.

In ecosystems, organisms constantly adjust themselves to geologic or climatic changes and to each other. As an example, the bats developed sonar to find the moths and the moths developed ears sensitive to the bat's frequency. The behavioral adaptations are also reflected in the anatomy or the body structure of the organisms. This evolutionary pattern is very common and is called **character displacement**. The process of life evolution started from lower plants and progressing to higher plants, lower animals, higher animals and finally to man.

1.5 ENERGY FLOW IN ECOSYSTEMS

The sun is the source of all our energy. It is a continuously exploding hydrogen bomb where hydrogen is converted to helium with the release of energy. This energy is mostly in the region of 0.2 to 4 m m (Ultraviolet to Infra Red). Around 50% of the radiation is in the visible range. The energy reaches the earth at a constant rate called the Solar Flux or Solar Constant, which is the amount of radiant energy crossing unit area in unit time. This value is approximately 1.4 KJ per sq. meter per second.

Chlorophyll bearing plants convert this energy from the sun into carbohydrates and sugars using carbon di oxide and water. This process is known as Photosynthesis. The generalized form of the photosynthetic reaction is

$$6CO_2 + 12H_2O \longrightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$$

Carbon dioxide + water ⟶ glucose + oxygen + water

The carbohydrates produced by photosynthesis undergo further modifications such as production of proteins and nucleic acids by combining with nitrogen, phosphorous and sulphur. Starch polymerizes to cellulose.

The sun's energy thus enters the living beings through photosynthetic reactions and is passed from one organism to another in the form of food. The flow of energy is uni directional and is governed by the thermodynamic law that states that Energy is neither created nor destroyed and can transform into different forms.

When energy travels from producers to different levels of consumers in an ecosystem there is loss at each level due to the energy dissipated as heat during the metabolic processes of the organisms. Hence as we move step by step away from the primary producers the amount of available energy decreases rapidly. Hence only 3 to 5 feeding levels are possible. These are referred to as Tropic levels. Figure 1.3 illustrates the energy travel in an ecosystem.

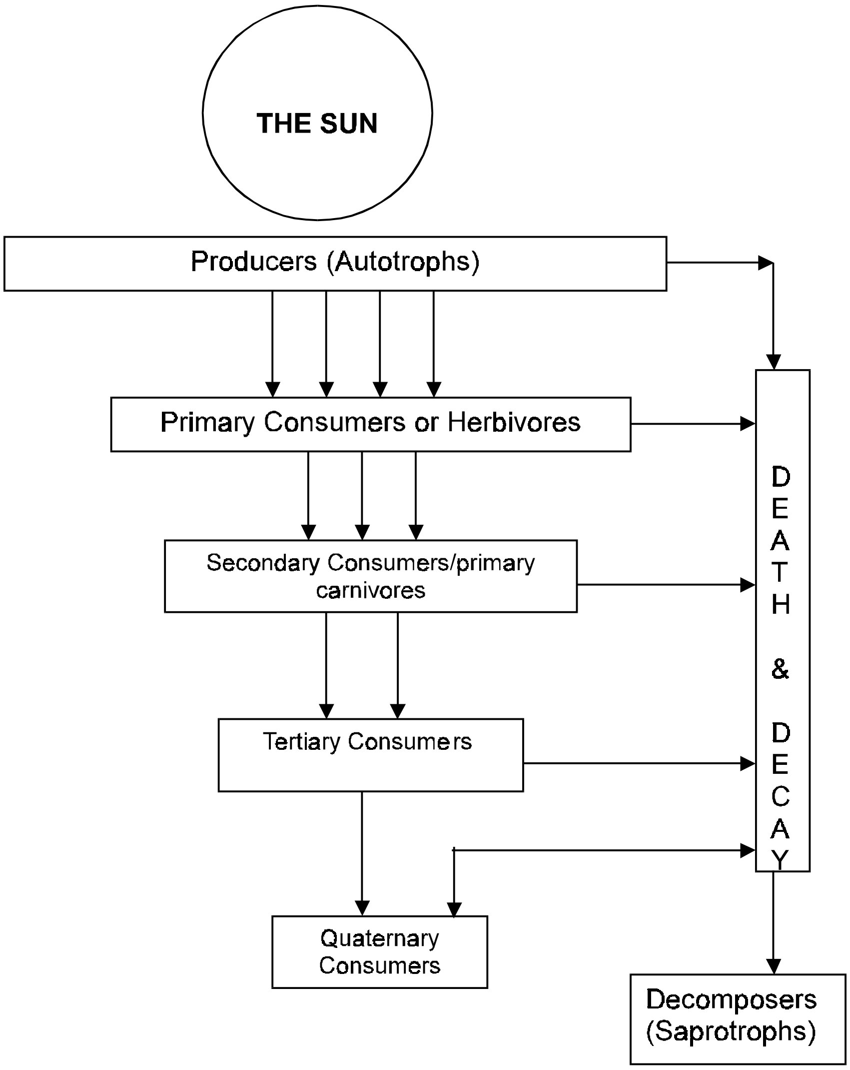


Figure 1.3

Food Chain and Food Web

The food chain is an ideal model of flow of energy in the ecosystem. According to this scheme the plants or producers are eaten by only the primary consumers, primary consumers are eaten by only the secondary consumers and so on. The producers are called Autotrophs. A food chain has three main tropic levels viz. Producers, consumers and Decomposers. The energy efficiency of each tropic level is very low. Hence shorter the food chain greater will be the availability of food.

A typical food chain in a field ecosystem might be

Grass ⟶ Grasshopper ⟶ Mouse ⟶ Snake ⟶ Hawk

Food webs are more complex and are interlinked at different trophic levels. This means that organisms have more than one alternative for food and hence survivability is better. Hawks don't limit their food to snakes, snakes eat things other than mice, mice eat grass as well as grasshoppers, and so on. A more realistic depiction of eating habits in an eco system is called a food web. An example is shown in Fig. 1.4

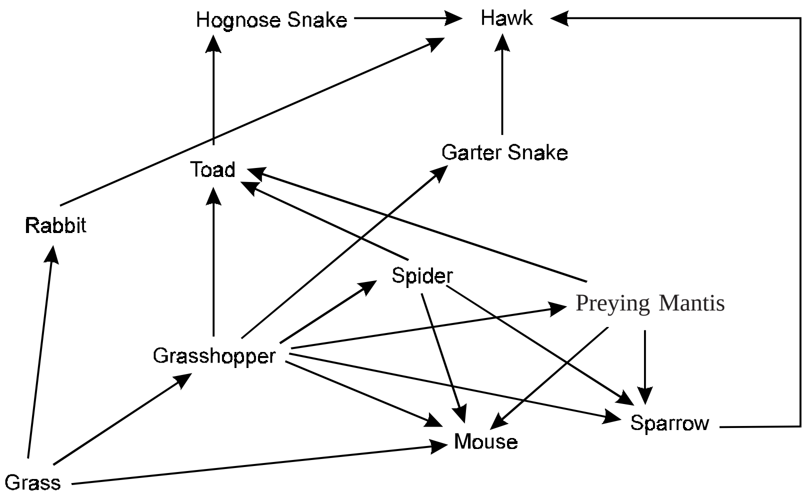


Figure 1.4

1.6 MATERIAL CYCLES IN ECOSYSTEMS

As energy flows through the ecosystem there is also a constant flow of matter. Living beings take up several nutrients from their abiotic environment and when they die they are returned to the environment. This cyclic movement of nutrient material between the biotic and abiotic environment is called **Biogeochemical Cycle.** These cycles depict the material movement and their conservation.

The most important and common biogeochemical cycles are :

(1) Water Cycle or Hydrological Cycle

(2) Carbon Cycle

(3) Nitrogen Cycle

(4) Oxygen Cycle

(5) Sulphur Cycle

(6) Phosphorous Cycle.

Water Cycle or Hydrological Cycle

There is a constant and continuous exchange of water between air, land, sea and living beings. Considerable part of the solar energy incident on the earth is used for the massive evaporation of water from the oceans, seas and other exposed water bodies leading to cloud formation and precipitation in the form of rainfall or snow. This is the major source of fresh water for the living beings. Surface water run off results in part of fresh water returning to the sea through rivers and streams. Underground water or simply Ground water is replenished by surface accumulated water from precipitation. Ground water depletion takes place due to exploitation of the same by pumping. The plants also absorb ground water. Thus hydrological cycle hence is the continuous and balanced process of evaporation, precipitation, transpiration and runoff of water.

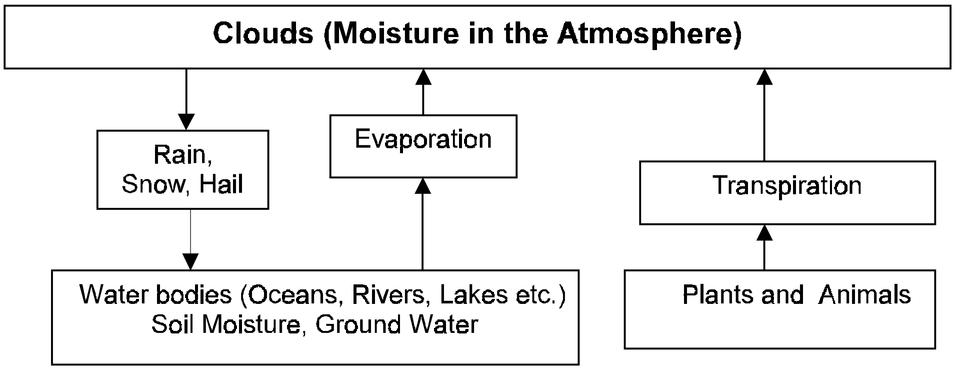


Figure 1.5

Carbon Cycle

Carbon is an essential component of all plant, animal and organic matter. The atmosphere is an important source of carbon which is present in the form of carbon dioxide which the plants or producers absorb by photosynthesis and generate several organic compounds. These

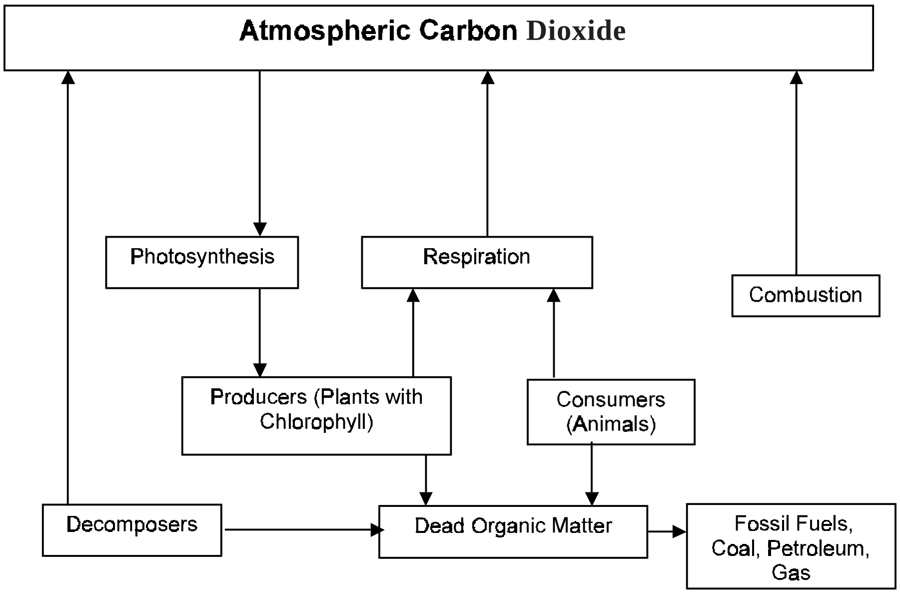


Figure 1.6

are passed to the consumers (Herbivores and Carnivores) in the form of food. Part of this is returned to the atmosphere by respiration. The dead organic matter from plants and animals are decomposed by microorganisms releasing Carbon dioxide to the atmosphere. Burning of fossil fuels releases large quantities of carbon di oxide. There is a steady buildup of carbon dioxide in the atmosphere due the increased utilization of fossil fuels as well as reduction of green plants (Deforestation). The seas and oceans also serve as sink for carbon oxide by absorbing the same and converting it into bicarbonates and mineral deposits and thus they play a vital role in regulation of carbon cycle.

Nitrogen Cycle

Nitrogen and its compounds form a vital ingredient in all forms of life in the biosphere. Availability of Nitrogen is from the atmosphere as molecular Nitrogen in the gaseous form, which cannot be directly absorbed by the plants or producers. In order to be absorbed by the plants it has to be converted into water-soluble compounds with elements like Hydrogen, Carbon, and oxygen. This process is known as Fixation of Nitrogen. Nitrogen fixation takes place by Bacteria, Algae and electrical storms. Synthetic fixation of Nitrogen is done by the manufacture of nitrogenous fertilizers through ammonia conversion route. The plants absorb the fixed Nitrogen from the soil and convert them into proteins and other compounds during the metabolic process. Decomposers, ammonifying bacteria and Nitrate bacteria also help in the fixing process by converting dead animal and plant parts into absorbable nitrates. The denitrifying bacteria complete the cycle, which helps in releasing gaseous Nitrogen back to the atmosphere from the soil.

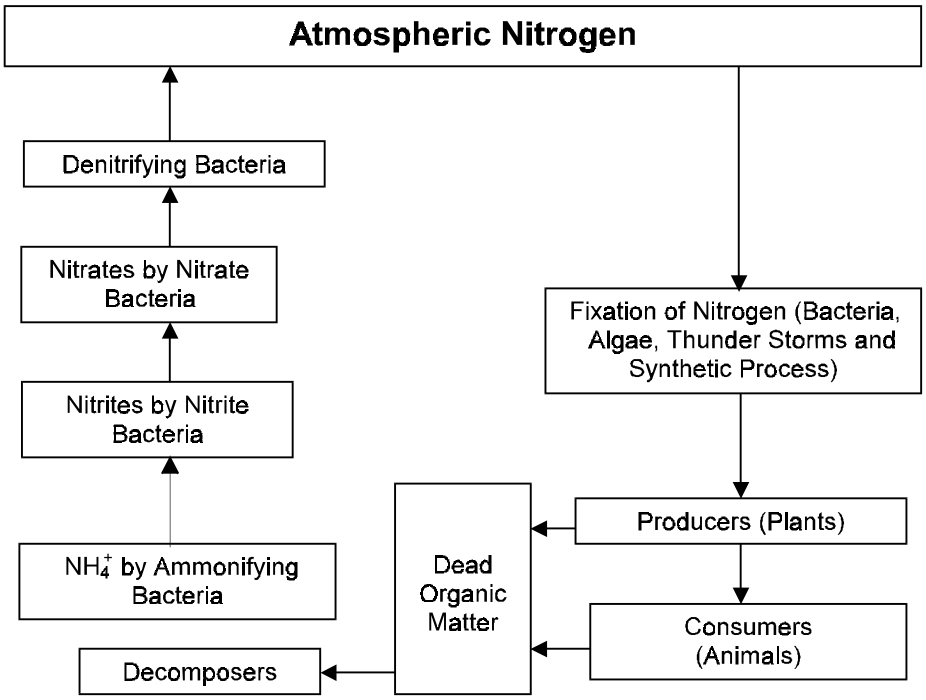


Figure 1.7

Oxygen Cycle

Oxygen is essential for the existence of all flora and fauna. The source of Oxygen is atmosphere. Plants and animals absorb oxygen during respiration either from air or water. Part of the Oxygen returns to the atmosphere in the form of carbon dioxide and water vapor in the respiration process itself. Gaseous oxygen is released during photosynthesis process (Refer photo synthetic reaction) completing the Oxygen cycle.

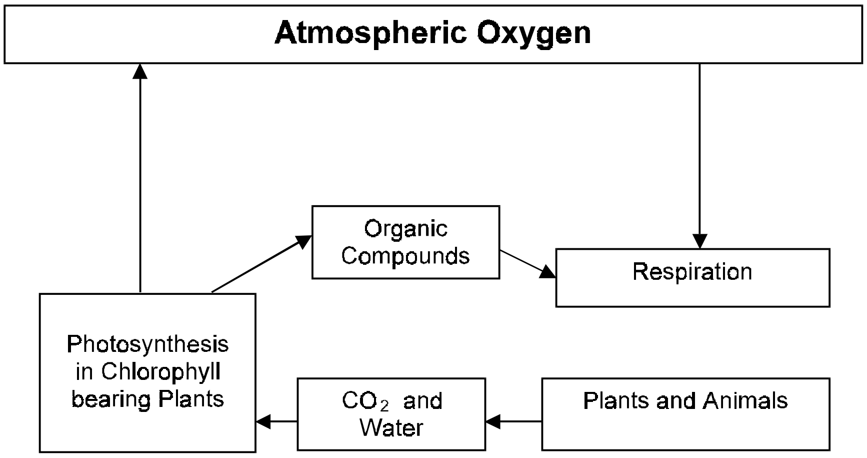


Figure 1.8

Sulphur Cycle

Amino acids and proteins need sulphur compounds for their production. In the atmosphere it is present as Sulphur di oxide and hydrogen sulfide and in the soil as sulfates or sulfides. Volcanic emissions and burning of fossil fuels are the supply of Sulphur dioxide to the atmosphere while hydrogen sulfide is from bacterial emissions. Atmospheric Sulphur dioxide is also oxidized to Sulphur trioxide, which eventually reaches the earth along with rainfall. Anaerobic and aerobic Sulphur bacteria also play a vital role in the interchange and movement of Sulphur compounds in the ecosystem. The Sulphur compounds in the plant and animal parts are absorbed by the soil after their death and decay and converted into sulfides and sulfates by Sulphur bacteria, which are subsequently used up by the plants. As in the case of carbon dioxide the atmosphere is receiving excess quantities of Sulphur dioxide, which is leading to adverse environmental effects.

Phosphorous Cycle

The bones and teeth of animals including human beings contain Phosphates, which is necessary for their development and growth. In addition phosphates are essential for cells in the production of DNA and RNA. Phosphates are available in the lithosphere in rocks and soil in inorganic form. Plants absorb them and convert them into organo phosphates. Phosphates are also added to the soil through phosphatic fertilizers. Soluble phosphates reaching rivers and streams from agricultural lands made rich in phosphates causes excess algal growth leading to eutrification. Return of phosphates to the earth is by the decay of plant and animal matter and subsequent absorption.

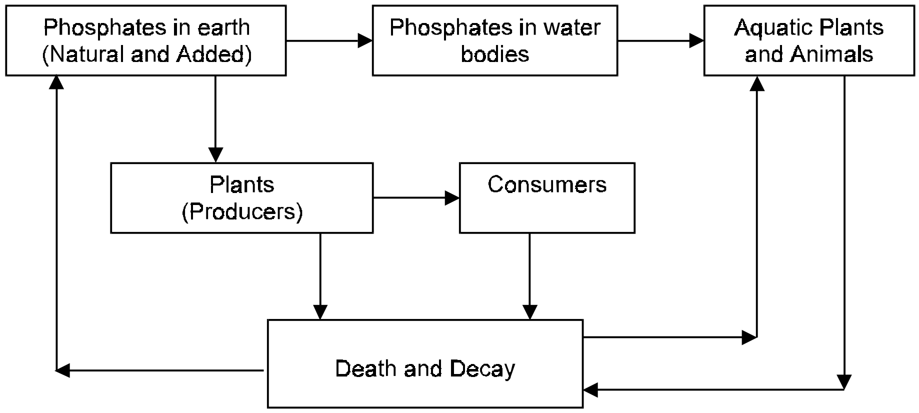


Figure 1.9

1.7 NATURAL AND MAN-MADE IMPACTS ON WATER, AIR AND LAND

1.7.1 Background

The damage to the environment is caused both by natural (Non Anthropogenic) and man made (Anthropogenic) reasons. The natural impacts are non-preventable and on many occasions unpredictable. However knowledge of natural hazards is essential in order to take mitigative actions so that loss of life and property can be minimized. On the other hand Anthropogenic detrimental impacts on environment are eminently preventable but only with a focused global effort.

1.7.2 Natural Hazards

For a systematic understanding the natural hazards can be structured as in Table 1.3

Table 1.3

Physical	Biological
(1) Earthquakes	(1) Fungal diseases
(2) Volcanic Eruptions	(2) Bacterial or Viral diseases
(3) Floods	(3) Infestations in Plants and Animals
(4) Cyclones, Hurricanes	(4) Poisonous weeds and plants
(5) Tsunamis	(5) Poisonous animal bites
(6) Snow and Ice	
(7) Avalanches and land slides	
(8) Heat waves	
(9) Forest fires	
(10) Fog, frost, hail	
(11) Droughts	

Earthquakes

Earthquakes occur as the result of the release of pressure along a fault in the tectonic plate boundaries but can occur anywhere. Earthquakes last only few seconds but they cause extensive damage to buildings, gas and water pipes, power and communication lines, and roadways. They can also serve as triggers for several other natural hazards. In fact, the primary cause of damage in recent earthquakes is fire from damaged gas pipes and power lines. Slope failures are triggered by the energy release associated with earthquakes. When earthquakes occur in an ocean or large lake, a tsunami may form and flood surrounding coastlines. Earthquakes often occur along with volcanic activity, which results in a variety of additional threats.

Volcanic Eruptions

Volcanoes are vents in the earth's surface through which magma, gases, and other materials are discharged from the core. They are found primarily at tectonic plate boundaries. They also exist at hot spots, which are places in the earth's crust where hot mantle plumes have broken through. Some volcanoes erupt explosively, while others erupt slowly. Explosive volcanoes present many potential threats including the release of toxic gases, flows containing fragments of hot rock and ash, fast moving clouds of extremely hot gases and fine ash and large volumes of ash. It is common for volcanoes to trigger other natural hazards like debris flows, earthquakes, floods, landslides and fires. Volcano and earthquake risk maps overlap considerably.

Floods

Floods are high water levels above the banks of a stream channel, lakeshore, or ocean coast that submerge areas of land usually not submerged. They are natural, reoccurring events in every stream, lake, and coastal environment. A flood can be caused by unusually intense or prolonged precipitation, storms, dam collapses, etc. Since most of the world's population lives on or near coasts and plains, floods are a threat to hundreds of millions of people. Floods can cause loss of life, extensive damage to property, contamination of drinking water, and destruction of crops and fields. They can also help produce rich soils for agriculture, which encourages people to live in floodplains. Floods occur in arid and wet environments, highlands and lowlands, and in both populated and unpopulated regions. They are less common in dry environments and highlands. Floods occur in many temperate regions around the world. However, floods can occur at any time of the year, depending on location. The timing of floods is largely dependent on climate and seasonal weather patterns. In India, floods are a common feature during monsoons.

Cyclones, Hurricanes and Tornadoes

Tropical cyclones are greatly intensified low-pressure areas that spend most of their lives over the oceans. In the Atlantic Ocean, they are called hurricanes. In the Pacific Ocean, they are usually referred to as typhoons. Warm temperatures and moisture drive them. When a hurricane moves over land or cool water, it loses strength. Tropical storms become hurricanes once their winds exceed 74 mph (119 kph). In a hurricane, building doors and windows are frequently broken by debris picked up in the hurricane's strong and sustained winds. These winds can rip roofs from buildings, topple trees, and damage power and communication lines. In some cases, hurricanes can produce tornado-like vortices (called "mini-swirls"), which can completely destroy buildings. Coastal flooding is a major threat in hurricanes, due to the combination of storm surges and torrential rain.

Storm surges are rises in ocean levels produced by the effects of high wind and low atmospheric pressure. Storm surges also increases coastal erosion, potentially resulting in slope failures. Hurricanes can even start fires by damaging power lines. Contamination of drinking water and disruption of utility services (such as electricity, communications, and sewer) are common occurrences during a hurricane.

Hurricanes are greatly intensified low-pressure cells born over the tropical oceans. They require vast amounts of warm, moist air to survive. Hurricanes lose strength over land or Cool Ocean water.

Tornadoes are fast rotating columns of air associated with severe thunderstorms. A thunderstorm can produce many tornadoes, and a tornado can have more than one vortex. Wind speeds as much as 450 kph are possible. These high winds can quickly destroy entire buildings and in some cases, entire communities. The debris carried by such high winds causes severe injury or death to people and other life. Hail is commonly associated with thunderstorms and is also capable of causing extensive damage in a very short time. Tornadoes move along the surface at up to 70 mph (113 kph) and remain on the ground for several minutes. Most tornadoes occur between the 4:00 P.M. and 6:00 P.M., when the lower atmosphere is most unstable. Many tornadoes also occur after sunset—these tornadoes can be very dangerous because they are difficult to see and people are less easily alerted.

Tsunamis

Seismic ocean waves are now commonly referred to as tsunamis (Japanese for “harbor waves”). A tsunami is traditionally defined as a series of ocean waves with very long wavelengths that can travel great distances. Tsunamis can also occur in large lakes. In deep oceans, tsunamis can reach speeds over 800 kph. Tsunami wave heights near a shore average 9 meters, but have been recorded over 30 meters. They can carry large ocean vessels inland, inundate coasts, and drag entire communities out to sea as they recede. Tsunamis can be generated by any event that displaces a large volume of ocean water, such as an earthquake, volcanic eruption or landslide. Tsunamis threaten coasts throughout the Pacific Ocean, which has frequent earthquakes. Although they are rare, Tsunamis do occur in the Atlantic Ocean, Mediterranean Sea, and large lakes.

Snow and Ice

Snow and ice are well known hazards to those living in mountainous areas or regions north of about 35 degrees N latitude. Prolonged power failures, automobile accidents, transportation delays, damage to buildings, and dangerous walkways are often attributed to snow and ice during the winter months. Slippery surfaces and reduced visibility are responsible for many accidents. Snow can be warm, causing wet and slushy conditions, or cold, creating dry and powdery conditions. The latter leads to blizzards and drifting when mixed with high winds. Blizzards can quickly reduce visibility to zero. Drifting can block roadways, airport runways, and even bury buildings. Both are often associated with low windchills, which are dangerous to exposed skin, especially when wet from snow. In many mountainous regions, **avalanches** are a common hazard. When large masses of mountain snow begin to melt in the spring, floods often become an imminent hazard to people living in valleys. The total amount of snow received at any location is dependent on temperature, atmospheric pressure, topography and proximity to moisture sources.

Thunderstorms

Thunderstorms are relatively small, organized parcels of warm and moist air that rise and produce lightning and thunder. They are one of nature's ways of balancing the amount of energy in the atmosphere—it is estimated that over 40,000 thunderstorms occur each day around the world. Although most last only 30 minutes, thunderstorms can create several dangerous phenomena:

- **Torrential rain** produced by thunderstorms is usually intense, but short in duration—flash flooding is often associated with this type of precipitation. In fact, flooding is the greatest threat from thunderstorms; also, slope failures can be triggered by the intense precipitation from thunderstorms in areas with steep, unstable hillsides.
- **High wind:** Inside a thunderstorm, air rises and descends rapidly, transferring vast amounts of energy. Such movement is dangerous for airplanes. Winds at the surface beneath a thunderstorm can reach well over 80 kph.
- **Hail** falling at speeds of several meters per second can result in extensive damage to crops and property in just a few minutes and can injure or kill people and other organisms
- **Lightning** frequently starts fires, which threaten homes, businesses, and lives. Power and communication failures caused by lightning (as well as wind) can result in large-scale disruption of everyday activities.

Droughts

A drought is an extended period of depleted soil water. Drought occurs when more water is taken out of an area than is added to it. This is often the result of a combination of persisting high pressure over a region, which produces clear skies with little or no precipitation, and excessive use of water for human activities. Droughts can result in decreased crop yields, decreased drinking water quality and availability and food shortages. Thus, as population increases and the demand for food and water increases the probability of drought increases and the implications of drought become more and more serious. Also, when vegetation becomes dry during a drought, fire risk increases, threatening homes, crops, and lives. The greatest threat from drought occurs when agricultural regions receive very low rainfall, leading to plant desiccation. When this happens, crop yields decrease resulting in increased food prices, food shortages, and even famine. Most agricultural crops are grown in the semi-arid and humid regions of the world. Water shortages in either of these regions can pose an immediate threat to agricultural productivity. With global climate change, droughts are expected to become a major problem for several agricultural regions. In semi-arid and arid regions, droughts commonly result in deteriorating drinking water quality and availability. Besides the immediate impacts associated with water shortages and poor water quality, delayed impacts (such as susceptibility to disease) are major problems in several less-developed regions of the world.

El Nino and La Nina

El Nino and La Nina are triggers for many natural hazards because they produce unusual weather throughout the world. The Earth's oceans and atmosphere are closely connected and hence a change in one produces an immediate or delayed change in the other. El Nino involves the warming of sea surface temperatures in the equatorial Pacific Ocean. This temperature change at the ocean's surface causes the usual positions of the jet streams and pressure cells to shift.

This causes changes in the global weather patterns produces floods , droughts and other hazards, leading to thousands of deaths and property damages. A La Nina event usually occurs the year after the end of an El Nino event and involves abnormal cooling of the same ocean waters. This can also cause changes in atmospheric circulation, thereby altering weather patterns for many locations around the world.

Because El Nino and La Nina produce considerable changes in atmospheric circulation, the effects are noticeable globally. However, certain locations feel the effects of El Nino and La Nina more than others due to a variety of factors. El Nino events usually begin between January and March and peak during the month of December. Not every El Nino event is followed by a La Nina event. When it happens, the effects of La Nina are usually most noticeable between the months of December and January.

Fog

Fog is a cloud near the ground. A cloud is an area of condensed water droplets (or ice crystals in the upper atmosphere). The processes that produce clouds high above the ground also produce clouds near the surface. Fog forms when air is unable to hold all of the moisture it contains. This happens when air is cooled to its dew point, or the amount of moisture in the air increases. Once air reaches its dew point, water vapor condenses onto very small particles forming tiny water droplets that comprise fog. Fog is a hazard because of reduction in visibility. Airport delays, automobile accidents, shipwrecks, plane crashes, and many other transportation problems are frequently caused by fog. When air pollution (such as smoke) combines with fog, visibility decreases even more. Acid fog, resulting from the combination of air pollutants (such as nitrogen and sulfur oxides) with water droplets can create health problems, for people with respiratory problems. Fog can also be beneficial. Several species of plants depend on fog for moisture.

Fog can occur during any season and almost anywhere in the world. The following are common types of fog:

- *Advection Fog:* When warm, moist air is blown over a cold surface, the surface can lower the temperature of the air to its dew point.
- *Evaporation Fog:* Water evaporates from the surface of streams, lakes, and oceans and accumulates near the earth surface.
- *Radiation (or Ground) Fog:* Common on clear nights with little or no wind, this type of fog is formed from the rapid cooling of the Earth's surface in the absence of clouds.
- *Upslope Fog:* Whenever air rises, it cools. If air is blown over high hills or mountains, it may cool enough to reach its dew point.

Forest/Wild Fires

Wild land fires most commonly occur in semi arid and temperate regions having abundant vegetation and extensive dry periods. Fire is a potential hazard whenever vegetation desiccates. This often occurs as the result of drought. Fires occur less frequently in colder and wetter climates, Winds can increase a fire's intensity while providing few escape routes. Lightning is a most common cause of wildfire during the growing season. Dry weather prior to thunderstorms during spring, summer, or fall increases the risk of a fire from lightning.

1.7.3 Manmade Impacts on Air, Water and Land

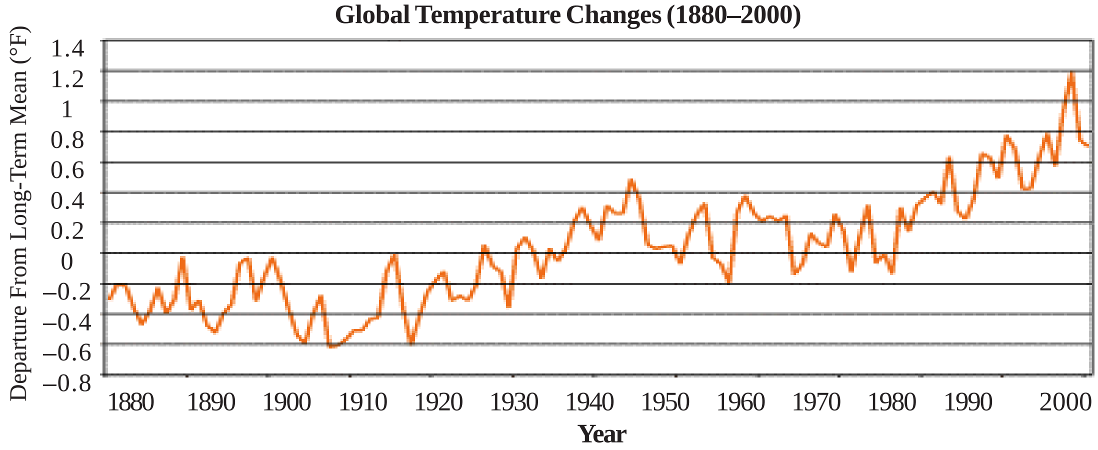
Increasing human population coupled with unprecedented technological growth has led to severe environmental stress. This has led to several problems on a global scale. The biotic as well as abiotic components of the environment has come to be seriously affected by the large scale human activities like agriculture, industrial production, energy production and consumption, transport, lumbering, harmful emissions, disposal of toxic chemicals etc. Some of the well-documented anthropogenic environmental impacts are

1. Global Warming
2. Acid Rain
3. Ozone layer depletion
4. Air, Water and land pollution
5. Eutrophication
6. Loss of Biodiversity

A brief analysis of the nature, causes, impacts and remedial measures of these global environmental issues is presented here.

Global Warming

During the 20th century, the average temperature of the earth has increased by about 0.6°C. The average temperatures in 1998 and 2002 were the highest ever recorded since reliable measurements began in the mid-19th century. This is attributed mainly to the emissions of carbon dioxide and other greenhouse gases in increasing quantities into the atmosphere. Some of the gases in the earth's atmosphere (in particular, water vapor and carbon dioxide) have an ability to absorb infrared radiation (heat). They do not prevent sunlight reaching the earth's surface and warming it, but they trap some of the infrared radiation emitted back into space by the earth. In other words, they function the same way as the glass in a greenhouse. Without the natural greenhouse effect of the atmosphere, life on earth would be impossible—the surface of our planet would be almost 35°C colder than it is now.



Source : U.S. National Climatic Data Center, 2000

Figure 1.10

Greenhouse gases (i.e. gases which contribute to the greenhouse effect) have always been present in the atmosphere, but now concentrations of several of them are rising as a result of human activities. This is intensifying the greenhouse effect.

Carbon Dioxide from Fossil Fuels

Carbon dioxide is produced and released into the atmosphere whenever organic material (which contains carbon) is burnt. As long as wood was the main fuel (Bio Fuel) there was no impact on the amount of this gas in the atmosphere. The carbon dioxide that is released into the air was absorbed by new vegetation. However, when usage of fossil fuels was started on a large scale by humanity natural cycling of carbon between plants and the atmosphere was disturbed. Over the last 100 years we have extracted and burnt a significant proportion of the oil, coal and gas from beneath the earth's surface. These fuels are the remains of plants and animals that inhabited the earth long ago. In a short space of time we have released into the atmosphere a large quantity the carbon taken up over millions of years by the organisms of past ages. The plants living today are unable to remove the surplus of carbon dioxide in the air. The problem is further aggravated by the widespread deforestation. This has led to a buildup of Carbon dioxide in the atmosphere, which is illustrated in Fig. 1.11.

The carbon dioxide concentration is about 30% higher than that of pre-industrial times (around 200 years ago), and every year the level rises by another roughly 0.4%. Unfortunately carbon dioxide is very stable. It can probably continue to circulate between the atmosphere and the oceans for many thousands of years. This means that carbon dioxide from fossil fuels could still contribute to the greenhouse effect several millennia hence, even if emissions were to cease completely in the near future. If emissions were instead held at their present levels, the concentration of carbon dioxide would go on rising in both the atmosphere and the sea, gradually strengthening the greenhouse effect

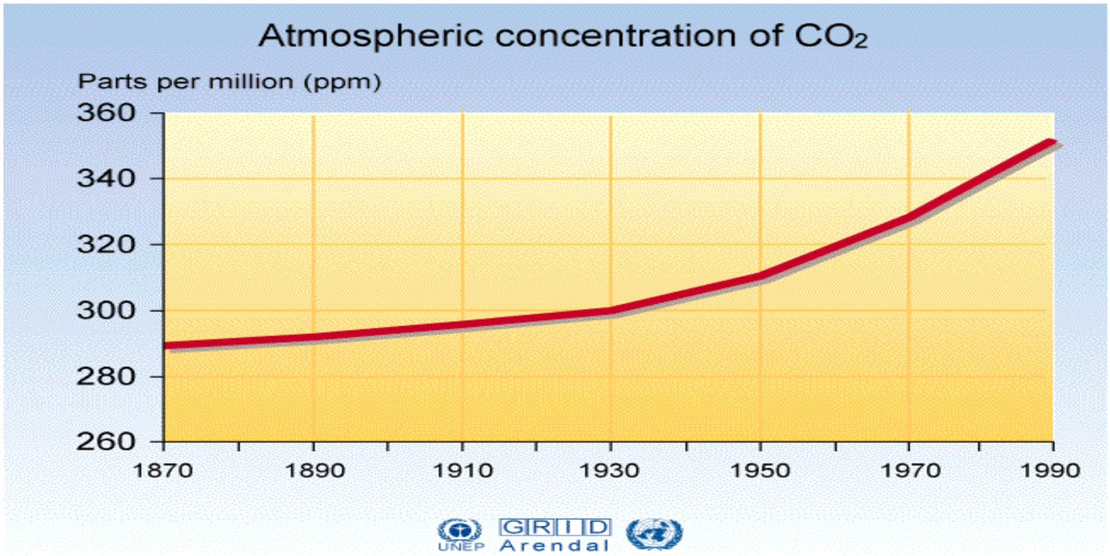


Figure 1.11

Apart from carbon dioxide, the other greenhouse gases being emitted in large quantities now are nitrous oxide, methane and compounds containing fluorine, among them HFCs (compounds of hydrogen, fluorine and carbon).

These substances are much more effective as greenhouse gases than carbon dioxide even though their concentrations are far less. Some of the fluorine compounds have a very long atmospheric life that they will contribute to the greenhouse effect for tens of thousands of years to come.

Impacts Global Warming

- Rapid change in climate will be too great that many ecosystems will not be able to adapt, and hence the rate of species extinction will most likely increase.
- In addition impacts on wildlife and species, biodiversity, agriculture, forestry, dry lands, water resources and health will be adverse.
- Melting of polar ice caps and glaciers will result in increased sea levels
- leading to flooding of coastal lines causing damage to life and property.
- Massive soil erosion, contamination of fresh water and water borne diseases.
- In temperate areas summers will be longer and hotter and winters shorter and warmer.
- Sub-tropical regions will become drier and tropical regions wetter.
- Desertification, droughts and famine.
- Altered weather patters will have altered crop patterns and adverse effects on plant and animal life.

Remedial Measures

- Reduce/avoid use of fossil fuels by encouraging use of renewable energy sources like solar energy, biofuels, wind and hydroelectric power etc. Per capita, the developing countries emit only a fraction of the carbon dioxide released by the industrialized nations, and the latter therefore have the main responsibility for reducing emissions.
- Reduce deforestation and increase vegetation to serve as sink for carbon dioxide.

Acid Rain

Gaseous atmospheric pollutants, particularly oxides of sulphur and nitrogen, can cause precipitation to become more acidic when converted to sulphuric and nitric acids, hence the term acid rain. This is also referred to as acid precipitation. Precipitation (rain or snow) is naturally acidic because of carbon dioxide in the atmosphere. The burning of fossil fuels (coal, oil and gas) produces sulphur dioxide and nitrogen oxides. These gases interact with water vapor and sunlight resulting in the production of Sulphuric acid and Nitric acid.

$$S + O_2 \longrightarrow SO_2 \quad \text{(Combustion of fossil fuels)}$$

$$SO_2 + 1/2O_2 \longrightarrow SO_3 \quad \text{(Photo chemical oxidation in the atmosphere)}$$

$$SO_3 + H_2O \longrightarrow H_2SO_4 \quad \text{(Sulphuric Acid–Acid Rain)}$$

When these acids are carried down to the earth by precipitation (rain, snow, dew or hail) acid rain or acid precipitation occurs. Sources of sulphur dioxide and oxides of nitrogen may be natural such as volcanoes, oceans, and biological decay and forest fires. The increasing demand for electricity and the rise in the number of motor vehicles in recent decades has increased emissions of acidifying pollutants Emissions of such pollutants are heavily concentrated in the northern hemisphere, especially in Europe and North America. Acid rain became an international concern since the air borne pollutants are transported over large distances i.e. thousands of kilometers.

The average pH of acid rain is below 5.5. (The pH scale ranges from 0, which is strongly acid, to 14, which is strongly alkaline, the scale point 7 being neutral.).

Impacts of Acid Rain

- Destruction of aquatic flora and fauna due to excessive acidification.
- Contamination of drinking water.
- Increase in the acidity of soil leading to loss of nutrients.
- Destruction of certain plants and trees due to loss of chlorophyll.
- Accumulation of toxic elements in the soil leading to the destruction of beneficial earthworms.
- Corrosive damage to buildings and structures.
- Damage to historic monuments like Taj Mahal.

Remedial Measures

- Reduce/avoid use of fossil fuels by encouraging use of renewable energy sources like solar energy, biofuels, Wind and hydroelectric power etc.
- Adopt sulphur recovery techniques for fuels to minimize SO_2 emission.
- Use of catalytic converters in automobiles to ensure lower acidic emissions.
- Treatment of stack gases to eliminate SO_2 and Oxides of Nitrogen emissions.

Ozone Depletion

Ozone (O_3) gas present in the stratosphere filters out incoming radiation from the sun the cell-damaging ultraviolet (UV) part of the spectrum. Concentrations of ozone in the stratosphere fluctuate naturally in response to variations in weather conditions and amounts of energy being released from the sun and due to major volcanic eruptions. During the 1970s it was realized that man-made emissions of Chlorofluorocarbons (CFCs) and other chemicals used in refrigeration, aerosols and cleansing agents may cause a significant destruction of ozone in the stratosphere, thereby letting through more of the harmful ultraviolet radiation. Then in 1985 evidence of a large ozone hole was discovered above the continent of Antarctica during the springtime. This reappeared annually, generally growing larger and deeper each year. More recently significant ozone depletion over the Arctic, closer to the more populous regions of the Northern Hemisphere is noticed. In response to this ozone depletion, the Montreal Protocol on Substances that Deplete the Ozone Layer was implemented in 1987. This legally binding international treaty called for the participating developed nations to reduce the use of CFCs and other ozone depleting substances. In 1990 and again in 1992, subsequent amendments to the protocol brought forward the phase out date for CFCs for developed countries to 1995. Near the ground, however ozone is considered to be a pollutant since it causes a number of respiratory problems, particularly for young children.

Impacts of Ozone Depletion

Protecting the ozone layer is essential. Ultraviolet radiation from the sun can cause a variety of health problems in humans, including skin cancers, eye cataracts and a reduction in the body's immunity to diseases. In addition ultraviolet radiation can be damaging to microscopic life in the surface of oceans which forms the basis of the world's marine food chain, certain varieties of crops including rice and soya, and polymers used in paints and clothing. A loss of ozone in the stratosphere may even affect the global climate.

Causes of Ozone Depletion

Ozone depletion occurs when the natural balance between the production and destruction of stratospheric ozone is disturbed in favor of removal. Halogens like chlorine and bromine released from man-made chemical compounds such as CFCs are the main cause of this depletion. Chlorofluorocarbons are not scrubbed back to earth by rain or destroyed in reactions with other chemicals. They simply do not break down in the lower atmosphere and they can remain in the atmosphere from 20 to 120 years or more. Due to their high chemical stability CFCs move into the stratosphere where they are eventually broken down by ultraviolet (UV) rays from the sun, releasing free chlorine. The chlorine is actively involved in the process of destruction of ozone. Two molecules of ozone give rise to three of molecules of oxygen. The chemical reactions involved are as under.

$$Cl + O_3 \longrightarrow ClO + O_2$$

$$2ClO + O \longrightarrow Cl_2 + O_2$$

The chlorine atom is released back and continues the process repeatedly leading to a reduced level of ozone. Bromine compounds can also destroy stratospheric ozone. Emissions of CFCs are responsible for around 80% of total stratospheric ozone depletion.

Remedial Measures

As has been earlier indicated the best way out is to avoid/minimize use of CFCs. These include proper disposal of old refrigerators, use of aerosols and refrigerants, which do not contain CFCs, use of halon-free fire extinguishers and the recycling of foam and other non-disposable packaging. While emissions of ozone depleting compounds are now being controlled, the ozone layer is not likely to fully heal for several decades due to the stable nature of these compounds. Hence we should take precautions when exposing ourselves to minimize the effect of UV radiation.

Air, Water and Land Pollution

Air pollution is a major problem since very long. In the middle Ages, the burning of coal released large amounts of smoke and sulphur dioxide to the atmosphere. In the late 18th century, the Industrial Revolution led to escalation in pollutant emissions by the industry. After the disastrous London Smog of 1952, pollution from industries and homes was sought to be reduced to prevent recurrence of these events. Recently pollution from motor vehicles has become a very important air quality issue. The number of vehicles in most countries around the world is steadily increasing.

Impacts of Air Pollution

Air pollution can be either natural or man-made, and occur both indoor and outside. Although natural emissions of air pollution may affect the environment from time to time, man-made air pollution leads to poor air quality on a more regular basis.

Common outdoor air pollutants, which affect ambient air quality, include sulphur dioxide, nitrogen oxides, carbon monoxide, particulate matter and volatile organic compounds (VOCs) emitted through the burning of fossil fuels for energy and transportation. Ozone, a secondary pollutant, is formed in the atmosphere near ground level when primary pollutants are oxidized in the presence of sunlight. The resulting pollution can have detrimental effects on human health, wildlife and vegetation. Asthma is an increasingly common respiratory disease, which may be triggered by air pollution. In addition, sulphur dioxide and nitrogen oxides cause acid rain.

Indoors, poor ventilation can lead to a build-up of air pollutants, including carbon monoxide and nitrogen dioxide from faulty gas heaters and cookers, carbon monoxide and benzene from cigarette smoke, and volatile organic compounds from synthetic furnishings, vinyl flooring and paints. Since most of us spend up to 90% of the time indoors, indoor air quality could have a real bearing on our health.

Water Pollution is yet another major manmade environmental problem. Water is essential for survival of all forms of life and it is also an important requirement in most of the industrial activities. Deterioration of water quality is a major environmental issue especially in developing countries like India. Increase in industrial activity and human population has adverse impact on the quality of not only surface water but also on ground water. The pollutants encountered in water are

- Oxygen Demanding Wastes (BOD)
- Pathogenic Micro Organisms
- Synthetic Organic and Inorganic Chemicals
- Heavy Metals
- Sewerage and Agricultural Runoffs
- Suspended Solids and Sediments
- Radioactive Materials
- Thermal Discharges.

Impacts of Water Pollution

Waterborne infectious diseases like typhoid, dysentry, cholera etc. are caused by consuming contaminated water. Fluoride in drinking water causes fluorosis a disease of the teeth and bones. Effluents from industries like paper mills, tanneries, diaries, breweries, slaughterhouses and municipal sewerage are contaminated with organic pollutants, which reduce the Dissolved Oxygen (DO) levels in the water killing aquatic organisms. Agricultural runoffs pollute water with plant nutrients like Phosphates and Nitrates and Pesticides. The plant nutrients promote wild growth of oxygen consuming Algae leading to the destruction of aquatic life. Pesticides are toxic to humans, and animal life. Industrial pollutants from certain factories contain heavy metals like Mercury, Lead, Cadmium, Nickel, and Chromium, which are absorbed by plants and animals including human beings. Oil pollutants from petroleum industry have resulted in the death of several birds and animals**.** Thermal discharges reduce DO levels of water bodies leading to destruction of aquatic life.

Remedial Measures

Adopting cleaner production technologies (Prevent Pollution rather than treat pollution) is the correct strategy. This should be coupled with water conservation measures and end of the pipe treatment techniques.

Land pollution is an area requiring urgent attention. Land pollution is also closely related to ground water contamination. Disposal of industrial and municipal solid wastes and hazardous chemicals on land has resulted in not only polluting land but also has resulted in increase of toxic chemicals in the underground water. In India around 90 million tones of solid waste and 6 million tones of hazardous waste are being generated annually. These wastes are mostly dumped in an uncontrolled fashion on public land .In addition to the municipalities and corporations (human dwellings) the major industrial sources of solid wastes are Thermal power plants, Ferrous and nonferrous metals manufacturing and processing units, Sugar, Paper, Textile, Petroleum Refining, Petrochemicals and fertilizers, Cements and Polymer Industries. Mining and quarrying industry uses up fertile land areas.

Biomedical wastes from hospitals like body parts, used and discarded syringes, needles and surgical instruments, dressing and hospital linen are mixed with municipal wastes, which pose a major health hazard in developing countries like India. Loss of soil fertility results from excess application of fertilizers and pesticides.

Developmental projects for housing, industry, road, rail, and air transport are using up agricultural or forestlands increasing pressure on the available land resource. Deforestation is a global issue, which is considered to be one of the major reasons of global warming.

Impacts of Land Pollution

Disruption of hydrological cycle, Ground water and surface water pollution, Air pollutants emission, destruction of the habitats of many plants and animals leading to loss of biodiversity, reduction in food production, negative effects on human, plant and animal health are some of the adverse impacts of land pollution.

Remedial Measures

Proper land development policies and their implementation, adopting correct solid waste disposal techniques like composting, sanitary land filling, incineration, pyrolysis will to some extent mitigate the adverse impacts on land or soil pollution. Waste minimization, recycle and reuse will pay rich dividends in this regard.

Eutrophication

When aquatic plant growth is stimulated to produce excessive choking growth eutrophication occurs. The process involves a complex series of inter-related changes in the chemical and biological status of a water body mostly due to a depletion of the oxygen content caused by decay of organic matter resulting from a high level of primary productivity and typically caused by enhanced nutrient input. Sewage is an important source of organic materials in water bodies. Fertilizers and detergents containing Nitrogen and Phosphorous are also the major sources of nutrients. These nutrients greatly increase the productivity in aquatic environments and contribute to eutrophication. Algal blooms are an indication of eutrophication of a water body. A small part of the algal blooms are consumed by zooplanktons and other aquatic organisms like fishes and most of them stay and decay in the water depleting dissolved oxygen. Toxic gases like Hydrogen sulphide is generated. An unpleasant greenish slimy layer is formed on the surface of the water body. This results in the suffocation and eventually death of aquatic organisms. The water body emits bad odor. The anaerobic conditions (Lack of Oxygen) generate toxins in the algae, which can kill surface organisms like birds and animals. The water body cannot be used as a source of water supply nor used for any other activity like recreational use.

Remedial Measures

Treated effluents devoid of nutrients only should be discharged into water bodies. Sludge removal and routine dredging is a must. Algaecides like copper sulphate, chlorine can be added in controlled quantities.

Biodiversity

Biodiversity in the broad sense means the different forms of life and life sustaining systems and processes available on the earth. Even though it is impossible to access the number of species of living things on earth an approximate estimate puts it at 10 to 80 million species. The different types of biodiversity are:

(1) *Genetic Diversity*: This is the difference in the genetic makeup in one individual species. (I.e.) Variability within the species

(2) *Species Diversity*: This is the variety or variance of distinct types of living organisms in different habitats.

(3) *Ecological Diversity*: This includes the different types of forests, grass lands, wet lands, water bodies like streams, lakes and oceans, coral reefs, rocky mountains etc.

(4) *Functional Diversity*: This includes the different types of biological and chemical processes such as mass and energy flow essential for the survival of living organisms.

Importance of Biodiversity

- Biological diversity is very important for the existence of the human race. In addition to the practical importance, Biodiversity lends aesthetic beauty to nature. The benefits arising from biological diversity are:
- **Ecosystem Services**
  - **Protection of water resources** like maintenance of hydrological cycles, regulating and stabilising water runoff, and buffer against extreme events such as flood and drought.
  - **Soils formation and protection:** Formation and maintenance of soil structure and the retention of moisture and nutrient levels.
  - **Nutrient storage and cycling:** Plants take up nutrients from the soil as well as from the air, and these nutrients can then form the basis of food chains, to be used by a wide range of other life forms. Pollution breakdown and absorption
  - **Breakdown and absorpion of pollutants:** Ecosystems and components of ecosystems from bacteria to higher life forms are involved in breakdown and assimilative processes of pollutants. Natural and artificial wetlands are being used to filter effluents to remove nutrients, heavy metals and suspended solids, reduce the biochemical oxygen demand and destroy potentially harmful microorganisms.
  - **Contribution to climate stability:** Vegetation influences climate at the macro and micro levels. Undisturbed forest helps to maintain the rainfall in its immediate vicinity by recycling water vapour at a steady rate back into the atmosphere.

- **Recovery from unpredictable events:** Healthy ecosystems improve the chances of recovery of plant and animal populations from unpredictable natural catastophic events such as fire, flood and cyclones and from disasters caused by humans.

■ **Biological Resources**

- **Food :** Existence of human beings and that of most other organisms is heavily dependent on primary producers, mainly plants.
- **Medicinal resources:** Plant and animal products have long since been used as medicines due to their curative properties. Indian and Chinese medical systems make elaborate use of herbs and herbal products.
- **Wood products:** Wood is a basic commodity used worldwide. It is a primary source of fuel, is used in construction, and forms the basis for paper production.
- **Ornamental plants:** Ornamental and horticultural purposes, for providing aesthetic beauty
- **Breeding stocks, population reservoirs:** Natural areas provide support systems for commercially valuable resources .
- **Future resources:** The wild and unknown population of plants and animals offer enormous scope for research and development in areas of agriculture, industry and medicine.

■ **Social Benefits**

- **Research, education and monitoring:** Natural areas provide excellent living laboratories for research in ecology and evolution.
- **Recreation:** Diverse biological assemblies like animal habitats, forests, mountains, parks and gardens, costal areas and beaches, provide aesthetic beauty to our environment.
- **Cultural values:** The aesthetic values of our natural ecosystems and landscapes contribute to the emotional and spiritual well-being of human beings.

Major Factors Responsible for Loss/Reduction in Biodiversity

- Overexploitation of natural resources and destruction of ecosystems for meeting the human requirements of food, shelter and comfort.
- Environmental pollutants like pesticides, heavy metals, chlorinated hydrocarbons, acid rain, global warming etc.
- Eutrophication leading to promotion of growth of some specific species suppressing others.
- Natural causes like earthquakes, floods, droughts, forest fires, epidemics.
- Excessive importance of specific species for cultivation (15 types of species provides 90% of the worlds food supply).
- Hunting for pleasure and poaching for commercial purposes of certain animal species like elephants, rhinos, whales, crocodile, snakes etc.

Restoration and Conservation of Biodiversity

The following remedial measures will be useful for the repair and revamping of the biotic resources in the globe.

- Assesment of the biodiversity inventory and prepare detailed mapping
- Wildlife conservation measures focussing on protecting animal and plant life in zoos, sanctuaries, parks and gardens, Biosphere reserves. Two basic approaches viz " *Ex-situ* conservation" and "*In-situ* conservation"
  - ***Ex-situ* Conservation:** In this approach, wild life conservation is done in capitivity under human care. Endangered plants and animals are collected and are cared for and reproduced in controlled conditions like zoos, sanctuaries and national parks. This approach ensures assured supply of basic requirements like food, water, shelter and mates. Due to the security provided hunting and poaching is avoided. In addition genetic research is possible. However the organisms kept under captivity are unable to adopt for changing environmental conditions leading to stagnation of the gene pool. It is also expensive.
  - ***In-situ* Conservation:** In this approach large areas of the earth surface are kept reserve for wild life.
- Modification of agricultural practices encouraging mixed cropping and poly culture and there by reducing excessive importance on specific species of plants.
- Setting up of seed banks and gene banks.
- Restoration of habitats and eco-systems which are important for biological communities. Reforestation, prevention of soil erosion, fencing, fertilisation , reintroduction of expired species etc.
- Imparting Environmental Education and awareness and motivate communities to conserve resources.
- Introduction of stringent legislations and implementation of the same.
- Population control and check on indiscriminate urbanisation.

Other Man Made Impacts on the Environment

Some of the other man made impacts on the environment, which has acute adverse effects, are briefly described.

Photochemical smogs are generated by the interaction of air pollutants (from automobiles and industries) like Hydrocarbons, Oxides of nitrogen and Sulphur, Particulate Matter in the presence of sunlight. The smog (Smoke + Fog) is the product of these interactions and contains toxic components like Ozone, Peroxyacylnitrate (PAN), Carbon monoxide, ketones and aldehydes. In stagnant air and in cold conditions the smog assumes lethal proportions and creates acute respiratory problems. The great London Smog killed around 4000 persons in December 1952 mainly due to suffocation. The incident repeated in 1956 and in 1962 in London and in 1966 in Los Angeles in US resulting in more deaths and respiratory disorders. Photochemical smogs also trigger eye irritation, degradation of natural and synthetic polymers and harms plant and animal life. Reduced visibility due to smogs has led to road and aviation accidents.

Nuclear disasters are yet another man made Environmental Tragedy. The Chernobyl Nuclear Disaster took place in 1986 in the former Soviet Union. A nuclear explosion in the atomic reactor used for power generation threw up radioactive material exposing over 400 million people to radiation. The death toll was more than 2000 and radioactive fallout was felt in regions as far away as 2000 kilometers in Scandinavian Countries. The radioactive pollution damages plant and animal life and produces chronic health effects in humans such as cancer, blood abnormalities, thyroid damages and mutagenic and somatic changes.

Two atom bombs were dropped on Japan in 1945 during World War II killing and injuring instantly lakhs of people .The radioactive fallout will cause generations to suffer from several physical, mental and genetic disorders in addition to the permanent damages to the flora, fauna and soil. The threat of a full blown nuclear war is a reality with several nations acquiring the technology for making the nuclear bombs.

The Bhopal Gas Tragedy is one of the deadliest environmental disasters that the human kind has ever encountered. Methyl Isocyanate gas used for the manufacturing of pesticides leaked into the atmosphere from a factory in the city of Bhopal in central India .The toxic gas killed thousands of people and the suffering continues for many more even today. The survivors are affected and disabled for not only a lifetime but even beyond due the severe genetic effects. The problem is more acute and painful since many of the victims are poor.

Mianamita disease occurred in a place called Minamita in Japan. A chemical plant dumped mercury-containing wastes in the sea in the Minamita Bay. It was assumed that the heavy elemental Mercury would sink to the sea floor and remain there inert and harmless. But the bacteria in the sediments of the sea floor converted the Mercury into water soluble methyl mercury and was absorbed by fishes and eventually by humans. This led to an epidemic affecting nervous systems, numbness, blurred vision, speech deficiencies loss of control of muscles etc. Many countries where mercury compounds are used as fungicides and algaecides are prone to Minamata disease.

2

SCIENCE OF ENVIRONMENT

2.1 CHEMISTRY, PHYSICS AND BIOLOGY OF AIR, WATER AND LAND

2.1.1 Introduction

The major components of our environment viz. Air, Water and Land are the recipients of the primary pollutants with which they interact and generate secondary pollutants. In addition air, water and land also serve as sinks for several pollutants.

A thorough understanding of physics, chemistry and biology of these components is essential for the Environmental Engineer.

2.1.2 Physics, Chemistry and Biology of Water

The characteristics of water which determine its ability to be used for human consumption and use, Industrial and agricultural use can be broadly divided under three categories viz. Physical, Chemical and Biological Water Quality Parameters

The Physical Water Quality Parameters

The Physical water quality parameters are characteristics of water that respond to the sense of sight, touch, taste or smell. These characteristics include suspended solids, turbidity, color, taste, odour and temperature.

Suspended Matters and Turbidity

Suspended Solids normally consist of inorganic and/or organic particles. Fine dispersion of immiscible liquids like oils and waxes also fall under this category. The Inorganic solids could be fine silica, clay, silt, and other components from the soil. Organic matters are normally from sources like plants and animals and synthetic organic materials. The ground water is normally not contaminated with suspended solids due to the filtering ability of the soil. Domestic and Industrial use of water result in a large variety of suspended matter which are both organic and inorganic in nature.

Suspended matter is not desirable since it spoils the appearance and is aesthetically unpleasant. In addition organic suspended matter under goes biological degradation resulting in objectionable by-products. Biologically active (live) suspended solids may include disease-causing organisms as well as organisms such as toxin-producing strains of algae.

Water containing Suspended solids cannot be used for industrial purposes since it may chemically interfere with the process. Frequent chocking of pipelines, filtration units, corrosion and erosive failures, sludge deposition are some of the problems associated with high-suspended solids in industrial process water.

Suspended solids are experimentally measured by filtering an known quantity of water sample through a filter paper. Suspended solids content is reported in mg/Lit or ppm.

The turbidity of water is mainly associated with suspended matter content. Since suspended matter in water scatters light and does not allow free passage, the visual depth of such water samples are restricted. Turbidity often results from a wide variety of suspended materials that range in size from colloidal to coarse dispersions.

Turbidity results from both natural as well as man made causes. Silica, clay, silt, and other components from the soil are the natural source of turbidity. Anthropogenic activities, both domestic and industrial contribute to organic, Inorganic and biological suspended matter.

Turbidity in water is objectionable from aesthetics, filterability and disinfections points of view. Turbid water is never a pleasing sight and is always associated with domestic waste and wash water and hence public water supplies should be turbid free. Turbidity measurement is carried out using a nephlometer and is expressed in Nephlometric Turbidity Units (NTU).

Colour

Colour is imparted to water mainly by the dissolved and suspended matter. The natural colorants in water are primarily negatively charged colloidal particles, which can be readily removed by coagulation using a salt having a trivalent metallic ion. Humic substances, resulting from organic debris, such as leaves, needles of conifers, and woods in various stages of decomposition also contribute to the natural colouring of water.

Industrial and domestic use of water increase dissolved as well as suspended matter content leading to colouring of water. Effluents from textile, tannery, paper and pulp and heavy metal processing industries are severely coloured due to the presence of pigments, dyes and salts of heavy metals. Colour caused by suspended matter is referred to as apparent colour and is differentiated from colour due to vegetable or organic extracts that are colloidal and which is called true colour. Colour intensity is generally related to pH and hence pH monitoring should be carried out along with colour monitoring for effective control.

The presence of colour is objectionable from the aesthetics and hygiene point of view in drinking water. In industrial process water the presence of color generating chemicals may interfere with the process especially in cleaning and washing operations. Colour is measured and expressed in Hazen units.

Taste and Odor

Taste and odor are closely related issues since substances that produce an odor in water will almost invariably impart a taste as well. The converse is not true, as there are many mineral substances that produce taste but no odor.

Substances with which water comes into contact in nature or during human/industrial use may impart perceptible taste and odor. These include minerals, metals, and salts from the soil, end products from biological reactions, and constituents of wastewater. Inorganic substances mostly produce taste without odor.

Organic materials produce both taste and odor. Biological decomposition of organics may also result in taste and odor producing liquids and gases in water.

Some of the odors inducing components in water are: Amines (Fishy), hydrogen sulfide (Rotten Eggs), mercaptans (skunk), Organic sulphides (Rotten cabbage). The odor of water is measured in terms of TON i.e. Threshold Odor Number, indicating the number of times the dilution should be carry out with odor free water to get water of acceptable quality.

Temperature

Temperature is one of the important parameters, which determines the quality of natural surface water systems. The temperature of surface waters governs to a large extent the biological species present and their rates of activity. Temperature has an effect on most chemical reactions that occur in natural water systems. Temperature also has a pronounced effect on the solubility of gases in water.

The temperature of water systems increases due to thermal discharges from industrial units. For example, power stations discharge large quantities of condensate water at high temperatures. A higher temperature reduces the DO content, which results in the reduced biological growth and activity.

Temperature changes the reaction rates and solubility levels of chemicals. Increased temperatures accelerate most chemical reactions involving dissolution of solids. The solubility of gases, on the other hand, decreases at elevated temperatures.

Temperature also affects other physical properties of water. The viscosity of water increases with decreasing temperature. The maximum density of water occurs at 40°C. Both temperature and density have a subtle effect on planktonic microorganisms in natural water systems.

Foam: Foam in water normally is caused by the presence of surfactant materials (soaps and detergents). Excess foaming causes problems in treatment and discharge.

The Chemical Water Quality Parameters

The chemical water quality parameters comprises pH, Hardness, Total dissolved solids, Metals, Organics, Surfactants, Nutrients, Oils and Greases and Hydrocarbons

pH

pH is a term used to express the acidity or alkalinity of a solution. It is a way of expressing the hydrogen-ion concentration. pH monitoring and measurement is important in every phase of Environmental Engineering and science. The pH of water is an important consideration which determines its ability to be used both for human consumption & use as well as for industrial purposes. pH of water influences chemical coagulation, disinfection, water softening, and corrosion control. In wastewater treatment employing biological processes, pH must be controlled within a range favorable to the particular organisms involved. Chemical processes used to coagulate wastewaters, dewater sludge, or oxidize certain substances, such as cyanide ion, require that the pH be controlled within rather narrow limits.

Hardness

Hardness in water is caused by the dissolution of multivalent metallic cations such as calcium, magnesium, strontium, ferrous iron, and manganese ions. Such ions are capable of reacting with soap to form precipitates and hence hard water does not produce a stable lather with soap. In addition with certain anion present scale formation occurs.

The hardness of waters varies considerably from place to place. In general, surface waters are softer than ground waters. The hardness of water reflects the nature of the geological formations with which it has been in contact.

Hardness is classified as carbonate hardness and noncarbonate hardness depending on the associated anion. Carbonate hardness is due to the presence of the presence of calcium or/and magnesium bicarbonates, which are sensitive to heat. They precipitate readily on application of heat as per the following reactions:

$$Ca(HCO_3)_2 \longrightarrow CaCO_3 + CO_2 + H_2O$$

$$Mg(HCO_3)_2 \longrightarrow Mg(OH)_2 + 2CO_2$$

Hence carbonate hardness is also called as temporary hardness. Noncarbonate hardness or permanent hardness is due to the presence of anions like sulphates and chlorides.

Hardness of water, within acceptable levels does not pose any major problem for human consumption and use. Because of their adverse action with soap, however, their use for cleansing purposes is quite unsatisfactory. From the taste point of view however, treated softened water has a higher public acceptability. Due to the tendency of scale formation hard waters are unsuitable for use in boilers and demineralization is essential.

Hardness is measured by using spectrophotometric techniques or chemical titration to determine the quantity of calcium and magnesium ions present in the given sample. Hardness levels are expressed in ppm or mg/Lit.

Total Dissolved Solids

The material remaining in the water after removal suspended-solids by filtration is called total dissolved solids. This material is left as a solid residue upon evaporation of the water.

Dissolved material results from the solvent action of water on solids, liquids, and gases. Like suspended material, dissolved substances may be organic or inorganic in nature. Inorganic substances include minerals, metals and gases. Materials from the decay products of vegetation, organic chemicals, and organic gases are common organic dissolved constituents of water.

Many dissolved substances are undesirable in water. Dissolved minerals, gases, and organic constituents may produce aesthetically displeasing color, tastes, and odors. Some chemicals may be toxic and disease causing. However, not all dissolved substances are undesirable.

In TDS measurement no distinction among the constituents is made. Hence TDS parameter is included in the analysis of water and wastewater only as a gross measurement of the dissolved material. However this is not sufficient for water intended for use in potable supplies, agriculture, and some industrial processes. When this is the case, tests for several of the ionic constituent of TDS will have to made.

Metals

Several metal salts are soluble in water. An excessive amount of any metal in water is a health hazard. However metals that are harmful even in minute quantities are branded as toxic. In natural waters metals dissolve from mineral deposits. The non-toxic metals present in water include calcium, magnesium, sodium etc. Presence of iron, manganese, aluminium, copper and zinc at low concentrations in natural waters does not present a health hazard. Toxic metals are harmful to humans and other organisms even in very small quantities. Toxic metals include arsenic, barium, cadmium, chromium, lead and mercury. The increase in the level of toxic metals in water is mainly due to mining, industrial and agricultural activities.

Organics

Organics in natural water systems occurred due to the dissolution of the decay products of organic solids. The primary problem of dissolved organics is color, taste and odor. The secondary affects results from the microbial action on the dissolved organics.

Synthetic organics are due to the wastewater discharges and agricultural practices. Dissolved organic materials in water are divided into two broad categories viz. biodegradable and nonbiodegradable.

Biodegradable organic materials are used as food by microorganisms/or can be oxidized to produce simpler components like carbon dioxide and water. Biodegradable organic material includes starches, fats, proteins, alcohols, acids, aldehydes and esters.

In **aerobic** environments (i.e. with the presence of oxygen) the biodegradable organics are oxidized to produce stable and acceptable components. In anaerobic environments (in the absence of oxygen) microbial reactions produce unstable end products, which can be further oxidized to produce aerobic end products.

The biodegradable organics are hence oxygen demanding and the amount of oxygen consumed during microbial utilization of organics is called **Biochemical Oxygen Demand (BOD)**. The BOD is measured by determining the oxygen consumed from a sample placed in an airtight container kept in a controlled environment for a specific length of time. BOD is expressed in ppm. Higher BOD levels indicate higher levels of organic contaminations.

Non-biodegradable organic materials do not decompose biologically or take a very long time to degrade. Very strong molecules like polysaccharides and aromatic components with ring structures (Benzene) are nonbiodegradable.

Surfactants like alkyl benzene sulphonate (ABS), which are used as detergents, are non-biodegradable. **Organic Pesticides** consisting of chlorinated hydrocarbons fall under the category of nonbiodegradable organics in water. Measurement of nonbiodegradable organics is done by the chemical oxygen demand test (COD). Another method of estimating non-biodegradable organics is by the determination of total organic carbon (TOC).

Nutrients

Elements and components, which help in the growth and reproduction of plants and animals, are called nutrients. A large amount of minerals and trace elements can be classified as nutrients but the most important are carbon nitrogen and phosphorous. Carbon is obtained from many sources like carbon dioxide in the atmosphere and decay of organic matter.

Nitrogen

Nitrogen is the major component in the earth's atmosphere. Nitrogen reaches surface waters through natural fixation process. In addition application of chemical fertilizers like urea, ammonium sulfate and decaying animal and plant waste contribute to increase of nitrogen content in both surface as well as ground water. Nitrogen is present in water as ammonia/ammonium ions, nitrates and nitrites and combined organic nitrogen. The nitrogen cycle, which ensures a balance of elemental nitrogen in different components of the environment, is illustrated in detail in Fig. 1.7.

Over enrichment of nitrogen in water leads to serious consequences. Oxidation of NH_3 and NH_4^+ by aquatic microorganisms increases the BOD of water. Nitrate poisoning in infant animals and humans causes serious problems and even death.

Nitrogen is measured in water by determining the available ammonia/ammonium, nitrate and organic nitrogen and the reserves are expressed as mg/L of the particular species of nitrogen.

Phosphorus

Phosphorus is present in aquatic environments as different types of phosphates viz. ortho, pyro, meta and poly phosphates and organically bound phosphates. Phosphorus may be present in animal and plant tissue either in soluble form or as particulate matter. Like nitrogen phosphorus also undergoes a cycle in the different components of the environment. The phosphorus cycle is illustrated in detail in Fig. 1.9.

The sources of phosphorous in surface and ground water include fertilizers, detergents, decaying animal and plant matters, soil constitutes, etc. Industrial waste containing phosphate compounds are also a source of phosphate in water.

Phosphates are not toxic and do not present a major health hazard to human beings or other organisms. However when the available supply of phosphorous in water increase rapid growth of aquatic plants results leading serious consequences. Phosphate also interferes with the water treatment process.

Phosphates are measured colorimeterically and the results are reported in mg/L of phosphorous or phosphates.

The Biological Water Quality Parameters

The Biological water Quality Parameters include the pathogens like bacteria, virus, protozoa and helminths.

Water is a carrier of thousands of biological species. Many of the species spend either their full life or part of it in aquatic environment. A healthy water system should be a host to large number of species of optimum numbers. Certain organisms due to their adverse effect on humans and plant and animal life are considered to be pollutants.

Pathogens are those organisms capable of infecting and transmitting diseases to human beings. Many pathogen species survive in water and maintain their ability to infect for considerable lengths of time. The water borne pathogens include species like bacteria, viruses, protozoa and helminths.

Bacteria are single cell microorganisms and are the lowest form of cell life. Gastrointestinal problems are mainly due to water borne pathogenic bacteria. Cholera transmitted by *Vibrio comma* causes vomiting and diarrhea, which can result in dehydration, and death if left untreated.

Salmonella typhosa transmits typhoid, which leads to high fever and ulceration of intestines. Immunization of individuals and disinfection of water are the only ways to eliminate cholera and typhoid. However in over crowded and poor sanitary conditions water pollution by these bacteria result in the outbreak of these diseases.

Viruses are small biological organisms, which can be seen only with the aid of an electron microscope. Water borne viral pathogens causes poliomyelitis and infectious hepatitis. Immunization of individuals and disinfection of water will reduce the incidence of polio and hepatitis. Effective viral disinfection is extremely difficult and hence utmost care should be taken while recycling waste water.

Protozoa are low form of animal life and are unicellular organisms. They are highly complex and are adaptable to different environment. They are widely distributed in natural waters. Protozoal infections result in gastrointestinal disorders of milder nature. *Entamoeba histolytica* and *Giardia lamblia* are examples of water borne protozoa causing gastrointestinal disorders. Disinfection and filtration are necessary for complete elimination of protozoa.

Helminths are parasitic worms, which thrive on human or animal hosts. Consumption of water contaminated with human or animal waste containing helminths propagates them. Helminths are effectively destroyed by modern water treatment processes. However persons dealing with untreated water like sewage plant operators, farm laborers dealing with cattle are at risk.

Analysis of water for pathogens is time consuming and costly. An indicator organism technique is used for checking the presence of most of the water borne pathogens. Relatively simple test have been developed for determining the presence of coliform bacteria. The membrane filtration technique is also very popular to get the direct count of coliform bacteria. The results are reported in number of organisms per 100 ml of water. Multiple tube fermentation test are also used to determine coliform organisms.

2.1.3 Physics, Chemistry and Biology of Air

A detailed account of the different segments of the atmosphere is provided in chapter 1.1. The different chemical species and particulates present in the atmosphere are summarized below.

Ions

At an altitude of 50 km to 100 kms considerable concentrations of electrons and positive ions such as O^+, NO^+ etc. exist for reasonably longer residence times. This zone of the atmosphere is called ionosphere. The UV radiations from the sun lead to the formation of ions in the ionosphere.

Radicals

The atmosphere also has free radicals that are highly reactive. These free radicals are generated by photochemical reactions and may be organic or inorganic. HO•, HCO•, NO_2•, ROO•, CH_3• are some examples of the free radicals available in the atmosphere. These radicals interact with other chemical components of the atmosphere producing a series of chain reactions.

Particulate Matter

Particles of wide range of sizes ranging from 0.1 µ to 10µ exist in the atmosphere. Highly polluted air may contain up to 105 particles per cc. Aerosols are particles with colloidal dimensions. Dust, fog, ash, mist, smoke, pollen, fumes and bacteria contribute to the presence of particulate matter. Particulate matter may be either organic or inorganic in nature. Inorganic particulates are volcanic ash, fine silica dust, iron oxide, and calcium oxide, Lead etc. Organic particulates are generated from automobile exacts, fuel combustion, and solid organic matter.

Particular matter may be generated either by natural means (Volcanic eruption, wild fires, dust storms etc.) or by anthropogenic means (Automobile exhaust, fossil fuel burning, mining and quarrying and various other industrial activities).

Particulate matter is a health hazard since they enter the human beings and animals through the respiratory tract and are absorbed by them. Removal of particulate matter from the atmosphere is a very important function in air pollution control. However the particulate matter also lead to certain beneficial effects. They provide the nuclei for condensation of water vapor and cloud formation. They also contribute to maintaining a radiation and heat balance on earth.

Chemical Reactions in the Atmosphere

The different chemical species available in the environment undergo chemical changes by reaction with other molecules. The chemical reactions are also assisted by the solar radiation. The chemical and photochemical reactions taking place in the atmosphere depend up on the temperature, nature and concentration of the chemical species available, humidity, and intensity of sun's radiation.

The **oxides of nitrogen** (Referred to as NO_x) viz. N_2O, NO and NO_2 originate from burning of fossil fuels and other anthropogenic activities. In the stratosphere, N_2O decomposes photo chemically to NO which intern depletes ozone layer.

$$N_2O + h \longrightarrow N_2 + O$$

$$N_2O + O \longrightarrow 2NO$$

$$NO + O_3 \longrightarrow NO_2 + O_2$$

$$NO_2 + h \longrightarrow NO + O$$

The oxidation of NO_2 and subsequent absorption in water produces nitric acid forming acid rain.

$$4NO_2 + O_2 + 2H_2O \longrightarrow 4HNO_3$$

The **oxides of sulphur** (Referred to as SO_x) viz. SO_3 and SO_2 originate from the burning of fossil fuels as well as from volcanic eruptions.). The sulphur dioxide absorbs solar radiation and produces electronically excited SO_2, which is oxidized to SO_3. In the presence of moisture SO_3 is converted to H_2SO_4, contributing to acid rain. The overall photochemical reaction is as under.

$$SO_2 + \tfrac{1}{2}O_2 + H_2O \longrightarrow H_2SO_4$$

Organic compounds like hydrocarbons, aldehydes and ketones actively take part in chemical and photochemical reactions assisted by solar radiation and particulate matter

$$CH_4 + O_2 \longrightarrow CH_3^* + HO^*$$

$$CH_3CH = CH_2 + HO^* \longrightarrow CH_3\text{–}CH^* - CH_2OH$$

$$RCHO + h \longrightarrow R^* + HCO^*$$

$$\begin{matrix} R \\ R \end{matrix}\rangle CO + h\nu \longrightarrow R^* + R^*CO$$

The alkyl or aryl radicals R react with oxygen to form peroxyl radical, which subsequently reacts with NO_2 to generate peroxyacyl nitrate (PAN), formaldehyde and a host of polymeric compounds. These compounds reduce visibility in the atmosphere and contribute to photochemical smog.

Photochemical smog can also be initiated by the dissociation of NO_2 and subsequent secondary reactions with hydrocarbons and other organic compounds. The stepwise chemistry of the formation of photochemical smog is illustrated below:

(1) Nitrogen oxides generate oxygen atoms by photochemical reaction.

$$NO_2 + h \longrightarrow NO + O^*$$

(2) Oxygen atoms form hydroxyl (HO*) radicals catalyzed by particulate matter (PM)

$$O^* + O_2 + PM \longrightarrow O_3 + PM$$
$$NO + O_3 \longrightarrow NO_2 + O_2$$
$$O^* + H_2O \longrightarrow 2HO^*$$

(3) Hydroxyl radicals generate hydrocarbon radicals (R*) from hydrocarbons (RH)

$$RH + HO^* \longrightarrow H_2O + R^*$$

(4) Hydrocarbon radicals form hydrocarbon peroxides (RO)

$$R^* + O_2 \longrightarrow RO_2$$

(5) Hydrocarbon peroxides form aldehydes

$$RO_2^* + NO \longrightarrow NO_2 + RO^*$$
$$RO^* + O_2 \longrightarrow RCHO + HO_2^*$$

(6) Aldehydes form aldehyde peroxides

$$RCHO + HO^* \longrightarrow RCO^* + H_2O$$
$$RCO^* + O_2 \longrightarrow RC(O)O_2^*$$

(7) Aldehyde peroxides form peroxyacylnitrates (PAN)

$$RCOO^* + NO_2 \longrightarrow RCOONO_2 \text{ (PAN)}$$

Photochemical smog result in very poor visibility leading to disruption/accidents in air and road traffic. It also causes irritation to the eyes and lungs and chronic respiratory problems. Damage to plants and rubber, polymer goods are also the adverse impacts of photochemical smog.

Ozone is an important constituent in the atmosphere. At an altitude of 30 kms, its concentration is around 10 ppm. This stratospheric ozone layer absorbs UV radiation from the sun and hence protects the life on earth against radiation damages like skin cancer, mutation of DNA etc.

The chemistry of ozone formation and depletion is as under:

$$O_2 + h \longrightarrow O + O$$
$$O + O_2 \longrightarrow O_3$$

This reaction is catalyzed by a third body viz. N_2 or O_2. Thus ozone is continuously formed in the stratosphere by photochemical reaction. Ozone is also destroyed by chlorine released in to the atmosphere by natural (volcanic activity) or anthropogenic (Refrigerants containing Chloro Flouro Carbons) causes. Nitric Oxide and reactive hydroxyl radicals also contribute to ozone depletion.

$$CI + O_3 \longrightarrow CIO + O_2$$
$$CIO + O \longrightarrow CI + O_2$$
$$O_3 + NO \longrightarrow NO_2 + O_2$$
$$O_3 + O \longrightarrow 2O_2$$

The overall ozone depletion reaction is $2O_3 \longrightarrow 3O_2$

Biological Air Quality

In addition to the chemical constituents, biological microorganisms are also present in the atmosphere. These microorganisms are dispersed in air as **bioaerosols**, which are extremely small living organisms or fragments of living things suspended in the air. Dust mites, molds, fungi, spores, pollen, bacteria, viruses, amoebas, fragments of plant materials, and human and pet dander (skin which has been shed) are some examples. They cannot be seen without a magnifying glass or microscope.

Some of the adverse impacts caused by these bioaerosols are listed below:

Viruses and bacteria, cause infections (like a cold or pneumonia). Others cause allergies. Both allergic responses and infections may be serious or even fatal.

An allergic reaction occurs when a substance provokes formation of antibodies in a susceptible person. We call substances, which will cause an allergic reaction in some people *antigens* or *allergens.* Bioaerosols may cause allergic reactions on the skin or in the respiratory tract. Rashes, hay fever, asthma (tightness in the chest, difficulty in breathing), and runny noses are common allergic reactions.

A few people develop a severe allergic reaction in the lung, which can destroy lung tissue. This is called *hypersensitivity pneumonitis.* It is not an infection, but repeated episodes can lead to infections of the lung, such as bacterial pneumonia.

Hypersensitivity pneumonitis can be triggered by exposure to very small amounts of the allergen, once a person is sensitive to it. Symptoms can range from tightness in the chest, cough, and difficulty in breathing, to low-grade fever, muscle aches, and headaches.

The bioaerosols may originate from natural or man-made surface. Soils, Surface waters, Decaying animal and plant parts and wastes are particularly rich sources of Bioaerosols. A list of common man-made sources of bioaerosols is given in Table 2.1.

Table 2.1

Sector	Source
Agricultural	Animal facilities
	Composting
	Harvesting, storage
Air systems	Heating and cooling humidifiers
Indoor surfaces	Ceilings and walls
	Carpet
	House plants and Animals
	Living room
Industrial	Lumbering and saw mill operations
	Food processing
	Tanneries, pulp and paper, sugar etc.
Water treatment	Aeration tanks
	Activated sludge
Hospitals and Health care	Discarded body parts, fluids
	Used syringes, bottles, dressing materials, and linen, surgical and other medical equipment.

Since the microorganisms are dispersed in moving air, they present a bigger risk in still air environments like closed factory sheds and indoors of residences.

The best way to minimize the risk of exposure to bioaerosols is to minimize their generation by adequate precautionary methods. A few of such methods is listed:

- Reduction in relative humidity using chemical or mechanical dehumidifier and elimination of sources of unnecessary moisture and leakages.
- Ensuring adequate ventilation in all living areas and bathrooms
- Practicing good house keeping and regular cleaning
- Proper maintenance and upkeep of equipment like humidifiers, dehumidifiers, air filters, air conditioners and air dryers

2.1.4 Physics, Chemistry and Biology of Land

Elemental Chemical Composition of soil.

The earth crust consists of different types of rocks and disintegrated loose derivatives of these rocks, viz. gravel, sand, silt and clay. The earth crust is made up of 12 major elements and a large number of trace elements. The approximate elemental composition of the earth is given in Table 2.2.

Table 2.2

Element	Weight %
Oxygen	50
Silicon	26
Aluminium	7
Na and K	5
Iron	4
Calcium	3
Mg	2
H	1
Mg, Ti, Cl, C and trace elements	Balance

The **rocks** on the earth's crust are classified in to three categories. They are

1. **Igneous rocks:** These are the oldest form of the rocks, which are formed by solidification of Magma. **Example:** Basalt and Diorite.
2. **Sedimentary rocks:** These consist of distinct sedimentary layers formed due to the weathering by wind and water of mineral matters on the earths crust followed by consolidation and hardening. **Example:** Limestone, sand stone and shale.
3. **Metamorphic rocks:** These rock types are formed due to metamorphosis of igneous and sedimentary rocks under the influence of high pressure, intense heat and time. **Example:** Quartzite, slate, marble and schist.

Minerals on the Earth Crust

Bulk of the earth crust is made up of around 10 minerals. The important group of minerals are: Felspars, Pyroxenes, Quartz, Micas, Silicates, Calcite, Magnetite, Hematite , Dolomite, Kaoline etc.

Soils are formed because of the interaction of the rocks with wind, rain and heat. As a result of this interaction, the rocks on the earths crust break into small fragments. This process is known as weathering, which results in the generation of sand, silt, gravel and clays. The weathering process can be physical, chemical and biological.

The Physical weathering is due to temperature, water and wind. Chemical weathering involves reactions like Oxidation, Reduction, Chemical dissolution and Precipitation, Hydration and Hydrolysis, Carbonation etc.

Biological weathering is brought about by organisms like bacteria, algae and fungi in humid conditions.

The Constituents of The Soil

Soil is a complex system, which has organic, inorganic, biological constituents. In addition water and gases are also present in the soil. The contents of the soil can be classified in to:

(i) **Mineral matter**, which consists of gravel, sand, silt and clay. Each of these is characterized by the respective particle sizes. While the average particle size is less than 2µ. The mineral matter are mainly made up of quartz and silicate minerals. The soil at any particular location may consists of different proportions of sand, silt and clay depending on the relative proportions, the soils can be classified in to sandy, sandy loam, Clayey loam, clayey

(ii) **Organic matter:** Plant and animal decayed products contribute to the organic matter in soil, which is called *humus*. The process of formation of humus from plant and animal parts and wastes by microorganisms called humification. The total organic matter content of a soil is generally 2-5%. Despite this low value the organic matter contributes to the nutritional value and hence the fertility of the soil. The soil also houses wide range of organisms like bacteria, algae, fungi, protozoa, worms, nematodes, etc. which are called "Edaphons".

(iii) **Soil moisture and air:** Since the mineral matter of the soil is porous in nature, the voids are filled by air and water. The quantity and the transport of air, gases and water depends on the porosity of the soil and hence the size of the soil particles. The nutrients in the soil are dissolved by water and is absorbed by the plants through the roots.

Functions of the Soil

The soil in the lithosphere serves several useful purposes without which life on earth will not be possible. The different functions of the soil are:

(1) It provides a platform for the growth of plants.

(2) It houses several types of bacteria and other micro organisms which help in decomposition of animal and plant matter and waste, regeneration and fixing of nutrients in the soil and mineralisation of organic matter.

(3) It is a reservoir of water and supplies water to the plants through the roots.

(4) It serves as storage of macro and micronutrients necessary for the growth of plants and animals.

Soil Pollution

Reckless dumping of industrial, municipal and biomedical wastes leads to the leaching and seepage of toxic material in to the soil, polluting both soil and ground water. Intensive agricultural practices call for application of synthetic fertilizers, pesticides, fungicides and insecticides contaminate soil and water.

2.2 ENVIRONMENTAL STRESSES—CAUSES, CLASSIFICATION AND IMPACT

We can view environment as all the external conditions that influence the life of a person or society. Environment ultimately determines the quality and quantity of life. An environmental stress may be defined as a condition of intense strain or pressure or any agent that threatens the integrity of the system or survival of life. The environmental stresses may be **caused** due to any one of the following reasons:

- *Population growth:* Higher population results in the requirement of more food, water, industrial commodities, and literally more of everything and results in increased generation of wastes of toxic nature and therefore more pollution.
- *Urbanization:* Concentration of people in smaller land areas such as cities results in increased demand on resources increases volume of wastewaters, solid wastes, problems of residential environment and air pollution.
- *Industrialization:* Urbanization is closely related to industrialization which results in additional environmental stresses.
  - Increase in Hazardous nature, complexity and number of the wastes
  - Problems of occupational environment/hazards
  - Increased demand on resources
  - Toxic, carcinogenic, cumulative and synergistic chemicals
- *Advances in agriculture*: The following impacts are likely to occur: Desertification, Dams and ecological disasters, Salinity problems, soil and ground water pollution due to use of fertilizers & pesticides, Infectious diseases transmitted from animals to humans (Zoonoses).
- *Ignorance, misinformation and disinformation*

The environmental stresses are broadly **classified** into two types which is given in Table 2.3

Table 2.3

Type of Environmental stress		Examples
Natural		Volcanic eruptions Earthquakes Drought Floods Forest fires (Also Refer : Section 1.7.2)
Human-Induced (Anthropogenic)	Air	Pollution of Air Acid rain
	Water	Pesticide poisoning
	Land	Deforestation

Based on the nature of the stress causing agents the environmental stresses are classified as below :

Type of stress causing agent

Physical Agents
(1) Thermal
(2) Radiation
(3) Noise
(4) Mechanical (Vibration)

Chemical Agents	Radio active materials Organic Chemicals Inorganic Chemicals Aerosols Toxic gases and vapors
Biological Agents	Bacteria Viruses Parasites

The chemical agents may present themselves in any and all the three states of matter viz. gas, liquid and solid and the biological agents may survive in any or all the three states.

■ **Physical Agents**

- *Thermal Stress* : Extremes of hot and cold temperature must be considered as thermal agents which induces heat and cold stresses. If the environment is too cold, the body loses heat faster than it can produce and it will lead to '*Hypothermia'* condition. If the environment is too hot and the body is unable to cool fast enough which results in heat stress. Heat stress affects humans in different ways, based on physical fitness, work capacity, age, health, living habits, and degree of exposure to heat. Some of the heat stress related illnesses are as follows :

  Heat stroke : Caused by considerable exertion in a hot environment, lack of physical fitness, dehydration etc.. Blood accumulates in the lower part of the body resulting in inadequate venous blood return to the heart.

  Heat stroke symptoms include hot skin, usually dry, red or spotted. The body temperature rises at 105F or higher. The victim is mentally confused, delirious, possibly in convulsions, or unconscious.

  Heat Cramps : They are painful spasms of muscles that occur in individuals who sweat profusely because of heat exposure

  Heat exhaustion, Heat rash, Transient heat fatigue are the other heat stress illnesses. Cold related stress is initiated by a peripheral vasoconstriction.

- *Radiation*: It is an important environmental stress inducing agent since absorption of energy in the body tissues causes physiological injury by means of ionization or excitation. Radiation causes cell damage by upsetting the cell chemistry/ physics, and by disrupting the ability of the cell to repair itself. Radiation affects the cells and organs during the lifetime of humans (somatic damage). It also causes genetic damage, which affects future generations.

- *Noise* : Excessive or unwanted sound is referred to as noise. Exposure to noise at specific range of frequencies for sufficient duration will result in damage to the auditory system and subsequent hearing loss. Noise may also cause physical and psychological disorders, interference with voice communications, disruption in job performance, rest, relaxation and sleep.
- *Vibration* : Vibration is an oscillating motion of a system ranging from simple harmonic motion to extremely complex movements. Continuous and over exposure to vibration while using hand tools may cause neurotics, decalcification of the carpal and metacarpal bones, fragmentation and muscle atrophy.

■ **Chemical Agents**

Chemical agents are classified into inorganic and organic materials and are most notable for toxicity and flammability which threaten life forms. Toxic chemical substance includes metals, aqueous-based acids and alkalis, petroleum based hydrocarbons etc. Chemical agents can be in the form of particulate matter like dusts, mists, fumes, fibers and smoke etc. Chemical agents induce biochemical and physiological changes in human systems following either systemic contact, via absorption into blood and tissues or local contact.

Some of the notable examples of stress causing chemical agents are listed below:

■ **Metals**

- Arsenic, cadmium, chromium, nickel and uranium are respiratory carcinogens.
- Berrylium can cause depilating lung disease–Berryllious.
- Lead, Arsenic, Mercury and Manganese are toxic to nervous system and lead to neuromuscular effects.

■ **Metal Oxides**

Metal oxides can cause metal fume fever—a flu like illness.

■ **Organic Solvents**

- They are the pure or substituted hydrocarbons derived from petroleum and are used to dissolve other organic materials.
- *Examples* : Benzene, Xylene, carbon tetra chloride, methyl Chloride.
- Most of these solvents cause central nervous system depression, decreased alertness, headaches, sleepiness, and loss of consciousness. They also can damage kidneys.

■ **Toxic gases**

- Many organic and inorganic gases causes toxic effects.
- Oxides of Nitrogen, Oxides of sulfur, ozone, chlorine, formaldehyde, hydrogen chloride, hydrogen chloride, hydrogen sulfide are respiratory and ocular irritants.
- Carbon monoxide is a chemical asphyxiant.

■ **Biological Agents**

Biological agents are commonly referred to as pathogenic organisms which may be present in the environment. When introduced in to the blood stream, they disrupt biochemical and physiological functions by infection or induction of toxicity. The disruption can result in illness and death if the immune system is not able destroy the biological agents. Table 2.4 lists out some of the pathogens.

Table 2.4

Biological agents	Examples
Bacteria	(1) Escherichia coli (2) Mycobacterium tuberculosis (3) Neisseria meningitidis (4) Rickettsiae (5) Salmonella (6) Staphylococcus aureus (7) Streptococcus pyogenes (8) Treponema pallidum (9) Yersinia pestis
Viruses	• Cytomegalovirus • Hantaviruses (including the Sin Nombre virus, which causes HPS) • Hepatitis B • Hepatitis C • Hepatitis D • Herpes simplex virus • Human Immunodeficiency Virus / HIV associated with AIDS • Molluscum contagiosum • Papillomavirus, know to cause warts • SARS (Severe Acute Respiratory Syndrome) • TMV Tobacco mosaic virus. (a plant virus)
Parasites	• giardia lamblia • roundworms • scabies • tapeworms

3

CURRENT ENVIRONMENTAL ISSUES

3.1 CURRENT ENVIRONMENTAL ISSUES AT COUNTRY LEVEL

3.1.1 Introduction

Our country has made rapid strides in different sectors like Information technology, space and nuclear research, general Engineering and automobiles and agriculture in the last 5 decades after independence. Rapid industrialization and urbanization coupled with population explosion has put a great stress on our environment. Rural India encounters environmental problems in the form of deforestation, soil erosion, water pollution and land degradation and Indian cities are faced with severe environmental stresses like air and water pollution, burgeoning solid and biomedical waste.

Bhopal gas tragedy ironically served as an eye opener for environmental awareness and activism in India. The Environment Protection Act was passed in 1986, creating the Ministry of Environment and Forests (MoEF) and strengthening India's commitment to the environment, which was enshrined in the 42nd amendment to country's constitution in 1976. The MoEF has the overall responsibility for administering and enforcing environmental laws and policies. Integrating developmental activities with environmental requirements has become a policy emphasis of the MoEF.

As per the UNEP mandate (United Nations Environment Programme) the state of the environment report prepared by government of India broadly covers the five priority issues pertaining to the environment. These five priorities environmental issues identified at country level are

(1) Land degradation,

(2) Biodiversity,

(3) Air pollution with special reference to vehicular pollution in cities,

(4) Management of fresh water resources,

(5) Hazardous waste management with special reference to municipal solid waste management.

The different issues identified are discussed in detail in the succeeding paragraphs.

3.1.2 Land Degradation

Land degradation occurs both due to natural and man-made causes. Land degradation shows up chiefly in the form of water erosion, followed by wind erosion, biophysical, and chemical deterioration. Deforestation is both, a type of degradation by itself, and a cause for other types of degradation, principally, water erosion.

India has a total geographical area of 328.73 million hectare (mha), out of which 264.5 mha only is under use for agriculture, forestry, pasture and other biomass production. India houses approximately 16% of the world's human population and 20% of the world's livestock population on merely 2.5% of the world's geographical area. This has placed heavy pressures on India's limited land resources to be used for forestry, agriculture, pastures, human settlements and industries. This has led to very significant land degradation. It is reported that approximately 57% of the land area has been degraded in one way or the other. The adverse impacts of land degradation is visible on India's environment and economy.

The major reasons for degradation of land in India are :

- Unstable use and inappropriate management practices.
- Loss of vegetation occurs due to deforestation cutting beyond the silviculturally permissible limit, unsustainable fuel wood and fodder extraction, shifting cultivation, encroachment into forest lands, forest fires and over grazing.
- Extension of cultivation to lands of low potential or high natural hazards.
- Non-adoption of adequate soil conservation measures.
- Improper crop rotation.
- Indiscriminate use of agro-chemicals such as fertilisers and pesticides.
- Improper planning and management of irrigation systems and extraction of ground water in excess of the recharge capacity.
- Land shortage, short-term or insecure land tenancy, open access resource, economic status and poverty of the agriculture dependent people.

Different strategies like policy intervention, promotion of research, stakeholder participation, and technological intervention are necessary to be implemented to check land degradation.

The strategies identified are as follows:

- Development of an Integrated Land use policy addressing issues like rural fuel wood, grazing and fodder etc.
- Instituting a national land use commission to frame, implement and monitor.
- Qualitative and quantitative assessment of existing degraded land.
- Evolve a classification method for lands suitable to Indian conditions and ensure that land is put to appropriate use as per the classification.
- Optimum application of organic manures, chemical fertilizers, bio-fertilizers, and other agrochemicals to ensure sustainable agriculture while maintaining and increasing productivity.
- Research on soil organic matter , nutrient balance, CO_2 build-up in the environment, climate change, biomass production, organic matter production, and long-term carbon storage.

- Clear property rights and/or tenure security.
- Community participation in technology development to utilize the knowledge and experience of people at grass root level.

3.1.3 Biodiversity

Biodiversity is the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems. This includes diversity within species,between species and of ecosystems. Conservation of biodiversity is the basis of sustainable development.

Loss of biodiversity has serious economic and social costs for any country. The experience of the past few decades has shown that as industrialization and economic development, has strained, altered and even destroyed ecosystems.

India is one of 12 mega diversity countries of the world. Even though India occupies only 2.4% of the world's land area its contribution to the world's biodiversity is approximately 8% (126 188) of the total number of species, which is estimated to be 1.75 million. The species recorded in our country includes flowering plants (angiosperms), mammals, fish, birds, reptiles, and amphibians, constituting 17.3% of the total. Nearly 60% of India's bio-wealth is contributed by fungi and insects. India ranks tenth in the world and fourth in Asia in plant diversity, and ranks tenth in the number of endemic species of higher vertebrates in the world

Major reasons for loss of biodiversity in India are:

- Habitat destruction like deforestation
- Overexploitation
- Pollution
- Species introduction
- Natural calamities such as fires, droughts, diseases, cyclones, and floods
- Lack of knowledge and low priority for conservation of living natural resources
- Poaching and trade in wildlife species
- Exploitation of living natural resources for monetary gain
- Urbanization and Industrialization
- Extension of agriculture and associated irrigation systems
- Filling up of wetlands
- Population explosion

Some important measures taken are as follows:

- Approximately 4.2% of the total geographical area of the country has been earmarked for extensive in situ conservation of habitats and ecosystems.
- A protected area network of 85 National Parks and 448 Wildlife Sanctuaries have been created.
- A programme entitled **"Eco-development"** for in situ conservation of biological diversity involving local communities has been initiated.
- To conserve the respective ecosystems, a **Biosphere Reserve Programme** is being implemented. Twelve biodiversity rich areas of the country have been designated as Biosphere Reserves.

- Specific programmes for management and conservation of wetlands, mangroves, and coral reef systems are also being implemented.
- Programmes like Project Tiger, Project elephant have been launched for increasing the population of highly endangered species.

Further strategies needed for conservation of biodiversity are :

- Introduction of policies for protection of wetlands, grasslands, sacred groves and other areas
- Improve enforcement of existing laws and ecodevelopment programs
- Enhancing role of NGOs and other institutions
- Documentation of biodiversity
- Increased allocation of financial resources for conservation of biodiversity.
- Integrating conservation with development
- Incentives and disincentives
- Continuous monitoring of biodiversity.

3.1.4 Air Pollution With Special Reference to Vehichular Pollution In Cities

Air pollution in India as in typical developing countries occurs due to rapid economic development, industrialization, growing cities, increasing traffic, and higher levels of energy consumption. The high influx of population to urban areas, increase in consumption patterns and unplanned urban and industrial development have led to the problem of air pollution. Vehicular emissions are of particular concern since these are ground level sources and thus have the maximum impact on the general population. Also, vehicles contribute significantly to the total air pollution load in many urban areas.

Major reasons for air pollution in India are:

- **Increase in urban population:** In the four decades from 1951 the urban population has tripled, from 62.4 million to 217.6 million, an increase of proportion from 17.3% to 25.7%.
- **Increase in number of Vehicles:** From 0.3 million in 1951 to 37.2 million in 1997. Out of these, 32% are concentrated in 23 metropolitan cities.
- **Increase in road based transport:** From 44.8 billion passenger kilometer (PKM) in 1951 to 2,515 billion PKM in 1996 and freight traffic handled by road from 12.1 billion tonne kilometer (TKM) in 1951 to about 720 billion in 1996.
- **Increase in consumption of gasoline and HSD** has grown more than 3 times in three decades.
- **Increase in Industrial activity:** Installation and augmentation of capacities of integrated iron and steel mills, thermal power plants, copper/zinc/aluminium smelters, cement, oil refineries, petrochemicals, pesticides and fertilizer units etc.
- **Increase in generation and consumption of power:** Since 1950-51, the electricity generation capacity in India has multiplied 55 times from 1.7 thousand MW to 93.3 thousand MW. Thermal power constitutes about 74% of the total installed power generation which utilizes low grade Indian coal containing a very high ash content

of 24%-45% leading to emissions in the form of particulate matter, toxic elements, fly ash, oxides of nitrogen, sulphur and carbon.

- **Domestic Pollution:** Pollution from different types of cooking stoves using coal, fuel wood, and other biomass fuels.
- **Other sources**
  - Diesel-based captive power generation units emitting high levels NO_x and SO_x
  - Waste incineration
  - Construction activities.

Some important measures taken are :

- Formulation of legislations, policies, and programmes for protecting the environment relating to air pollution.
- Fixing of Ambient air quality standards both for short-term, and long-term for industrial, residential, rural and other sensitive areas with respect to pollutants such as SO_2, NO_x, NH_3, Suspended Particulate Matter (SPM), Respirable Particulate Matter (RPM), Pb, and CO.
- Guidelines for siting of industries
- Environmental impact assessment (EIA) made mandatory for 29 specific activities/ projects
- Emission standards for industries fixing the maximum permissible limits for different pollutants for many categories of industries that contribute to air pollution.
- Introduction of Environmental audit made mandatory
- Encourage industries to implement pollution prevention and cleaner technologies
- Control of vehicular pollution :
  - Stringent emission norms comprising mass emission standards for new vehicles
  - Cleaner fuel quality specifications
  - Formulation of an inspection and maintenance (I&M) system for vehicles.
  - Other stringent measures :
    - The specifications for 2T oil became effective
    - Premixed 2T oil dispensers
    - Proposal for banning vehicles more than 15 years old
    - Use of CNG.

Further strategies needed for preventing Air Pollution are :

Vehicular Air Pollution

- Priorities for cleaner technology and land use planning.
- Assessment of effectiveness and impact of various policies.
- Monitoring of additional air quality parameters such as ozone, benzene, PM2.5, dry deposition of sulphates and nitrates.

- Monitoring at hotspots, traffic intersections, more stations to be established and frequency of monitoring increased.
- Air pollution modeling as a tool for forecasting and urban planning.
- Augmentation of public transport system.
- Mass Rapid Transport System for the fast expanding and major urban areas in the country.
- Traffic planning and management, construction of express highways linking major urban areas.
- Pollution surcharges on fuels and vehicles
- Further tightening of emission norms and fuel quality specifications.
- Use of alternate fuels such as CNG, LPG, Propane, battery operated vehicles etc.

Industry

- Prevention based environmental policy
- Waste utilization technologies involving reclamation, recycle and reuse
- Flue gas desulphurisation, combustion modification for NO_x reduction
- Strengthening of emission standards for various categories of industries
- Introduction of mass based standards instead of concentration-based standards.
- Appropriate location of polluting industries
- Fiscal incentives for pollution prevention and control
- Increase in green cover and green belts.

3.1.5 Mangement of Fresh Water Resources

India is attempting to meet its water requirement by development of its water resources. Our country is facing the stiff environmental challenge of preserving the quality and availability of freshwater. There has been considerable stress on water resources due to increased Industrial and agricultural activity and growth of mega cities. Deterioration in water quality and contamination of water bodies like lakes, rivers and ground waters has resulted.

The water quality monitoring results obtained during 1998 indicate that organic and bacterial contamination still continue to be critical sources of pollution in Indian aquatic resources. Observations in different locations of the country indicate that biological and bacteriological contaminants in surface waters like BOD, total coliform and faecal coliform has been steadily increasing with time. Ground water quality in terms of pH, dissolved oxygen, BOD and total Coliform in several locations have been found adverse. In many cases high concentrations of nitrates, potassium, Phosphates, heavy/toxic metals, fluoride are found.

The major reasons for degradation of quality and availability of fresh water in India are :

- Uneven distribution of the annual receipt of 4000 billion cubic metres (BCM) both spacially and temporally. Most of the rainfall is confined to the monsoon season, from June to September, and levels of precipitation vary from 100 mm a year in western Rajasthan to over 9,000 mm a year in the ortheastern state of Meghalaya.

- Out of a mean flow of 1900 BCM of the country's rivers only 690 BCM is utilizable.
- Increase in demand for water in agriculture, Industry and domestic sectors due to unprecedented population growth.
- Resource degradation :
  - Discharge of untreated/partially treated domestic /industrial wastewater
  - Inefficient resource utilization – Distribution losses of treated water range between 25% and 40%, losses in irrigation are to the extent of 45% due to seepage and excess application and storage losses are estimated to be about 15%.
  - Industrial consumption of water is 5 to 6 times more as compared to the developed countries.
  - Unsystematic use of synthetic fertilizers and improper water management has affected the groundwater quality in many parts of the country.

Some important measures taken for improving water quality and availability are :

- Formulation of National water Policy according top priority to drinking water supply and allocation of water resources for various uses like irrigation, hydropower, navigation and industrial and other uses.
- Establishment of Central and State pollution control boards with the prime objective of preventing and controlling pollution.
- Introduction of major economic incentives for pollution abatement, besides the regulatory mechanism.
- Introduction of water cess act to levy a cess on water consumption for specific purposes.
- Environmental Impact Assessment has been made mandatory for 30 categories of development activities.
- Implementation of the National River Action Plan (NRAP) for reducing the pollution load on majors rivers. At present, 156 towns located on several river basins are being considered under the NRAP.
- Implementation of national lake conservation plan (NLCP).
- Construction of Common Effluent Treatment Plants (CETP) for the treatment of effluents from a cluster of industries.

Further strategies needed for improvement of availability and quality of fresh water:

- River basin approach instead of state based approach.
- Increasing resource availability by developing surface irrigation sources, rain water harvesting and prevention of water run offs.
- Prevention overexploitation of existing resources.
- Reduce the quantity of wastewater generated.
- Development and use of cost-effective water appliances such as low-flow cisterns.
- Implementation of zero discharge concept.

- Conversion of large number of scattered sources of pollution from high-density low-income communities into concentrated point sources that are easier to monitor and control.
- Implementation of low-cost and effective technologies for waste water treatment like UASB, duckweed ponds, and horizontal filter utilizing associated advantages like low power consumption, generation of bio gas and sludge as manure.
- Adoption of cleaner technologies by the industry.
- *Baseline information*. Development of wide data base on water quality,and availability, water consumption and effluent discharge patterns.
- Benchmark resource consumption and increase the productivity levels per unit of water consumed.
- Increase community participation in water conservation through awareness and education.
- Continuous R & D for pollution abatement and Reduction of water consumption in agriculture and industry.

3.1.6 Hazardous Waste Management with Special Reference to Municipal Solid Waste Management

The need to manage the hazardous waste generated in the country in a scientific manner was felt after the Bhopal gas tragedy on December 1984. As the pace of industrialization accelerated in India, increasing amounts of hazardous wastes were getting generated every year. This coupled with a growing amount of municipal solid waste and hospital waste continues to be a major environmental issue in India.

Sources of hazardous waste are:

- Industrial processes like mining, extraction, pesticides, petrochemicals, pharmaceuticals, paint and dye, petroleum, fertilizers, asbestos, caustic soda, inorganic chemicals and general Engineering industries.
- Hazardous wastes from the industrial sectors mentioned above contain heavy metals, cyanides, pesticides, complex aromatic compounds and other chemicals, which are toxic, flammable, reactive, corrosive and explosive properties.

Improper storage, handling, transportation, treatment and disposal of hazardous waste results in adverse impact on ecosystems including the human environment. When discharged on land, heavy metals and certain organic compounds are phytotoxic and can affect soil productivity.

As per a 1999 estimate, around 7.2 million tonnes of hazardous waste is generated in the country of which 1.4 million tonnes is recyclable, 0.1 million tonnes is incinerable and 5.2 million tonnes is destined for disposal on land This means around 5.3 million tonnes of hazardous waste requires some treatment and disposal. This will require an investment of around Rs 15,900 million every year for treatment and disposal of the hazardous waste in a scientific way. The land area required to dispose this waste in an engineered landfill would be around 1.08 sq.km. every year.

The major generators of non-hazardous industrial solid wastes in India are thermal power stations producing coal ash, steel mills producing blast furnace slag and steel melting slag, non-ferrous industries such as aluminum, zinc and copper producing red mud and tailings, sugar industries generating press mud, pulp and paper industries producing lime sludge and fertilizer and allied industries producing gypsum. Since these wastes are generated in huge quantities in the country (147 million tonnes per annum as per a 1999 estimate), the recycle/reuse potential of these wastes should be explored, otherwise a huge land area would be required for disposal.

The quantities of industrial waste produced per annum from these industrial sources are presented in Table 3.1.

Table 3.1

Waste	Quantities MTPA	
	1990	1999
Steel and blast furnace slag	35.0	7.5
Brine mud	0.02	-
Copper slag	0.02	-
Fly ash	30.0	58
Kiln dust	1.6	-
Lime sludge	3.0	4.8
Phosphogypsum	4.5	11.0
Red mud / bauxite	3.0	4.0 - 4.5
Lime stone	-	50.0
Iron tailings	-	11.25
Total	77.14	147.05

There has been a significant increase in the generation of MSW (municipal solid wastes) in India over the last few decades. This is largely a result of rapid population growth in the country. The daily per capita generation of municipal solid waste in India ranges from about 100 g in small towns to 500 g in large towns. The recyclable content of waste ranges from 13% to 20%. An estimate indicates that 23 Indian cities generate around 14 million tons of MSW annually. The characteristics of MSW collected from any area depends on a number of factors such as food habits, cultural traditions of inhabitants, lifestyles, climate, etc. MSW generation is expected to increase to 300 million tonnes per year by the year 2047 (490 g per capita to 945 g per capita). The estimated requirement of land for disposal would be 169.6 sq km in 2047 as against 20.2 sq km in 1997.

There has also been considerable increase in the generation of biomedical waste which is approximately 250 gms per bed per day out of which 85% is non-infectious, 10% is infectious but non-hazardous and 5% is hazardous.

If disposed unscientifically waste attracts birds, rodents, fleas, etc. to the waste and creates unhygienic conditions (odor, release of airborne pathogens, etc.). Moreover, biomedical waste also contains sharp objects (scalpels, needles, broken glasses/ampoules, etc.) the disposal of which poses a risk of injury and exposure to infection to sanitary workers and rag pickers working at these dumpsites.

Some important measures taken are as follows:

- Introduction of The Hazardous Wastes (Management and Handling) Rules (referred to as HWM Rules 1989) which provide for control of generation, collection, treatment, transport, import, storage and disposal of wastes these rules.
- Guidelines for Management and Handling of Hazardous Wastes for (a) generators, (b) transport of hazardous waste, and (c) owners/operators of hazardous waste storage, treatment and disposal facility.
- Additional incentives for industries to comply with environmental provisions.
- Compilation of hazardous waste inventory.
- Training programmes for personnel in ports and customs and in pollution control boards to familiarize them with precautionary measures and testing methodologies for hazardous waste constituents.
- Decision to impose a restrict/ban on import of hazardous wastes containing beryllium, selenium, chromium (hexavalent), thallium, pesticides, herbicides and their intermediates/ residues, cyanide wastes and mercury and arsenic-bearing wastes.
- Regulated imports of waste oil and metal bearing wastes such as zinc ash, skimming, brass dross and lead acid.
- Constitution of NWMC (National Waste Management Council). NWMC which formed a national plastic waste management task force to suggest measures to minimize the adverse environmental and health impacts arising out of plastic recycling.
- National Programme on Energy Recovery from urban-municipal and industrial wastes.

Further strategies needed are :

- Constantly update this waste inventory
- Improve infrastructure for proper treatment and disposal of hazardous waste
- Introduction of segregation of waste followed by treatment
- Introduce waste minimization programs with the primary focus on reduction of waste
- Additional Infrastructure for tracking and monitoring of hazardous waste
- Set targets for waste reduction
- Introduction of fees and tax incentives
- Education and voluntary compliance.

3.2 GLOBAL ENVIRONMENTAL ISSUES

Man-made and natural environmental damages do not confine themselves to limited geographical/atmospherical areas around the place of its occurrence. This is mainly because of the constant transfer of mass and energy between the four major segments of environment namely: atmosphere, hydrosphere, lithosphere and biosphere. The problems hence become global in nature. The radio nuclides thrown in to the atmosphere from Chernobyl in Russia were carried by atmosphere thousands of kilometers and was deposited in the soils of north European countries contaminating food. This event eminently illustrates the global nature of many environmental issues. Some of the major global environmental issues are :

- Global Climatic Change/Global warming
- Acid Precipitation
- Ozone layer depletion
- Air, Water and land pollution
- Eutrophication
- Loss of Biodiversity

The above issues have been discussed in detail under Section 1.7.3: Manmade Impacts on Air, Water and Land.

4

ENGINEERING INTERVENTIONS TO REDUCE ENVIRONMENTAL STRESSES

1.1 MINIMIZATION OF ENVIRONMENTAL STRESSES

Considering the rate of population growth, urbanization and industrialization, it is evident that total elimination of the environmental stresses can at best be an ideal goal. However every effort should be made to minimize the stresses to a tolerable level. Engineering principles can be applied and practiced to prevent the environment from getting further degraded. A hierarchy of the Engineering Interventions successfully implemented is enumerated below.

- Introduce cleaner production technologies to reduce pollution at source.
- Practice waste minimization techniques by process and equipment modification.
- Employ end of the pipeline treatment methodologies.
- Awareness improvement and training.

Specific engineering interventions and management practices for control of physical, chemical and biological pollutants are listed below:

Nature of stress	*Management Practices/Engineering Interventions*
Thermal	Acclimatization, proper work and rest periods, distribution of work load, scheduling hot jobs for coolest part of the day protective clothing, shielding from sun and other hot sources, adequate ventilation and air conditioning systems
Radiation	Minimizing the time of exposure and keeping maximum distance from the source. Proper shielding.
Noise	Reduce time of exposure by worker rotation and planning of equipment operation. Minimize noise at source, Path control methods like installation of sound barriers between the equipment and personnel, proper maintenance, use of personnel protective equipment such as ear plugs.
Vibration	Isolating the disturbance, reducing friction, absorbing energy created by vibration by suitable design.

Chemical and Biological*	Source reduction, minimization techniques, Treatment of effluent disinfection methods by: Chlorination, heat sterilization, irradiation, filtered supply of air, air pressure differentials use of personnel protective equipment.

*Detailed discussion on engineering interventions for chemical and biological environmental stresses can be found under chapters on air pollution and control, waste water treatment and Solid waste management.

4.2 AIR POLLUTION AND CONTROL

4.2.1 Introduction

Air pollution may be defined as the presence of one or more contaminants (Chemicals, Dust, Smoke, Fume, Particulate Matter etc.) in such quantities and duration, which is detrimental to the health of plants and animals, property. The air pollution can be caused both by natural (Volcanic eruptions, Forest and wild fires, plant and animal matter decay, sand storms, electric storms, pollen and fungal spores, bacteria, marsh gas) and man-made sources (Industry, transport, agriculture, radio active materials etc.) The different segments of the atmosphere [Refer: Chapter (1)] receive emissions and absorbs them and on many occasions serves as a natural sink . The pollutants in the atmosphere are also dispersed by the action of winds and hence harmful emissions travel long distances spreading the magnitude of the problem. For example, the radioactive nuclides emitted from a nuclear reactor at Chernobyl in Russia travelled thousands of kilometres and were deposited in north European countries contaminating land and food. Hence air pollution is a trans boundary issue and needs a closer understanding.

4.2.2 Classification of Air Pollutants

Air pollutants can be classified in to different ways. They are:

- **Primary Pollutants.** Those directly emitted into the atmosphere. e.g. CO, NO_2, SO_2, Hydrocarbons.
- **Secondary Pollutants.** Those derived due to the interaction between the primary pollutants and / or the gases in the atmosphere. (Ozone, Smog, Peroxy Acyl Nitrate).
- **Organic Pollutants** (Hydrocarbons, Aldehydes, Ketones, Alcohols, etc.).
- **Inorganic Pollutants.** Oxides of Carbon, Nitrogen, Sulphur, Halogen Compounds, HNO_3, H_2SO_4, Ozone, Metallurgical dust, Fly ash, Silica etc.
- **Gaseous Pollutants.** Those, which freely mix with air and do not settle.
- **Particulate matter.** Fine solid dust or liquid droplets like smoke, fumes, fog, smoke, sprays etc.

4.2.3 Major Air Pollution, Their Characteristics and their Impacts

Table 4.1

Pollutant	Sources	Characteristic	Impact
Carbon monoxide (CO)	Automobile exhaust, Incomplete combustion of fossil fuels, coal mines, blast furnaces, Cigarette smoking	Colorless, odoroless and and tasteless gas	Highly toxic, absorbed by hemoglobin in blood and causes depletion of oxygen in cells, Causes headaches, drowsiness, can also lead to death.

Carbon dioxide (CO_2)	Automobile exhaust, fossil fuel burning, decay of organic matter	Colorless odorless and and tasteless gas less toxic, green house gas	Nause and headache, Gobal warming
Sulphur Dioxide (SO_2)	Burning of fossil fuels, Roasting of sulphide ores, sulphuric acid plants, oil refineries	Colorless, pungent smelling gas	Breathinproblems, bronchitis, reduces visibility, causes acid rain leading to damage of soil, plants, aquatic life and property damage by corrosion
Oxides of Nitrogen	Automobiles exhaust, coal/gas burning furnaces, manufacture of HNO_3	Reddish brown irritating gases	Lung irritation and damage, aggravates and bronchitis, causes acid rain, reduces visibility
Hydro carbons	Automobile exhaust, petroleum and other organic chemical industries	Foul smelling reactive, reactive, undergoes photochemical reactions reactions with other pollutants.	Detrimental to human health, carcinogenic, causes photo-chemical smog.
Ozone (O_3)	Chemical reaction with hydrocarbons and other organic compounds	Highly reactive irritating irritating gas, unpleasant unpleasant odor	Breathing problems, eye, nose and lung irritation, damages plants and trees, source of smog leading to reduction in visibility, damages rubber, plastics, paints and fabrics
Chloro fluro Methanes	Refrigerators and air conditioning systems,	Reacts with ozone	Causes and ozone depletion in the stratosphere
Suspended Particulate Matter (SPM)	Burning of fossil fuels, automobile exhaust, mining, metallurgical, cement, ceramic and refractory industries, saw mills and flour manufacture of asbestos	Dispersed fine dust of solid particles or coll-oidal liquid droplets in droplets in the form of aerosols (Particle size 0.1 to 100 microns)	Respiratory tract irritation, lung damage, aggravation of bronchitis and asthma, carcinogenic, reduces visibility, discoloration of buildings cloths, fabrics and paints.
Lead	Automobile exhaust, storage batteries, smelters and refineries for lead	Highly toxic heavy metals	Accumulates in the body causes brain and nervous damage, digestive problems, carcinogenic

4.2.4 Impacts of Air Pollution On Man And Environment

As discussed earlier in this chapter, the air pollution impacts are not merely local. Some of the major impacts of air pollution (Both global and local) are enumerated below

1. Global warming
2. Acid rain
3. Ozone layer depletion
4. Damage to materials, vegetation and animals

5. Reduction in visibility
6. Impact on human health and activities.

Out of these impacts, global warming, acid rain and ozone layer depletion are discussed in detail in chapter 1.7.3. A brief outline of the other impacts is given below:

Damage to materials: Direct or indirect chemical attack by the air pollutants causes damage to a variety of materials like surface coatings and paints, polymeric materials like rubber, plastics, paper and textiles, metals and alloys, leather and building materials. The damage manifests itself in the form of corrosion, abrasion, deposition or direct chemical reaction. Factors like humidity, Temperature, Wind and sunlight also have profound influence on the nature of the damage created. Several historic monuments for example Taj Mahal are affected by air pollution.

Damage to vegetation and animals: Air pollution causes extensive damage to vegetation and animals. Acid precipitation, Fluorides, smog, ozone, organic compounds causes damages like loss of chlorophyll, stunted growth, Discoloration and banding of leaves. Soil conditions, Time of exposure, Relative humidity and sunlight also determine the extent of sunlight.

Farm animals like cattle and sheep are susceptible to toxicity by airborne pollutants. The pollutants accumulated in the plants and vegetation are consumed by many animals, thereby getting contaminated. Acid deposition reduces the pH of water bodies leading to destruction of aquatic flora and fauna.

Reduction in visibility: Emissions of heavy smoke, dust storms and formation of smog reduce the visibility by scattering sunlight. The intensity of visibility reduction will depend on the particle size, aerosol density, position of the sun, wind speed, humidity etc. Visibility reduction results in disruption of road and air traffic. Catastrophic accidents also have resulted.

Effect on human beings: Air pollution affects larger segments of general population. The infamous Bhopal gas tragedy and London smog are examples. Air pollution affects human beings mainly through the respiratory system. The extent of damage in human health varies with age, sex, general health status, length of exposure and amount of exposure. Chronic bronchitis, bronchial asthma, pulmonary emphysema and lung cancer are few of the deceases associated with air pollution. Air pollution also causes convulsions, delirium, coma, cardio vascular diseases, kidney and liver damages etc. Radioactive fall out causes genetic disorders. Damage to the health of industrial workers involved in the processing of toxic chemicals becomes an occupational decease, which causes decrease in efficiency of human activities.

4.2.5 Air Quality Standards

The levels of different pollutants that cannot be exceeded during a specified time period in a specified geographic area is termed as air quality standard. These are derived from air quality criteria, which is based on the affects of ambient air pollution on human health, vegetation, animals etc.

The ambient air quality standards adopted by CPCB for specified pollutants in different geographical locations like industrial areas, residential, rural and other areas, Sensitive (Schools, hospitals etc.) areas is given in the succeeding Table 4.2.

Table 4.2

Pollutants	Time-weighted average	Concentration in ambient air		
		Industrial Areas	Residential, Rural and other Areas	Sensitive Areas
Sulphur Dioxide (SO_2)	Annual Average*	80 µg/m^3	60 µg/m^3	15 µg/m^3
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3
Oxides of Nitrogen as (SO_2)	Annual Average*	80 µg/m^3	60 µg/m^3	15 µg/m^3
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3
Suspended Particulate Matter (SPM)	Annual Average*	360 µg/m^3	140 µg/m^3	70 µg/m^3
	24 hours**	500 µg/m^3	200 µg/m^3	100 µg/m^3
Respirable Particulate Matter (RPM) (size less than 10 microns)	Annual Average*	120 µg/m^3	60 µg/m^3	50 µg/m^3
	24 hours**	150 µg/m^3	100 µg/m^3	75 µg/m^3
Lead (Pb)	Annual Average*	1.0 µg/m^3	0.75 µg/m^3	0.50 µg/m^3
	24 hours**	1.5 µg/m^3	1.00 µg/m^3	0.75 µg/m^3
Ammonia1	Annual Average*	0.1 mg/ m^3	0.1 mg/ m^3	0.1 mg/m^3
	24 hours**	0.4 mg/ m^3	0.4 mg/m^3	0.4 mg/m^3
Carbon Monoxide (CO)	8 hours**	5.0 mg/m^3	2.0 mg/m^3	1.0 mg/m^3
	1 hour	10.0 mg/m^3	4.0 mg/m^3	2.0 mg/m^3

*Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.

**24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days. Likewise emission standards for different industries have also been specified. A few examples of emission standards adopted by CPCB is given in Chapter 8.

4.2.6 Air Pollutants From Industries

Depending on the nature of the industry, the air pollutant emissions vary. The summary of the major air pollutants from some industries are given in the following table:

Table 4.3

Industry	Major Air pollutants emitted
Thermal power plants	CO_2, CO, SO_2, Oxides of Nitrogen, Fly ash, soot, Hydrocarbons, ash
Metallurgical Industries	CO_2, CO, SO_2, Oxides of Nitrogen, Metal dust, Acid fumes, dust, smoke etc.
Refractory and Cement Industries	Particulate matter (Lime, silica, cement, fly ash)
Petroleum refineries and Transport of Petroleum Products	Volatile organic compounds (Methane-butane), SO_2, Smoke, CO, CO_2, Mercaptans, Aromatic compounds
Petro Chemical and Fertilizer industries	CO_2, CO, SO_2, NH_3, acids fumes, urea and fertilizer dust, hydro volatile organic compounds

Chemical industries	CO_2, CO, SO_2, NH_3, acids fumes, fluorides, chlorine, Particulate matter
Tanneries and Lather manufacture	Vapors of organo sulfur compounds
Paper and Pulp	Mercaptans, H_2S
Paint Industries	Volatile organic compounds (aniline, nitrobenzene, phenol, solvents and thinners)

4.2.7 Air Pollutants From IC Engines (Automoibiles and Stationary Engines)

The current technology available uses mainly petroleum derived fuels viz. gasoline or petrol, diesel, furnace oil etc. for the IC engines. In addition to the base hydrocarbons present in these fuels, additives like lubricants, octane number enhancing compounds like Tetra Ethyl Lead (TEL) add to the pollution stress generated by these engines. The emission from IC engines can be broadly classified as under.

Emission from exhaust consists of CO_2, CO, SO_2, NO_2, Volatile organic compounds due to unburnt fuel, particulate matter containing lead and carbon.

Emission from crankcase and evaporative emissions are due to leakage beyond the piston during compression stroke, lubricant oil vapors from crankcase, evaporation of fuel etc.

Methods of Reducing Air Pollutants from IC Engines

The strategies to be adopted for reduction of air pollution from IC engines involve both prevention of pollution as well as end of the line treatment of exhaust gases. Some of these strategies are enumerated below.

1. Development of enviro-friendly fuels

Alternate lighter fuels for gasoline and diesel are being developed. These include natural gas (CNG), reformed gasoline, Bio-gas etc. These fuels burn freely with little or no hydrocarbons in the exhaust. Alcohol blended fuels are also being developed to reducing emission. Alternative additives for TEL are being used and lead free gasoline is being increasingly available. Addition of barium salts also have been tried and further research is in progress.

2. Engine design changes

Improving the efficiency of IC engines by design modification has paid rich dividends. Use of leaner air fuel ratios has broad down emissions. Improved fuel distribution systems, computer controlled timing mechanisms; lower compression ratios are some of the modification which has proved to be successful. Preheating of fuels using exhaust gases results in heat recovery leading to fuel consumption reduction.

3. Exhaust gas treatment

Use of catalytic converters in the exhaust pipes is becoming mandatory for automobiles. These catalytic converters operate in to two stages. Oxides of nitrogen are reduced to N_2 at higher temperatures in the presence of catalysts like Pt, Pd using reducing gases like CO, hydrocarbons. In the second stage of the catalytic converter, oxidation of carbon monoxide and hydrocarbons takes place. Lead free gasoline needs to be used in these cases since lead leads to the poisoning of the catalyst.

Considerable reduction of air pollution from IC engines can also be brought about by proper operation of the equipment (driving at the correct gear level and speed, avoiding frequent braking and acceleration) and correct and timely upkeep and maintenance.

4.2.8 Air Pollution Abatement

As discussed under air pollutants reduction for IC Engines the strategies for general air pollution abatement consists of both preventing at source as well as treatment of polluted air. The approaches for air pollution are :

1. Source correction
   - Process modification
   - Substitution of raw materials
   - Equipment modification
   - Equipment maintenance
   - Use of clean technology
2. Pollution control devices
   - Combustion
   - Absorption
   - Adsorption
   - Mechanical devices (for Particulate Matter)
     - Cyclone separators
     - Gravity settling chambers
     - Filtration systems-Bag filters
     - Electrostatic precipitators
     - Wet collectors like spray towers, Venturi Scrubber
3. Diffusion of pollutant air
4. Vegetation and zoning

Source correction methods are implemented at the generation stage or prior to the generation stage. Process modification aiming at energy conservation results in reduced fuel consumption and hence lower air pollution load. Cleaner fuels and desulphurised fuels are viable options today. Substituting conventional fossil fuels with renewable biofuels and adopting alternate non conventional energy forms like solar, wind, tidal power will go a long way in reducing the air pollution.

Proper upkeep and maintenance of all process equipment ensures less consumption of energy. Cleaner technological options options like fuels cells are to be increasingly adopted.

Pollution control Devices are broadly classified into two categories viz. Gaseous pollutant control devices and particulate matter control devices. The gaseous pollutants are controlled by techniques like combustion, absorption and adsorption. Pollutants like Inflammable and volatile organic compounds and carbon monoxide are completely oxidized before letting out in to the atmosphere since the products of combustion are less toxic. In absorption/ adsorption techniques, the pollutants are confined to smaller volumes and space by physical dissolution in solvents or by adsorption on porous surfaces like activated charcoal etc.

The particulate matter control is mainly carried out in mechanical devices where the fine particles are made to settle either by centrifugal action as in the case of cyclone separators or by gravity as in the case of settling chambers. Fabric filtration systems are also efficient devices for particulate matter control. Wet collection methods using water as the wetting agent is utilized in spray towers, and Venturi Scrubbers. Electrostatic precipitators are also widely in use. These work on the principle of developing a static current charge on individual particles and moving these particles towards collector plates which are oppositely charged. Schematic diagrams of few devices used for particulate matter control is illustrated in Figs. 4.1 to 4.6.

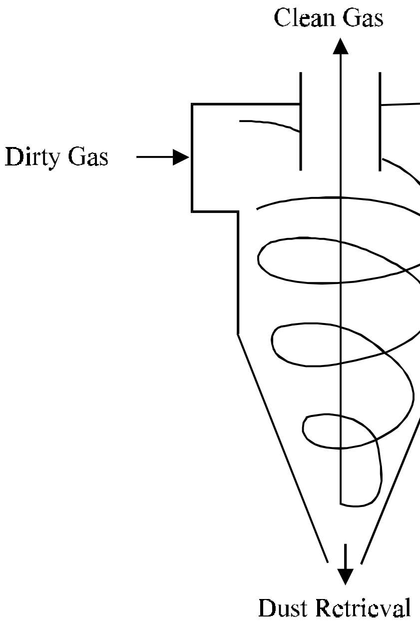


Figure 4.1: Cyclon Separator

Dispersion and dilution is yet another technique in dealing with air pollution. The pollutants are diluted to below permissible levels before they reach the target or receptor. Use of tall stacks will ensure this process. However adequate care should be taken regarding the design of the stack/chimney taking into account local meteorological conditions, human settlements in the vicinity, topography of the location etc.

Vegetation and Zoning techniques are also employed to bring down the impact of air pollutants. Green belts and Green covers in sensitive areas prone for air pollution ensure abatement by acting as sinks and filters. The zoning concept is used in siting decisions of industries and human settlements.

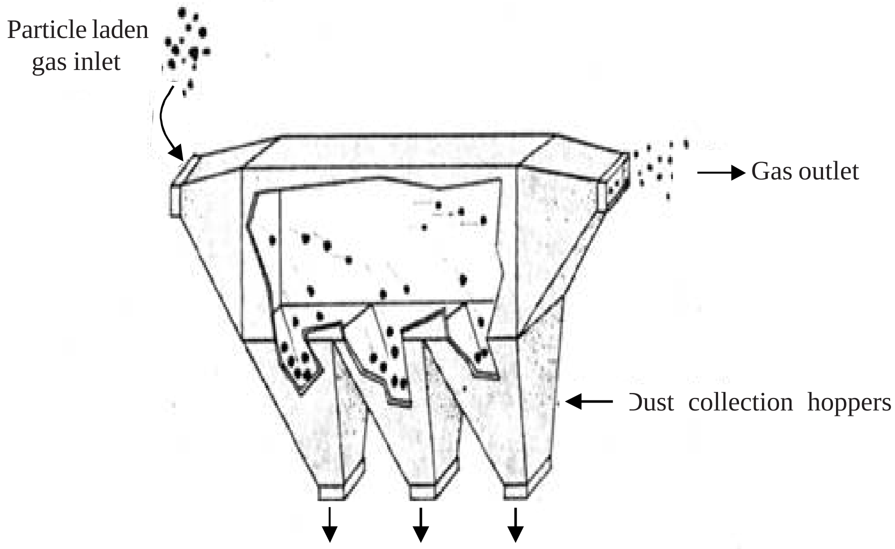


Figure 4.2: Gravity settling chambers

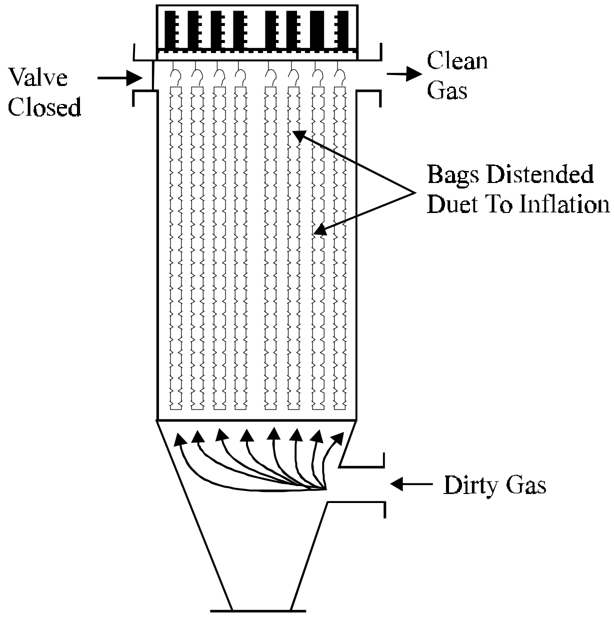


Figure 4.3: Bag Filters

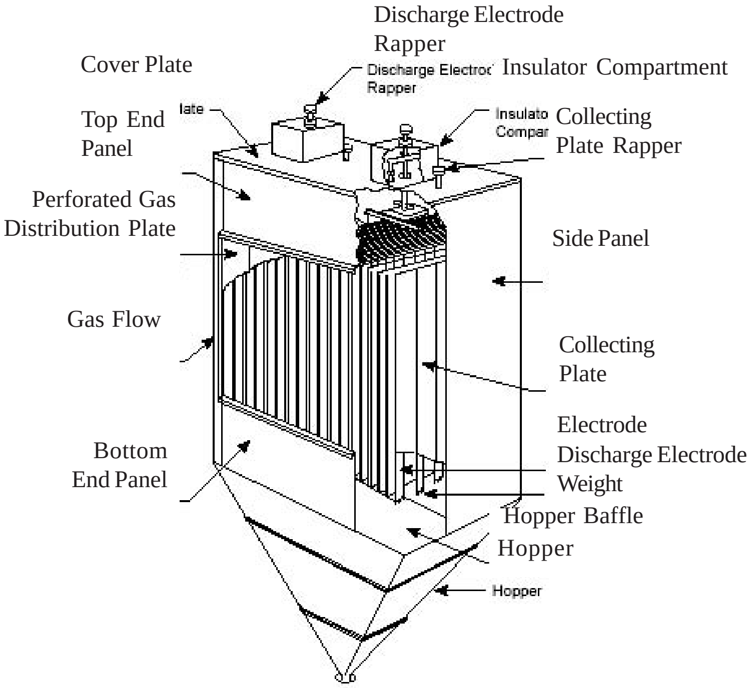


Figure 4 **cipitator**

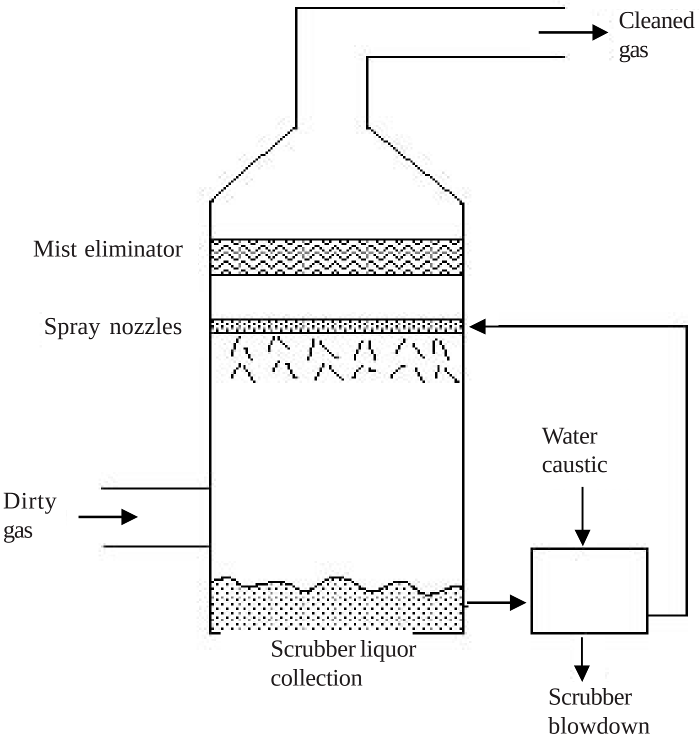


Figure 4.5: Spray tower

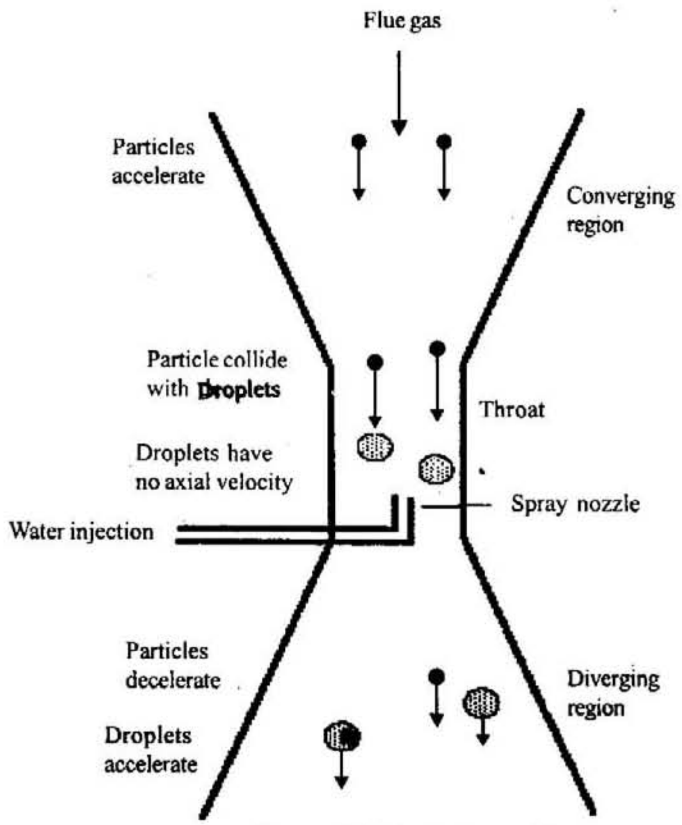


Figure 4.6: Venturi scrubbers

4.3 WASTE WATER TREATMENT

4.3.1 Waste Water–Sources and Constituents

Waste water can be broadly classified as municipal/Domestic and Industrial wastewater. Domestic wastewater is derived principally from dwellings, business buildings, institutions etc. which also includes sanitary wastewater and sewage. Industrial wastewater is process and non-process wastewater from manufacturing, commercial, mining, and silvicultural facilities or activities, including the runoff and leachate from areas that receive pollutants.

The characteristics of the waste water streams depend on the source or the type of process from which it emerges. The composition of the wastewater also varies on seasonal basis, reflecting different water uses.

Water polluting sources are of two fold. They are :

Point sources are those which can be monitored and regulated. Municipal and industrial wastewaters come under this category.

Non point sources are those which cannot be regulated and enforced, but can be minimized or managed through appropriate policy interventions. Agricultural run-off containing ammonia, nitrates and pesticides, storm water containing washouts etc come under this category.

A detailed discussion on the physical, chemical and biological characteristics of water is found in chapter 2 The characteristics of waste water from certain industries is provided in the succeeding Table 4.4.

Table 4.4

Sl. No	Sector/Industry	Source for waste water	Constituents and characteristics
1.	Domestic waste water	Spent water originating from all human sanitary water usage activities (Like: Kitchen Bathroom, laundry etc.).	Surfactants, Suspended matters.
2.	Agriculture and food processing	Irrigation and run off.	Organics, Pesticides, Fertilizers and herbicide residues.
3.	Textile Industry	Dyeing, washing, bleaching, desizing of yarns and cloth.	Color, Dissolved and suspended solids, High pH, High BOD Sulphides and Heavy metals Sodium.
4.	Tannery	Dehairing, Organic and chemical tanning operations, soaking, washing.	Hair and flesh, organic solids sludges, High pH, High BOD, odor sulphides and Heavy metals (especially chromium).
5.	Pulp and Paper	Pulp manufacture, bleaching, paper making.	Colour, fibers and suspended solids Chlorine compounds, High BOD NaOH, Na_2S, Na_2CO_3.
6.	Metallurgical plants including iron and steel plant	Coking ovens, blast furnace and steel melting, rolling mill.	Suspended solids, dissolved solids oil and grease, fluorides heavy metals.
7.	Dairy unit	Production of milk powder other milk products.	High BOD, colloidal solids, offensive odours, dissolved and suspended solids.
8.	Fertilizer plant	Ammonia, urea manufacture, phosphatic fertilizer manufacture.	Nutrients like N, P and K, acids dissolved solids.
9.	Petroleum industry (Refining and tranport)	Atmospheric distillation, chemical processing, transport by pipelines, tankers and ocean liners.	Grease, oil, emulsions, solids phenols and sulphides. Odour toxicity, high pH, and thermal pollution. Also contains phosphates and non-degradable organics.
10.	Drugs and Pharmaceuticals	Manufacture of fine chemicals.	Total solids, Toxic organics, metal pollutants.

4.3.2 Treatment of Waste Water

The main aim of wastewater treatment is the removal of contaminants from water so that the treated water can be used for beneficial purposes or can be discharged in to local water bodies or sewer lines without affecting the environment. It is imperative that the treated water satisfies the norms prescribed by statutory authorities like Pollution control boards (PCB), Environmental Protection Agency (EPA). As quoted earlier the characteristics of wastewater significantly vary for industries and domestic sector. Hence the treatment strategy and process involved also vary. Most of the treatment schemes follow the following sequence. (Figure 4.7) The selection of process for different stages like preliminary, primary and secondary treatments will be specific to the industry and will depend mainly on the pollution load involved and the necessary outlet characteristics of treated waste water.

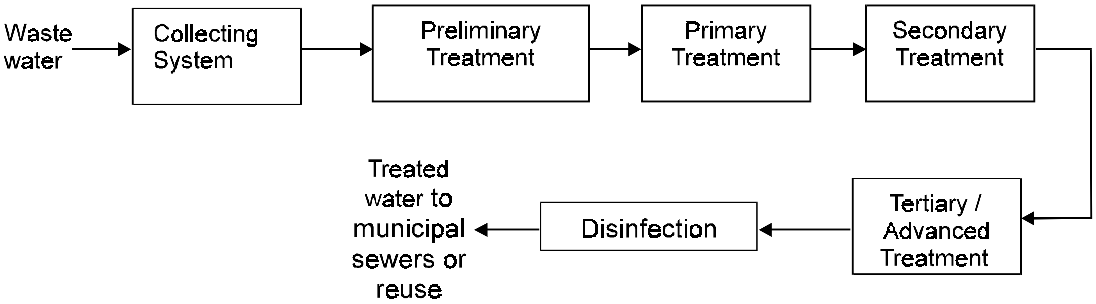


Figure 4.7: A generalized scheme for waste water treatment

A brief outline of the different stages involved in the preliminary ,secondary & Tertiary treatment is enumerated in Table 4.5.

Table 4.5

Treatment category	Equipment / Process	Nature of the treatment
Preliminary	Screening, Grit Chambers, Skimmers	Physical
Primary	Sedimentation, Flocculation Neutra-lization Coagulation, Equalization	Physical Chemical
Secondary	Lagoon, Trickling Filter, Activated sludge process, Oxidation ditch, Oxidation pond, Anaerobic digestion, Rotating Biodisc	Chemical and Biological
Tertiary or advanced treatment	Evaporation, Adsorption, Electro-dialysis, Reverse osmosis	Physical
	Ion Exchange	Chemical

The nature of treatment may be physical, chemical or biological or any one of the advanced treatment methods.

In **physical treatment**, the pollutants are removed using physical phenomena like settling, surface adhesion, filtration etc. without employing a chemical reaction and biochemical agent.

Chemical treatment involves processes like neutralisation, precipitation, oxidation and coagulation which employs selected chemicals to condition or modify the characteristics of the waste water according to the requirements.

Biological treatment resembles the natural bio-degradation of organics in the environment which occurs slowly (may take few weeks). With proper technical design and maintenance of optimum conditions, biodegradation process can be speeded up so that it is completed within few hours/days. This technique is very common in the treatment of municipal waste water and also applies equally for the treatment of Industrial waste water. Here most of the treatment is done by microorganisms (mostly bacteria), which uses the organic materials in the waste water as substrate for energy and as a source of carbon for new bacterial cell growth. Such microorganisms require a variety of nutrients for growth.

Preliminary, Primary and secondary treatment handles most of the non-toxic waste waters; other waters have to be pretreated before being added to this flow. Preliminary and primary treatment prepares the wastewaters for biological treatment. Large solids are removed by screening and the grit is allowed to settle out. Oils, greases are removed by skimmers. Equalization, levels out the time-to-time variation of volume of inflows and concentrations. Neutralization, where required follows equalization to balance pH of the effluent. Suspended solids are removed by settling and sedimentation or floatation at appropriate stage.

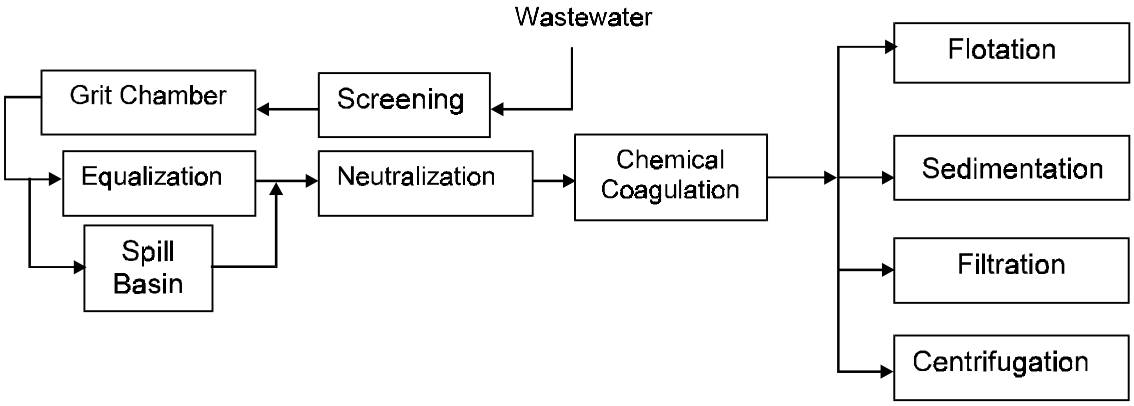


Figure 4.8: A typical arrangement of Pre and priliminary treament

Secondary treatment is the biological degradation of dissolved organic compounds using microorganisms. The process may be done aerobically (carried out in an open, aerated vessel or lagoon) or anaerobically (carried out in pond or closed vessel without exposure to oxygen). After secondary treatment the microorganisms and other carried over solids are allowed to settle as sludge. A fraction of this sludge can be recycled in the process to maintain the microbial load and the remaining sludge is disposed off using different techniques. Thus secondary treatment usually associates with sludge management and disposal. Most of the ETPs operating in our country necessarily employs the primary and secondary treatment along with the systems for removing the substances that would be toxic to micro-organisms.

Tertiary treatment processes are added after biological treatment in order to remove specific types of residuals. For example, adsorption using activated carbon removes organics and heavy metals, filtration removes suspended or colloidal materials.

The limitations for inclusion of tertiary treatment processes are two fold :

(1) They are expensive for large volumes of waste water

(2) They can also be in-efficient because the process are not pollutant-specific. For example to remove a specific organic pollutant if ozonation or Granulated Activated Carbon process are employed then it not only removes the specific organic pollutant but also completely removes the entire organic load.

4.3.2.1 Preliminary Treatment

Screening

Screening is the first physical operation carried out in waste water treatment. Screens are the devices, which are used to remove course solids like small stones, sticks, rags, boards etc. from the wastewater. Thus screens are helpful in preventing the clogging in valves and pipes and also protects pumps from wear and damage. The screens are classified in to coarse screens and fine screens based on the screen opening size. In few industrial applications a course screen followed by a fine screen arrangement is also employed.

- **Bar screens:** Bar screens are coarse screens which are equally spaced steel bars that cross a flow stream of wastewater and interrupts debris carried by the flow. The large objects like rocks, rags, boards etc. are captured by the screen and removed by racks. The bars are sloped normally 30-45° from the horizontal. Cleaning of the screen is carried out either manually or mechanically. In mechanical cleaning, the racks are periodically pulled through the screen spacing by pullers. Bar screens are usually used for the removal of materials of size range 25 to 150 mm.

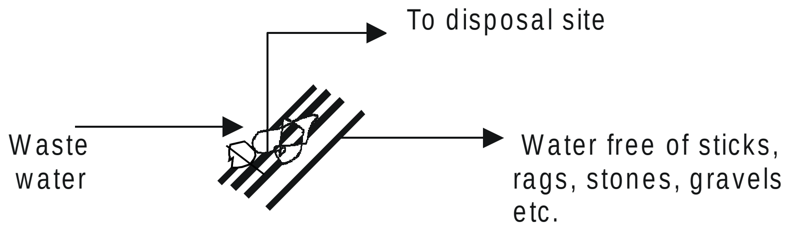


Figure 4.9: Schematic diagram of screening operation (bar screens)

- **Communitors :** These are the devices that reduce the size of larger objects to smaller sizes (6 to 20 mm) so that the subsequent plant operation is not affected and the solids are removed by sedimentation operation.
- **Wedge wire screens :** Static and rotary screens are used for screening of coarse and fine materials in the waste water. Rotary screens consist of woven/wire cloth or perforated plates mounted on a rotating disk or drum partially submerged in the flow.
- **Vibrating screens :** By incorporating a vibratory mechanism to the screens, a vertical, circular or elliptical action can be imparted. Upon making contact with the screening surface at the feed end of the machine, material is accelerated and, therefore, thinned out immediately, causing a more uniform distribution. This is highly advantageous when the load is high.

Grit Chambers

Grit chambers are normally placed after the screening equipment for the purpose of removal of sand, rocks, and other heavy material (generally called as 'grit') from waste water. They allow grit to get settled either by gravity (Gravity Grit Chambers) or aerated rolling action by passing air (Aerated Grit Chambers). The settled grit mainly contains inorganic matter and are disposed in landfills. Gravity Grit chambers are rectangular in shape and fairly shallow in depth. They also require more space and time for the settling of the grit as compared to the aerated grit chambers. If the collected grit is not removed from the chamber frequently or settled grit contains considerable amount of the organic matter, grit-washing facility is required.

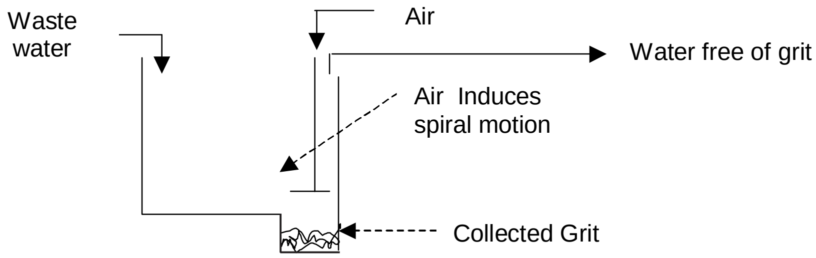


Figure 4.10: Schematic diagram of Aerated Grit chamber

Skimmers

If the wastewater contains grease and fatty oils, and if not removed, they will accumulate at the surface and may clog and interfere with oxidation in the aeration tank. Normally skimmers are narrow rectangular tanks with at least two longitudinal baffle walls. Air diffusers are fixed at the bottom of the tank. Compressed air is supplied through air diffusers to agitate the waste water. This prevents settling of solids and the oils and grease are made in to a soapy mixture. The soapy mixture is carried to the surface by the air bubbles and are skimmed off. Mechanical skimming arrangement to collect the oil/ grease layer is also employed.

4.3.2.2 Primary Treatment

Equalization

Variability of wastewater flow rates and compositions to the ETP occur because of any one of the following reasons:

1. Origination of different waste streams having different characteristics at different time intervals
2. Variation in Plant-Production schedules
3. Sudden surge in flows from domestic sources
4. Unexpected rainfall.

Equalization process will minimize or control such fluctuations in waste water characteristics (inflows and concentration) to provide an optimum or stabilized condition for subsequent treatment processes. This operation produces a homogenous and equalized effluent. Equalization is more routinely employed in industry than in municipal facilities because many industries use batch production processes. Installation of an equalization basin has the following main advantages:

- High treatment efficiency as the flow and strength of the waste water is relatively stable.
- Sizes of the subsequent process equipment like clarification, biological treatment systems etc. can be optimized and made smaller.
- Capital expenditures is reduced

Equalization basins can be either off-line or online. All flows go through on-line basins, which discharge at constant rate. Off-line basins receive flow only when plant influent flows or concentrations heavily fluctuate. Equalization system may be also located after headworks or after primary clarification or before any advanced treatment.

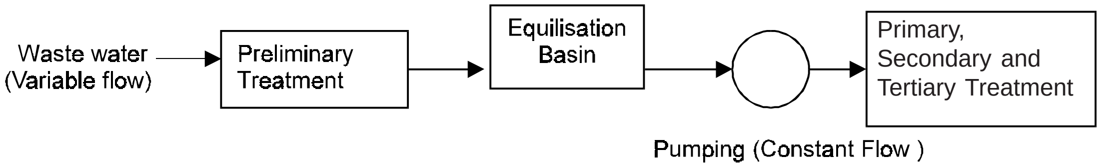


Figure 4.11: Online Equilization basin

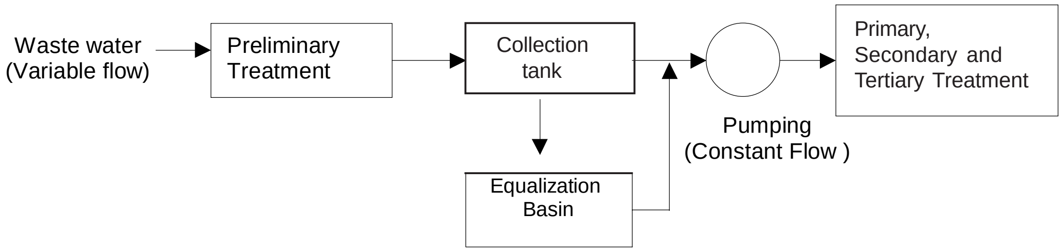


Figure 4.12: Off-line Equilization basin

Neutralization

The waste water coming out of an industry may be acidic (pH < 7) or alkaline (pH > 7). For secondary treatment (biological) the pH of the waste water should be maintained between 6.5–8.5 to ensure optimum biological activity. Neutralization is the process which utilizes acidic and basic chemical agents to bring down or to rise the pH of waste water to this range . Table gives few common neutralizing agents and their characteristics.

Table 4.6

Chemicals (Formula)	*Relative Neutralization Potential*
Basic Agents	
Calcium Carbonate ($CaCO_3$)	1.00
Calcium Oxide (CaO)	0.56
Calcium Hydroxide ($Ca(OH)_2$)	0.74
Magnesium hydroxide ($Mg(OH)_2$)	0.58
Sodium Hydroxide (NaOH)	0.79
Sodium Carbonate (Na_2CO_3)	1.06
Acidic Agents	
Sulphuric Acid (H_2SO_4)	0.98
Hydrochloric Acid (HCl)	0.72
Nitric Acid (HNO_3)	0.63

The selection of neutralizing agents depends on the following factors.

1. Neutralizing reaction rate
2. Quantity required
3. Amount of sludge generation, scale formation
4. Safety, handling and storage.
5. Availability
6. Economics
7. The effect of over dosage.

Neutralization process is generally accomplished in single or multiple stages using either feedback, or feed forward control. Some times it is economically advantageous for an industry to mix an acidic waste stream and an alkaline waste stream together to achieve neutralization of both streams. While doing this care must be taken to ensure that undesirable side reactions do not occur.

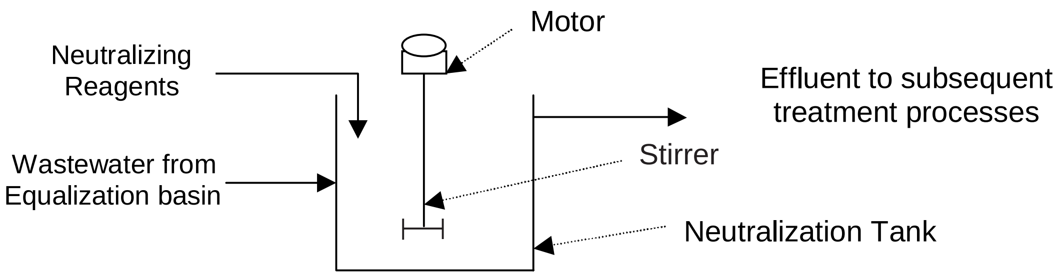


Figure 4.13: Neutralization process

Sedimentation

Suspended solids present in the industrial wastewater can cause problems in the sewer system or in subsequent treatment units where they may settle out or cling to pipe or on reactor walls. Sedimentation is the process of removal of suspended solids from wastewater utilizing their ability to settle under the influence of gravity.

The settling characteristics of suspended particles may be classified into one of the following types.

- Discrete settling—Type 1
- Flocculent—Type 2
- Zone settling—Type 3
- Compression Settling—Type 4

Discrete Settling

The particle or pollutant while settling does not change in size, shape or density and also does not interact with other particles. It settles due to the competing forces of gravity and buoyancy. This type of settling is ideal and occurs in the following cases:

1. Granular inert materials that do not stick together.
2. Materials present in dilute suspension.
3. In flow system, for small liquid flow velocity.
4. For uniformly distributed particle sizes.

Flocculent settling

This occurs when particles do not settle in an independent manner. Most of the industrial water particles follow this type of settling. As the particles settle, (heavier) some particles move faster and collide with other settling particles. Thus the particles will stick together (flocculate) and becomes a larger particle with higher settling velocities.

Zone Settling

Zone settling occurs with flocculated chemical suspensions and biological flock particles adhere and the mass settles as blanket.

Compression Settling

This occurs when solids reach the bottom of a reactor, pile up, and continue compacting as water is squeezed from between the particles.

Coagulation

Gravity separation or plain sedimentation do not remove very small and colloidal particles or pollutants in wastewater due to the following reasons:

1. They are too small and light and hence the gravitation effect in settling is poor.
2. They usually have a surface electrical charge that carries them to repel other particles, thus preventing agglomeration to a size that could settle easily.

For removal of such particles the coagulation practice is preferred. Coagulant is added and rapidly mixed with the wastewater which neutralizes the surface charges, collapses the surface layer around the particles, and allows the particles to come together, and agglomerate. Such agglomerated particles called floc are heavier and settle easily. While such flocs start to settle, they grow in size as they interact with other particles and flocs.

Coagulants induce reactions, which cause charge destabilization and produce insoluble hydroxide flocs. Most of these reactions consume a considerable amount of alkalinity and the water slowly starts to become acidic. Therefore a base/alkali should be added (normally lime) so that the coagulation reaction should proceeds well. The general scheme followed for coagulation/ flocculation of wastewater is given in figure 4.14. Rapid mixing is provided to disperse the coagulant uniformly through out the flow. Detention time is normally 20 sec and 1 minute to ensure that all particles have a contact with the coagulant.

$$Al_2(SO_4)_3 \cdot 14H_2O + 3\,Ca(HCO_3)_2 \longrightarrow 2\,Al(OH)_3 + 3CaSO_4$$

$$2FeCl_3 + 3Ca(HCO_3)_2 \longrightarrow 2\,Fe(OH)_3 + 3CaSO_4 + 6CO_2$$

$$2FeSO_4 \cdot 7H_2O + 2CA(OH)_2 + \tfrac{1}{2}\,O_2 \longrightarrow 2\,Fe(OH)_3 + 2CaSO_4 + 13\,H_2O$$

$$Fe_2(SO_4)_3 + 3Ca(HCO_3)_2 \longrightarrow 2Fe\,(OH)_3 + 3CaSO_4 + 6\,CO_2$$

Coagulation aids are also sometimes used to improve coagulation by promoting larger, more rapidly settling flocs. Polyelectrolytes or particulate materials can be used for this purpose. Polyelectrolytes are large weight polymers with a long chain molecular arrangement. These act as bridges between the particles, bringing them together. Particulate materials, such as clays or activated silica, can be added to bind particles together and to serve as nuclei for the floc formation. The following table gives the details about different commercial coagulants used in the treatment of waste water :

Table 4.7

Coagulant	Characteristics and applicability
Ferric Sulfate*	It can be effectively applied in the pH ranges of 4–6 and 8.8.–9.2.
Ferric Chloride*	Effective in pH range 4–11 and promotes sludge dewatering
Ferrous Sulfate*	Can be used over a large pH range
Alum*#	Most effective in the pH range of 6.8–7.5. Easy to handle and apply and produces less sludge
Lime#	Very effective and does not increase TDS. Sludge dewaters easily

* Their addition usually increases dissolved solids

Most commonly used

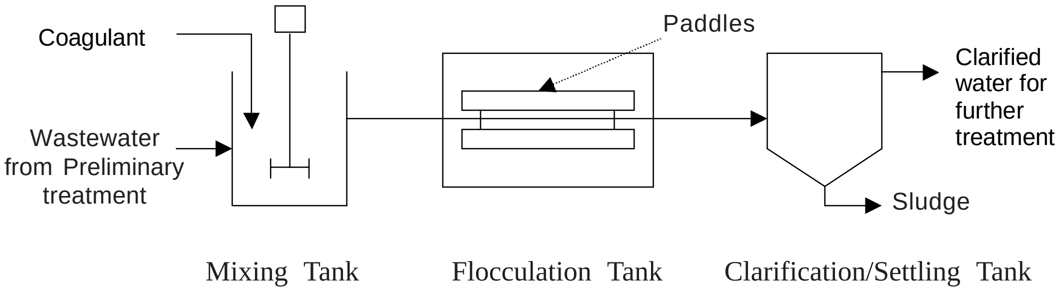


Figure 4.14: Steps involved in coagulation of wastewater

Floatation

If the contaminants present in the wastewater are very fine or have a density close to water or oily/sticky in nature it is difficult to use sedimentation process since it takes very long time for the particles to settle. In such cases flotation cells can be utilized. Floatation process is based on the following principle: When very fine gas bubbles are introduced in to the waste water, the suspended solids get attached to the bubbles and rise to the surface . Such air entrained solids in the form of foam will be collected and separated at the surface of the waste water and disposed off. The entrapment of gas bubbles often is promoted by the use certain chemicals called 'Floatation Agents' e.g : Pine oil, soaps and detergents

4.3.2.3 Secondary Treatment

Aerobic biological treatment

In aerobic biological treatment process, the microorganisms are made to act on the organic part of the waste to produce CO_2 and H_2O in the presence of oxygen. The biological wastewater systems can generally be classified as suspended growth systems and attached growth systems. Suspended growth systems consist of reactors where wastewater and bacteria are mixed. The bacteria grow in aggregates known as flocs, are suspended in the wastewater so that there is direct contact between the bacteria and soluble organics in wastewater. Examples of suspended growth systems are the activated sludge process and aerobic stabilization ponds.

In attached growth systems or fixed film systems, the microorganisms are attached to a stratum or solid object and the wastewater flows past them. The biomass support surface may be stones or plastic sheets that are essentially fixed. In case of fluidized systems sand or other particulate material are used. Examples of fixed film systems are trickling filters, rotating biological contactors and fluidized bed reactors.

Continuous flow aerobic biological process provides treatment for domestic and biodegradable industrial wastewater. Overall treatment process includes preliminary, primary treatment before the aeration basin. Subsequent to the aeration basin, the waste water is passed to a secondary clarifier where the microorganisms are settled and the sludge produced is partially recycled in to the aeration basin.

Anaerobic Biological treatment

Anaerobic treatment process is a biological process carried out in the absence of oxygen. Anaerobic microorganisms convert the organic compounds present in the waste water into methane, Carbon dioxide and other simpler organic compounds. Mechanism of such conversion is given in Fig. 4.15.

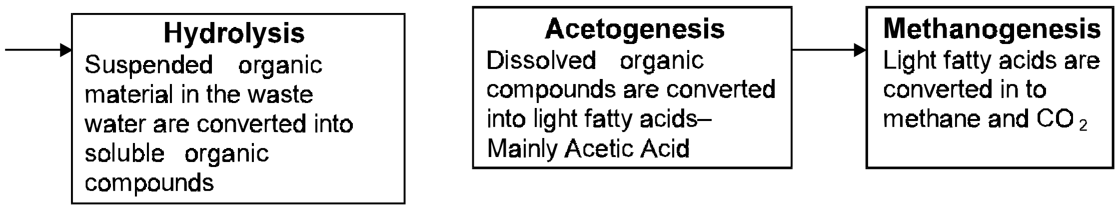


Figure 4.15: Three stage Mechanism of Anaerobic treatment

Anaerobic process is preferred for high BOD wastewaters for the following reasons :

(*i*) The energy value of Methane produced can be utilized for thermal and electrical applications.

(*ii*) Sludge growth rate is very slow.

(*iii*) sludge has a manure value.

Anaerobic microorganisms require nutrients which are different from the requirements of aerobic organisms because of lower cell yield. Along with Nitrogen and Phosphorous, the other nutrients required are Sulfur, Iron, Calcium, Magnesium, Sodium and Potassium. Many of the above are available in most of the industrial wastewaters and hence separate addition is not required. The optimum pH and temperature conditions for this microbial process are 7–8 and 25–40°C respectively.

Lagoons

The organic discharges in the waste water are often stabilized (Organic matter converted to simple inorganic substances) by retaining the discharges in large shallow ponds called lagoons. Stabilization in these systems is due to the combined metabolic activity of bacteria and algae. When ponds are designed and operated in such a manner that the stabilization is completely aerobic, they are referred to as ***oxidation ponds***. When the condition is anaerobic, or alternatively aerobic and anaerobic, the pond is called ***stabilization lagoon***.

In oxidation ponds, the symbiotic relationship between bacteria and algae is responsible for the treatment. The bacteria utilize organic waste materials for growth and energy, the latter provided through an oxidation of a portion of organic carbon to carbon dioxide. The carbon dioxide, along with ammonia and other nitrogenous decomposition products that are released by hydrolysis, are utilized for algal growth (photosynthesis).

The waste stabilization lagoons are generally utilized in the treatment of wastes containing settable solids. The solids upon settling to the bottom of the lagoon decompose anaerobically. The unsettled portion of the waste undergoes either aerobic or anaerobic decomposition depending upon the organic loading on the lagoon.

Activated Sludge Process

Activated sludge process is a secondary treatment process, which maintains intimate contact between the wastewater, a large population of bacteria and oxygen. Rapid bio-degradation of the organics in the wastewater is possible due to bacterial action and hence the process has high efficiency. The mechanism of aeration and mixing are very important in designing the process. Proper aeration is important to ensure that there is sufficient oxygen to keep the system aerobic under high growth-high oxygen utilization conditions. Adequate mixing will be helpful in ensuring a good contact between the bacteria and the wastewater organics.

The schematic representation of an activated sludge process is represented in the diagram.

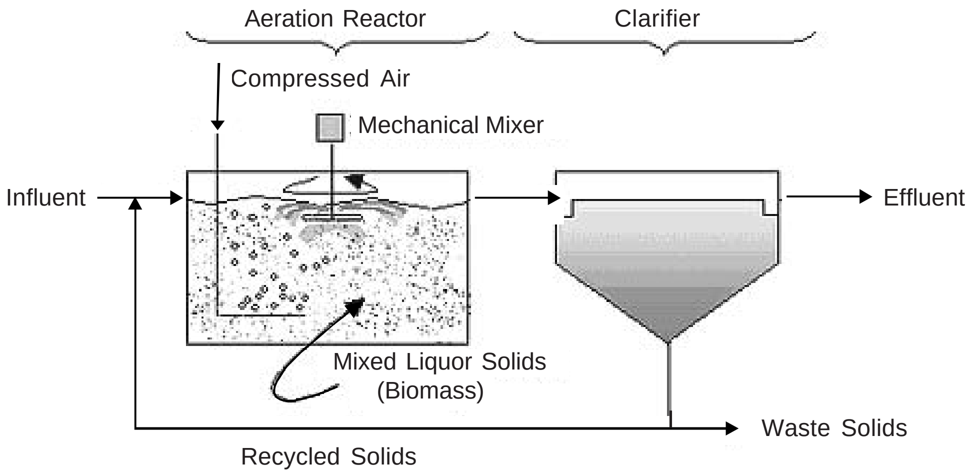


Figure 4.16: Activated sludge process

The microbes will multiply with the consumption of wastewater organics, stick together and form small floc particles. Thus in the aeration tank the microbes are vibrant and active in consuming all the available organic wastes. Since the microorganisms are activated for degrading more and more wastewater organics, the term ‘activated sludge’ is used to represent this biomass. When the wastewater enters the final clarifier, microbial flocs settle as sludge. This sludge enriched with the microbes is partially returned to the aeration chamber to maintain a constant biomass population (normally termed as Mixed Liquor Suspended Solids or MLSS). The remaining waste activated sludge should be carefully handled and disposed off after disinfection (any one suitable process described in section 4.3.2.5 can be used). The biomass balance can be maintained by recycling an amount of sludge equal to the amount of biomass loss in the aeration tank.

The recent trends in the activated sludge process are

1. Step aeration
2. Contact stabilization
3. Oxidation ditch, high - rate activated sludge
4. Extended aeration process
5. PACT process

Oxidation ditches

Oxidation ditch is a modified activated sludge process which consists of an oval shaped channel where the incoming waste water is aerated with mechanical rotors. Simple representation of this process is given in Fig. 4.17.

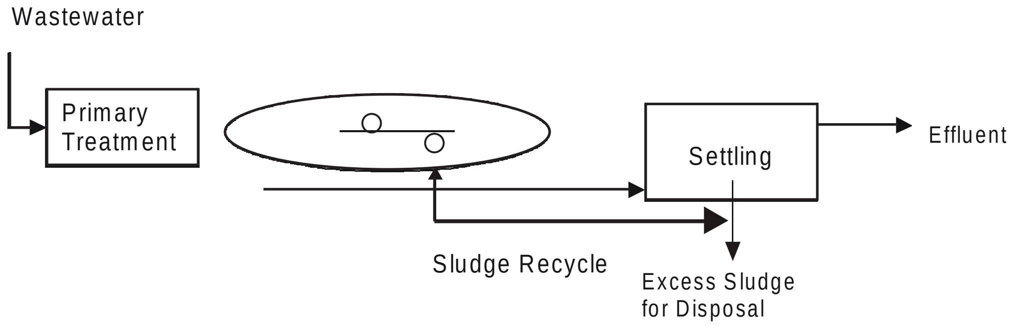


Figure 4.17: Schematic diagram of Oxidation ditches

Usually long retention time is needed for treatment and most of the sludge formed is recycled and excess will be dried on drying beds and disposed.

Trickling Filter

Trickling filters are fixed bio film systems used in secondary wastewater treatment. Unlike activated sludge process where microbes are allowed to float freely, settled and partially reused, here in trickling filters they grow on solid media and allowed to develop as a fixed biofilm on solid surface. The biofilm so formed is stable and retains itself in the treatment chamber itself. As the wastewater passes the biofilm, organic matter and nutrients diffuse into the biofilm and gets converted into CO_2 and other metabolic by products. This mechanism is illustrated in Fig. 4.18.

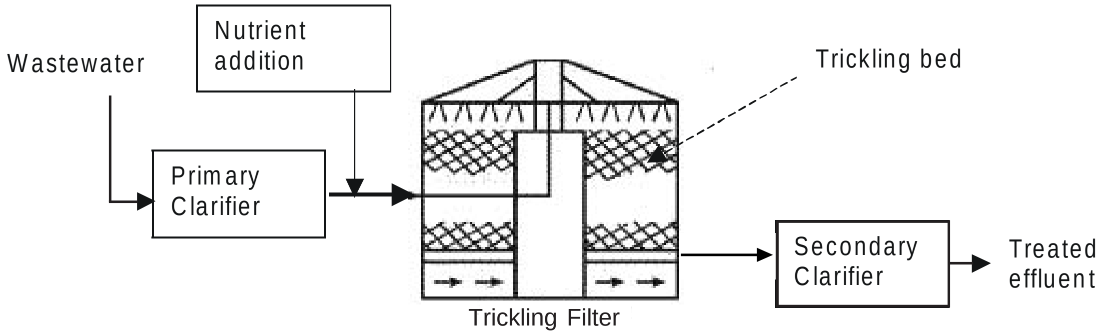


Figure 4.18: Schematic diagram of Trickling filter

Sometimes the biofilm is called slime. The thickness of the slime layer increases due to growth of microorganisms until the outer layer absorbs all the organic matter and causes the inner layer adjacent to the media to enter an endogenous growth regime and lose its ability to cling to the media.

The solid media is some times referred to as 'carrier' or 'packing material'. Some of the commonly used materials are rocks, plastic arrays etc. A trickling filter consists of a bed of packing material over which the wastewater is sprinkled. Wastewater distribution is usually accomplished using a rotary distributor that gently distributes the flow over the bed for short periods, allowing the water to trickle down through the bed over the media in thin films, where the biodegradation of pollutants (organic) and growth of microbes take place.

The wastewater after passed through the trickling filter is allowed to pass through a clarifier to remove any detached biofilm or other suspended solids before being discharged. Clarified wastewater may be recirculated to the top of the trickling filter which has the following advantages:

1. Stabilized flow rate.
2. Dilution of high strength influent.
3. Additional retention time for removal of organics.
4. Less fluctuation in the treated effluent.

Rotating Biodisc Contactor (RBC)

In a rotating biodisc contactor the micro-organisms are attached to circular rotating discs which are submerged in the treatment tank as shown in Fig. 4.19. Here the media rotates and intimately contacts wastewater. This rotary action also induces oxygen transport in to the system and hence promotes aerobic process. It is a common practice to construct RBCs placed in parallel traits with multiple units.

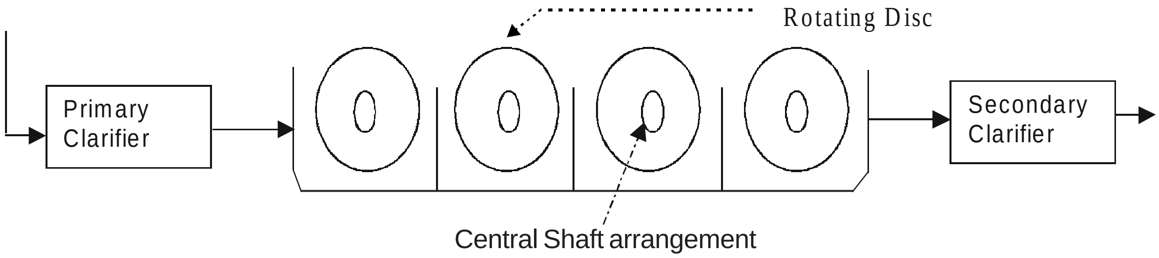


Figure 4.19: RBC low schematic

4.3.2.4 Tertiary or Advanced Treatment

Evaporation

Evaporation is a process used for concentrating a solution containing a non-volatile solute in a volatile solvent. It is normally used to produce a concentrated liquid, often prior to crystallization of the solute. In wastewater treatment, evaporation is used as a means of volume reduction. Water and low boiling compounds of the effluent are evaporated, leaving behind dissolved and suspended solids in much smaller volume of water which can be easily handled. Evaporation is also used for recovering costly chemicals. Rate of the evaporation process depends on temperature difference between the effluent bulk and the surroundings, exposed surface area and rate of vapour removed from the surface.

The equipment in which the evaporation process-taking place is called an evaporator. The tube bundle called calendria, is an essential part of an evaporator. Steam is normally utilized as heating media. Several types of evaporators are in use. Some of the common types are:

1. Long tube falling film evaporators in which the liquid flows as a thin film on the walls of a long, vertical, steam–heated tubes.
2. Long tube evaporators with upward flow in which the feed flows upward through tubes because of forced pumping or because of the decrease in liquid density with increase in temperature as it rises up in the steam heated tubes.
3. Direct heated evaporators (such as solar pans and submerged combustion units).

In most of the commercial applications multiple effect evaporators are used in which the vapor from one evaporator serves as the heating medium for the next. This significantly reduces tube amount of steam required.

Adsorption

This process is utilized to remove soluble organic compounds from wastewater. Adsorption is the process of transfer of the contaminant from the wastewater (or aqueous phase of the wastes) to the surface of the adsorbent material. Adsorption occurs primarily due to the Vanderwaal's forces, molecular forces of attraction between the solute and adsorbent surface (physical adsorption).

Adsorbents are highly porous materials, and adsorption of pollutants takes place primarily on the walls of the pores or at specific sites inside the particles. The pores are generally very small and the internal surface area ranges from 500 to 1000 m^2/gm. Adsorption can continue until all available adsorption sites are covered. Physical adsorption is a reversible phenomena and it is possible to remove the contaminants from the adsorbent surface.

Chemical adsorption occurs as a result of chemical reactions between the solute molecules and the adsorbent surface. This type of adsorption occurs on specific sites like the corners of the micro crystallites of the adsorbent. Chemical adsorption is usually irreversible and separation of adsorbent from solute is difficult. In wastewater treatment adsorption processes used is combination of both physical and chemical processes.

The commercially used adsorbents are : Activated charcoal, Diatomaceous earth, and certain types of clays. Adsorption process can be carried out in either fixed bed or fluidized bed adsorbers.

Adsorption process is used in treating waste water containing colored chemicals, herbicides, pesticides, certain petrochemicals and heavy metals.

Ion Exchange

Ion exchange is a chemical treatment process used for the removal of unwanted ionic species from wastewater. The process works by exchanging undesirable cations (positively charged particles) like heavy metals or anions (negatively charged particles) like cyanide, chromite, arsenates etc. in wastewater with less harmful ions like Na^+, K^+, OH^- etc. The exchange reaction is reversible and the contaminant ion concentrated in the resin is later removed with a back wash solutions of mineral acids, their salts or strong chelating substances which react with contaminants to form durable, non-sorbable complexes making the resin available for reuse. Ion exchange capability exists in some natural materials such as clay and zeolites. But nowadays most processes use synthetic ion-exchange resins prepared from organic polymers such as cross linked polystyrene to which ionizable groups have been added. These resins contain sulfonic, carboxylic or phenolic groups.

Each resin will have a maximum capacity for exchanging ions, based on the number of exchange sites available on resin. This is known as the ion exchange capacity of the resin. It is used to calculate the amount of resin needed to treat a given volume of wastewater or the time between resin regeneration.

The Ion exchange equipment consists normally of two columns in which the anion and cation exchange resins are kept in the form of a fixed bed usually supported on a bed of gravel. Auxiliary equipment for preparation and storage of the regenerant is also required. A schematic representation of an ion exchange process is given in Fig. 4.20.

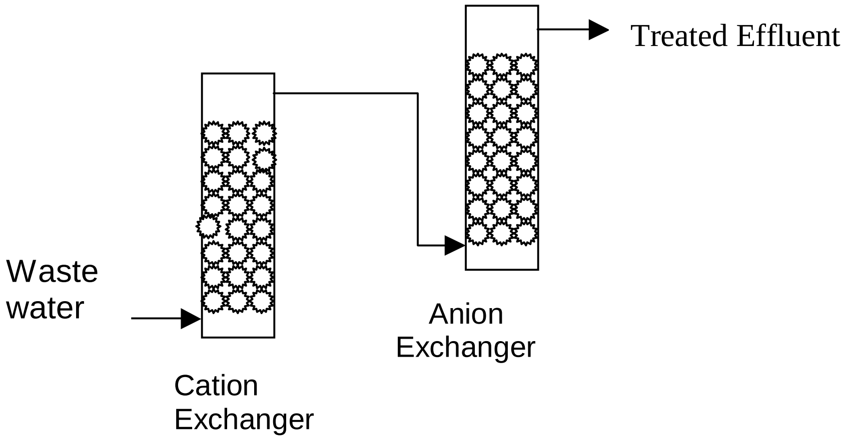


Figure 4.20: Ion exchange process schematic

Membrane Separation Operations

Use of membrane separation processes in water pollution management has acquired special significance in the recent past. Large industries are opting for advanced waste water treatment technologies such as Reverse Osmosis (RO) and Ultra Filtration (UF) with a view to reuse and recycle treated waste water. In conjunction with coagulation, flocculation, filtration and other conventional treatment operations, RO/UF, is a useful adjunct to waste water treatment. The following membrane technologies are well developed and are being widely adopted.

- Micro filtration
- Ultra filtration

- Reverse osmosis
- Electro dialysis

Each of the above technologies utilizes specific membranes and hence related specific mechanisms.

4.3.2.5 Disinfection Methods

The process of destruction of disease causing microorganisms or pathogens is known as disinfection. The wastewater from treatment plants is often enriched with microorganisms since most of the plants employ biological treatment processes. These pathogens should be destroyed before final discharge.

The techniques available for disinfection can be categorized as under:

(A) Physical methods

In these methods, Physical techniques like radiation, ultrasound, ultra filtration, reverse osmosis, heating, freezing, and ionizing radiation are employed .

(B) Chemical methods

Chemical methods involve use of selected chemicals with oxidizing and biocidal properties. The most commonly used chemicals include ozone, bromine, chlorine and its compounds, potassium permanganate, phenols, alcohols and hydrogen peroxide

Some of the common methods employed are discussed :

Chlorination is probably the most popular technique in use. Chlorination changes taste and odor causing substances into innocuous forms because chlorine controls the growth of algae and microorganisms. Chlorine also has a residual germicidal action that provides continuing antibacterial protection.

Chlorination utilizes the application of elemental chlorine, hypochlorites, or chlorine dioxide. Nowadays operations of mixing, flocculation, sedimentation and chlorination are carried out in the coagulation basin itself.

Chlorine also has some drawbacks. Chlorinated organics (i.e., certain trihalomethanes) are produced when organic chemicals combine with chlorine in water. Some of these chlorinated organic chemicals are suspected of being carcinogenic. However, these substances occur more often in surface water than in ground water supplies because surface waters have higher concentrations of organic materials.

Ozonation uses ozone as an oxidizing agent. Ozone is an unstable form of oxygen having three atoms per molecule. Ozone is more reactive than oxygen and is therefore a powerful oxidizing agent. Ozonation has a greater germicidal effect against bacteria and viruses than chlorine. Ozone can also destroy odor and taste producing bacteria. Also, ozonation adds no chemicals to water because it purifies naturally with a form of oxygen. Ozonation also produces residual germicidal power. However ozonation equipment and operating costs are higher than other treatment procedures.

In addition to disinfection ozonation can also remove iron, manganese, and sulfur by oxidizing them into insoluble compounds that can be removed by filtration. Organic constituents may be oxidized.

UV radiation provides pathogen-killing action much the same way sunlight helps to kill them. It is a physical agent, which penetrates the cell wall of microorganism and is absorbed by cellular materials including DNA and RNA. This either prevents replication or causes cell death. The ultraviolet radiation unit consists of one or more ultraviolet sources (Usually low-pressure mercury lamp) enclosed in a quartz sleeve, around which the water flows. The lamps are similar to fluorescent lamps, while the quartz sleeve surrounding each lamp protects the lamp from the cooling action of water.

Water flow must be regulated in a relatively thin layer around the lamp to ensure that all organisms receive adequate exposure since the germicidal action of ultraviolet irradiation depends on the intensity of the light, depth of exposure, and contact time. Turbidity and minute traces of iron compounds reduce the light's transmission. Therefore, the water should be pre-filtered so that untreated organisms do not slip by.

Ultraviolet irradiation units are automatic, require little maintenance, and do not add undesirable materials to the water.

Thermal Disinfection

Reduction in the number of pathogenic organisms can be achieved by using the thermal agent 'Heat'. Usually low-temperature steam or boiling water can be used as heating media. Most bacteria and viruses are killed by exposure to moist heat achieved with dry saturated steam at 73°C for greater than 10–15 minutes. This method is effective, reliable but is unsuitable for heat-sensitive items.

4.4 WASTE WATER TREATMENT FLOW SHEETS

4.4.1 Flow Sheet For Sewage Treatment

Water is an essential requirement for human living. Fresh water is used for different utilities like washing, bathrooms, kitchens toilets etc. The spent water from a human settlement is normally termed as sewage. The sewage normally contains organic and inorganic impurities, bacteria, and viruses. Organic impurities arise from human and waste, detergents, fats and carbohydrates. The sewage needs to be treated for the purpose of public health and hygiene. Untreated sewage can lead to spread out diseases like cholera, dysentery, typhoid, hepatitis etc. Sewage also creates problems of odor. Contamination of water supplies and bodies will lead to a destruction of aquatic life and eutrophication.

The sewage treatment aims mainly at removal of the suspended solids, and reduction of BOD to acceptable levels before being discharged in to moving water streams. The sewage treatment involves the following steps.

1. **Preliminary treatment** in which bulk solids like large floating and suspended materials, grit, oil and grease are eliminated by filtering through screens, grit chambers and skimming tanks.
2. **Primary treatment** in which the balance suspended solids are removed by processes like sedimentation, flocculation and coagulation.
3. **Secondary treatment** in which the dissolved and colloidal organic matter is removed by coagulation and flocculation of colloidal matter and oxidation of dissolved organic matter. These are carried out in aerated lagoons, trickling filters, oxidation ditches and ponds. The sludge obtained from aerobic processes along with the sludge and solids from the primary and preliminary tanks can be subjected to anaerobic digestion producing fuel gas (methane). The digested sludge is dried in drying beds and disposed off latter as a low grade fertilizer.

4. **Tertiary treatment** which is also called polishing treatment is done for further improvement of treated sewage. The tertiary treatment removes fine suspended solids, dissolved inorganic and organics, bacteria and nutrients like Nitrogen and phosphorous. Tertiary treatment is carried out in areas where reuse of sewage is necessary. The tertiary treatments include coagulation, precipitation, and filtration, adsorption, disinfection etc.

A general scheme for sewage treatment is provided in Fig. 4.21.

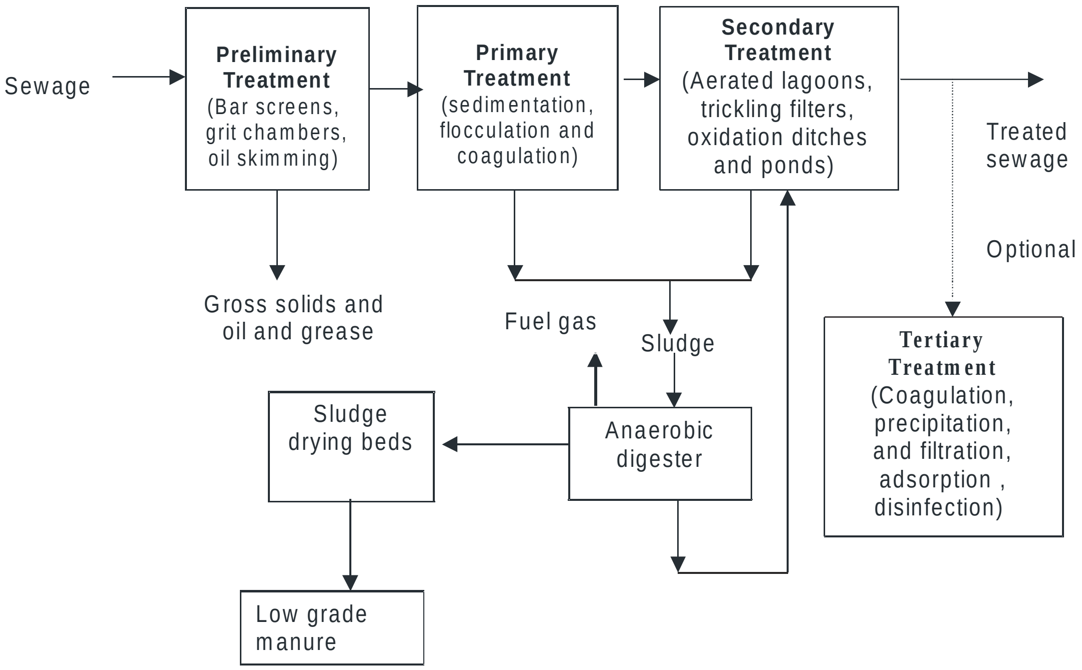


Figure 4.21: Municipal Sewage Treatment

4.4.2 Wastewater Treatment Flow Sheets for Different Industries

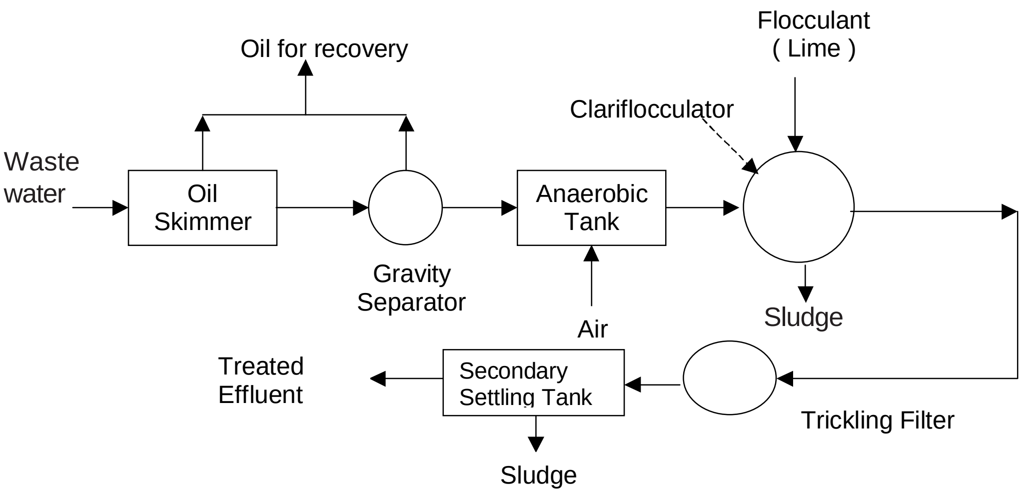


Figure 4.22: Treatment of Petroleum Crude Refinery Wastewater

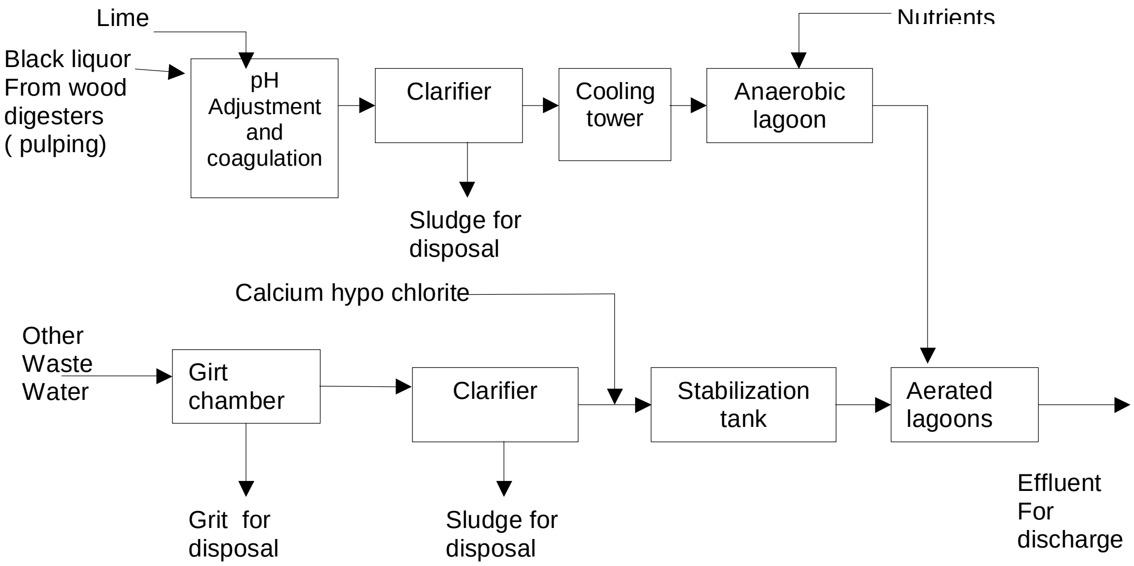


Figure 4.23: Treatment of wastewater from a paper and pulp mill

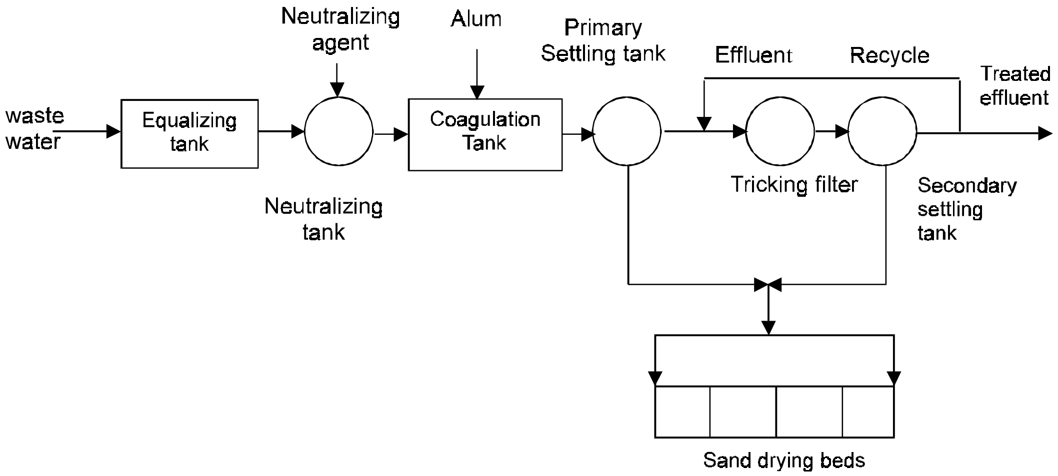


Figure 4.24: Treatment of wastewater from a paper and pulp mill

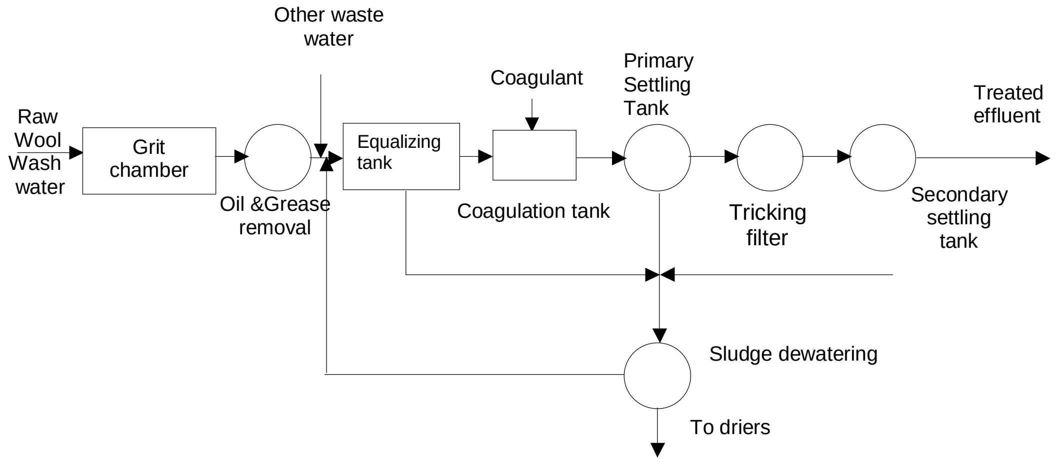


Figure 4.25: Treatment of woolen textile mills waste

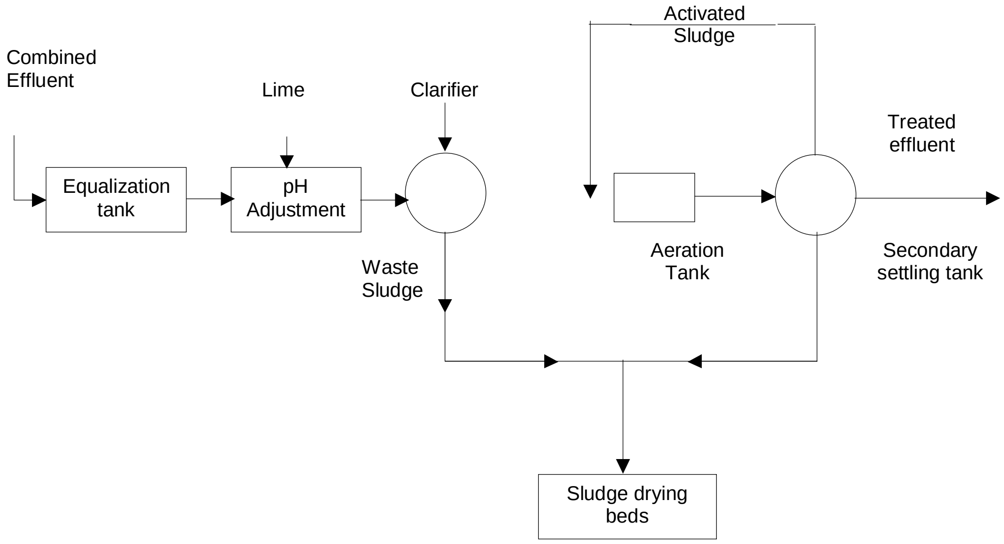


Figure 4.26: Treatment of wastewater from a pharmaceutical plant

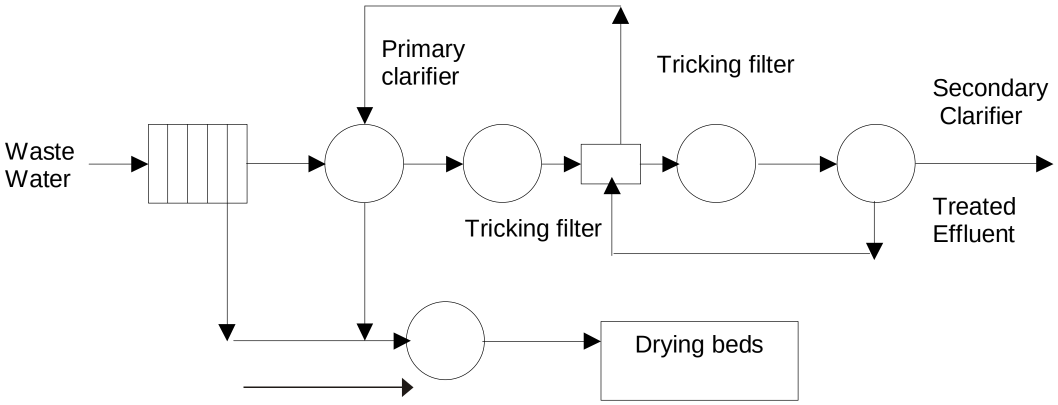


Figure 4.27: Treatment of brwery wastewater

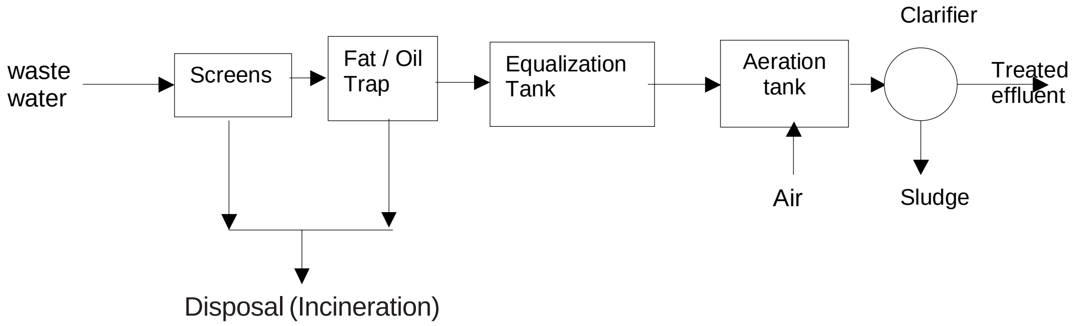


Figure 4.28: Treatment of wastewater from diary

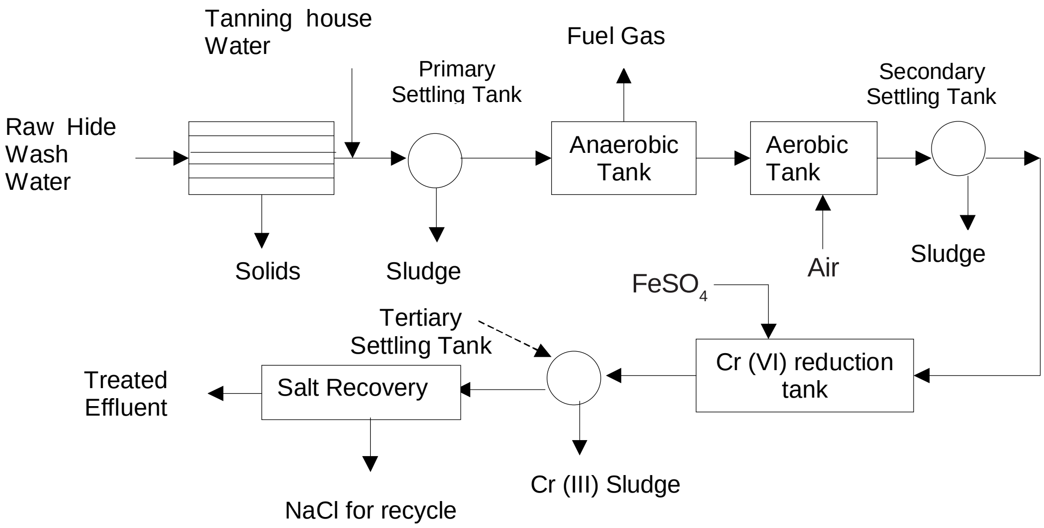


Figure 4.29: Treatment of wastewater from tannery

4.5 SOLID WASTE MANAGEMENT

Waste—An Introduction

Any material that is discarded, useless or unwanted is considered as a waste. Any substance which constitutes a scrap material or an effluent, or other unwanted surplus substance arising from the application of a process, and any substance or article which requires to be disposed of as being broken, worn out, contaminated or otherwise spoiled is classified as waste material. Wastes may be generated in the community by several means. It may be due to natural causes like volcanic eruption due to manmade causes like an unwanted by product of a process etc. The major sources/factors influencing the generation of waste is represented in the Fig. 4.30.

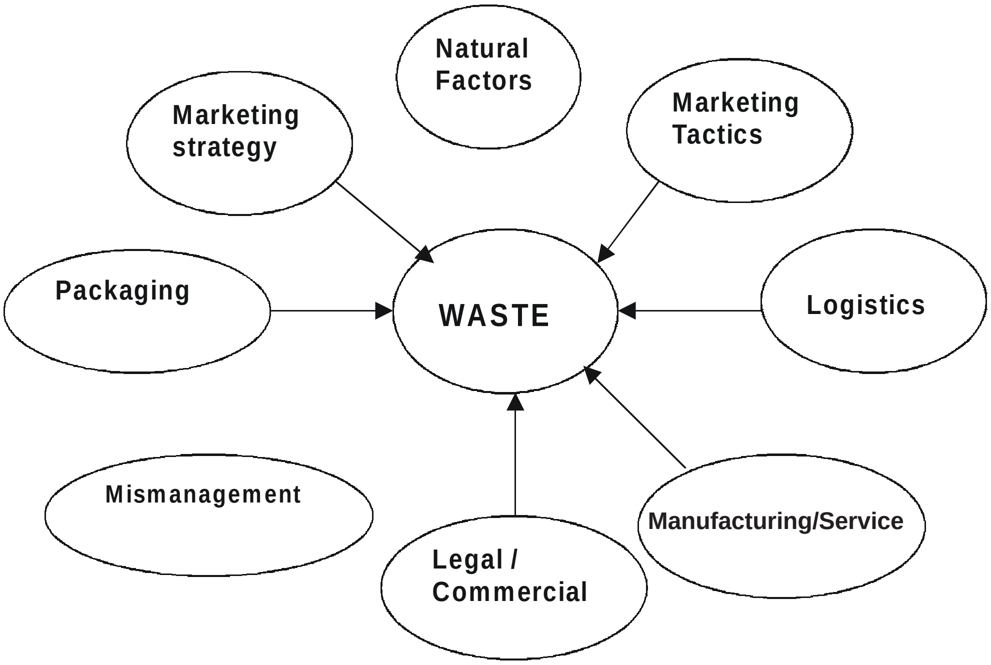


Figure 4.30: Source of waste

Classification of Wastes

Various types of wastes are generated in the community. These wastes may be of domestic, commercial or industrial origin. An overview of the classification of different types of wastes is given in Fig. 4.31.

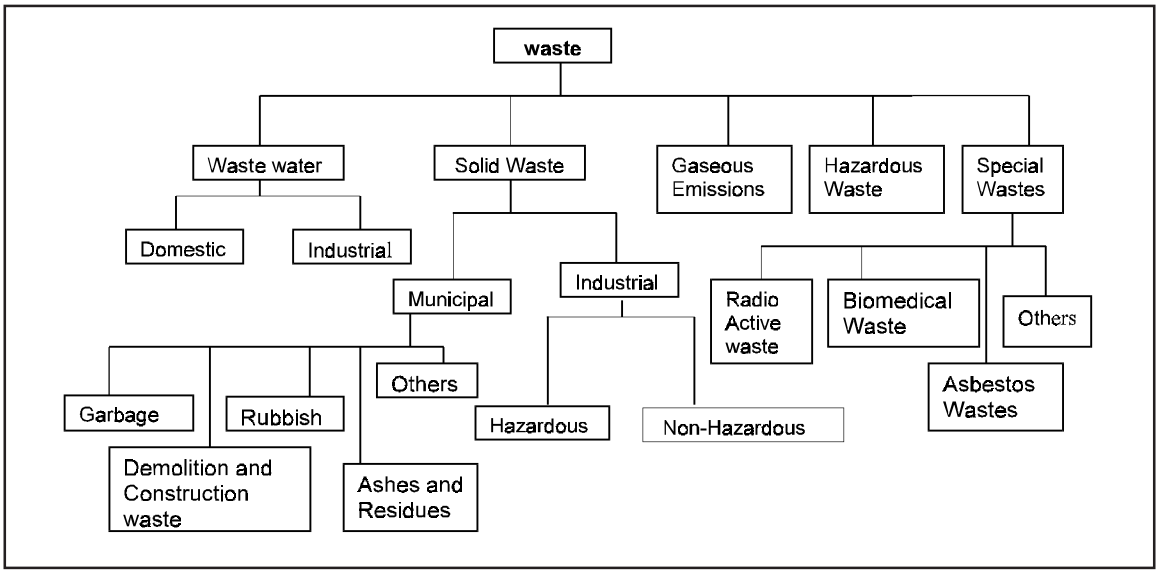


Figure 4.31: Types of wastes

Terminologies involved in characterizing a waste

- **Industrial Wastes**: Any solid, liquid or gaseous substance discharged, permitted to flow or escaping from any industrial, manufacturing, commercial or business establishment or process or from the development, recovery or processing of any natural resource as distinct from sanitary sewage is categorised as Industrial waste. Industrial waste is that waste specific to a particular industry of industrial process. It typically contains higher levels of contaminants such as heavy metals and man-made chemicals than municipal solid waste. and needs to be managed with environmental controls appropriate to the specific waste(s).
- **Municipal Waste**: Waste generated by domestic premises, homes or human settlements. Includes a wide variety of materials such as paper and cardboard, food, garden waste, glass, plastic, metal etc.
- **Special wastes**: Includes asbestos wastes, radioactive and biomedical wastes that are regarded as hazardous but which, with special management techniques, may be disposed of safely.
- **Clean Fill**: Have no harmful effects on the environment.
- **Inert**: largely non-biodegradable, non-flammable and not chemically reactive.
- **Putrescible**: Food wastes or wastes of animal or vegetable origin, which readily biodegrade within the environment of a landfill.
- **Intractable**: Waste that is a management problem by virtue of its toxicity or chemical or physical characteristics which make it difficult to dispose of or treat safely and is not suitable for disposal.
- **Hazardous Wastes**: These are the wastes which poses a threat or risk to public health, safety and environment. The Hazardous waste can be further classified as under.

  (i) *Ignitable*: Hazardous waste that is classified as ignitable includes the following:
  - Liquids with a flashpoint of less than 60°C/140°F
  - Solids that burn spontaneously
  - Flammable compressed gas
  - Oxidizers

  (ii) *Toxic*: Wastes containing one or more of 39 specified contaminants.

  (iii) *Reactive*: Waste that is classified as reactive includes the following:
  - Materials that tend to be unstable at normal temperatures and pressures
  - Water reactive materials
  - Explosives
  - Cyanide or sulfide bearing wastes

  (iv) *Corrosive*: Waste that is classified as corrosive includes:
  - Aqueous solutions with pH less than 2 or greater than 12.5
  - Liquid that corrodes steel at a rate greater than 6.35 mm per year (0.25 inches per year) at a test temperature of 55°C (130°F).

Properties of Waste

Composition: The composition of solid waste varies with several factors such as degree of urbanization and industrialization, per capita income, social customs, climatic conditions of the area, Acceptability of packaged foods, Frequency of collection by the municipality, etc.

Density: The Density of solid waste varies from 150 kg/m^3 to 800 kg/m^3 depending upon the waste composition and degree of compaction

Energy content: Municipal solid waste generally contains about 50% of combustible matter. he average calorific value of the solid waste is found to be 900- 1800 KCals/kg.

Moisture content: The moisture content of solid wastes is the amount of combined and free moisture present which is expressed as the mass of moisture per unit mass of wet or dry material.

Solid waste management—Objectives

The main consideration for solid waste management (Reduction and control of solid waste, collection, handling, transport and disposal) can be enumerated as below :

1. Public hygiene and health
2. Reuse, recovery and recycle
3. Energy generation
4. Sustainable development
5. Aesthetics.

4.6 MANAGEMENT OF MUNICIPAL SOLID WASTE

The frequently used municipal solid waste disposal methods are :

(*a*) Composting
(*b*) Sanitary landfill
(*c*) Incineration and pyrolysis
(*d*) Reuse recovery and recycle.

Composting

Composting is the process of aerobic decomposition of organic matter in the solid waste by bacteria and fungi. To ensure a reasonable composting rate, the following parameters are to be maintained.

Temperature	:	25–50 C
pH	:	5–8
Moisture	:	50–70%

Natural composting is carried out under existing environmental conditions. In mechanized composting units, controlled conditions are maintained. The material to be composted has to be segregated to remove non biodegradable materials like glass, plastics, and metals and alloys. A proper mix of nutrients like animal waste, sewage sludge is necessary to ensure proper growth of bacteria and fungi. Excess compaction may be avoided and a porous structure should be maintained to ensure free circulation of air. This mixture is arranged in windrows (Fig. 4.32) of about 2.5 meters width and is turned over twice a week. The composting process takes about 4 to 6 weeks and the color of the mass becomes dark. The organic matter in the solid waste transforms in to a stable humus. Using continuous aeration and mixing the composting time can be considerably reduced. The waste volume shrinkage depending on the amount of organic matter can be as high as 60%. The composted solid waste is good source of nutrient and can be used as a manure after addition of certain conditioners.

Figure 4.32: Composting windrows

Landfilling

Landfilling or sanitary landfilling is a very common technique for solid waste disposal since it offers an economic solution to the problem. Historically the developing cities and towns had a dumping areain a low lying place near a water body. This unscientific and unsanitary dumping of the waste results in water pollution, bad odors, fires, flies, rodents, etc. The above issues can be tackled by a proper burial technique which is called "sanitary landfill" (Figure 4.33). Careful and scientific site selection, controlled dumping, compaction of waste, provision for collecting leachates are the starergies involed in sanitary landfill.

In sanitary landfill, organic wastes are degraded by soil micro-organisms. Since gaseous oxygen supply is limited, aerobic or facultative bacteria and fungi decompose the organic solid waste by utilizing oxygen present inside the landfill. This is followed by anaerobic decomposition by the micro-organisms and this accounts for the degradation of most of the solid waste present in the landfill. The water soluble organic compounds generated in this process percolates through the landfill soils. The bacteria and fungi present in the soil convert these organic compounds into CO_2 and water.

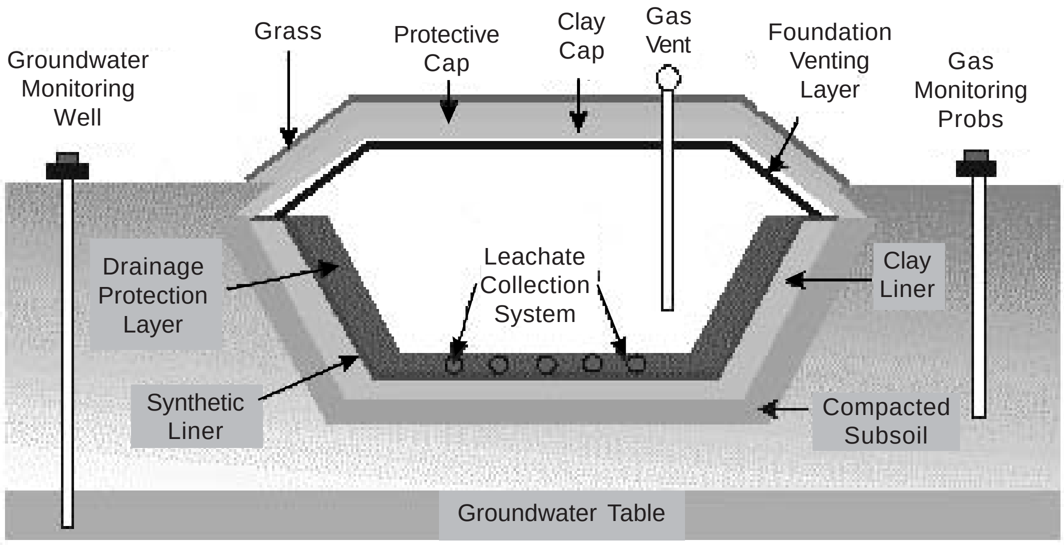


Figure 4.33: Sanitary Landfill

However the technique of sanitary landfill suffers from a few disadvantages. The land occupied by the landfill becomes unproductive. Even after the landfill area is closed only surface development is possible. Land becomes unsuitable for construction of buildings and other commercial structures. Insects, rodents, snakes and scavenger birds, dust, noise, bad odor are some of the aesthetic problems associated with sanitary landfill. Emission of methane and carbon dioxide and leachate contamination of ground water and soil are the environmental issues connected with sanitary landfill.

Thermal Processes

Since segregated solid wastes consist mainly of combustible organic material they can be subjected to controlled combustion or conversion by application of heat. The process is autogenous since the heat required for the process is generated from the process itself. In fact excess heat is generated which can be commercially exploited. The thermal processes are classified in to two main processes namely incineration and pyrolysis.

Incineration

In this process the organic matter in the solid waste is burnt in excess oxygen to produce gaseous products and a stable incombustible residue. Considerable reduction in the volume of the waste results and the extent of land required for land fill is vastly reduced. The residue can be easily and safely disposed since it is non toxic. The disadvantages however are high capital and operation costs, emission of air pollutants. The smaller capacity incinerators are batch type while for large feed stock continuous incinerators are in use. The air pollutants are taken care of water scrubbing and electrostatic precipitators. Care should be exercised to ensure removal of polymeric materials containing chlorine since toxic dioxin is generated during incineration.

Pyrolysis

Pyrolysis is the process of destructive distillation of solid waste (in the absence of oxygen). The combustible organic matter in the solid waste decompose thermally in a pyrolysis reactor kept at a temperature of 600–1000°C in a low oxygen or an oxygen free environment. The pyrolysis process yields compounds like tar and oils, gaseous phases containing fuel gases like hydrogen, methane, carbon monoxide etc. The solid residue will be carbon and inert materials like glass, metals, silica etc. The pyrolysis process produces less emissions and produces fuel gas as a byproduct. Chlorine contained polymers also can be handled.

Waste Minimization, Recovery, Recycle and Reuse

For a detailed treatment of these topics refer to Chapter 5.

4.7 HAZARDOUS WASTE MANAGEMENT

Due to their high toxic character hazardous waste require special precaution in its storage, collection, transportation, treatment or disposal. A hazardous waste management plan should comprehensively take care of all aspects from start to finish.

The important steps of the hazardous waste management plan includes the following:

- Inventorising generation and ensuring that every kg of hazardous waste generated is accounted.
- Ensuring proper storage and transport of hazardous waste
- A disaster management plan for taking care of unexpected spillage or spread of contaminants.
- Setting up of special treatment plants for chemical and physical treatment of hazardous.

Treatment and Disposal

Treatment and disposal consists of physical, chemical and biological methods. The physical methods involve pretreatment of hazardous waste using physical unit operations like filtration, sedimentation, floatation, distillation, absorption and certain membrane processes like dialysis and reverse osmosis.

The chemical processes involve chemical conversions which reduces the toxicity or reactive potential of the wastes. Some examples are oxidation, reduction, precipitation, ion exchange, neutralization etc. Biological processes like aerobic and anaerobic processes, bacterial leaching are also in use.

Offsite disposal methods include common waste treatment facilities co disposal with municipal waste and use of secure landfill (Fig. 4.34). In common hazardous waste treatment facilities, incineration, pyrolysis, detoxification, neutralization etc. can be carried our and the waste is further concentrated, stabilized and solidified and ultimately disposed as a landfill. In co-disposal technique relatively small quantities of hazardous materials are mixed with large volumes of municipal waste so that the contaminants are diffused and diluted.

A secure landfill is a sophisticated repository for hazardous waste. In a secure landfill the wastes are encased in more or less impermeable boundaries. The bottom of the landfill is lined with synthetic materials over which a layer of compacted clay is applied. After filling the waste the secure landfill is covered with synthetic membranes and clay covers. The land fill depth should be such that it is atleast 1.5 meters above the ground water table. Proper provisions for venting of gases generated, leachate collection and monitoring, Ground water and air pollution monitoring are to be done.

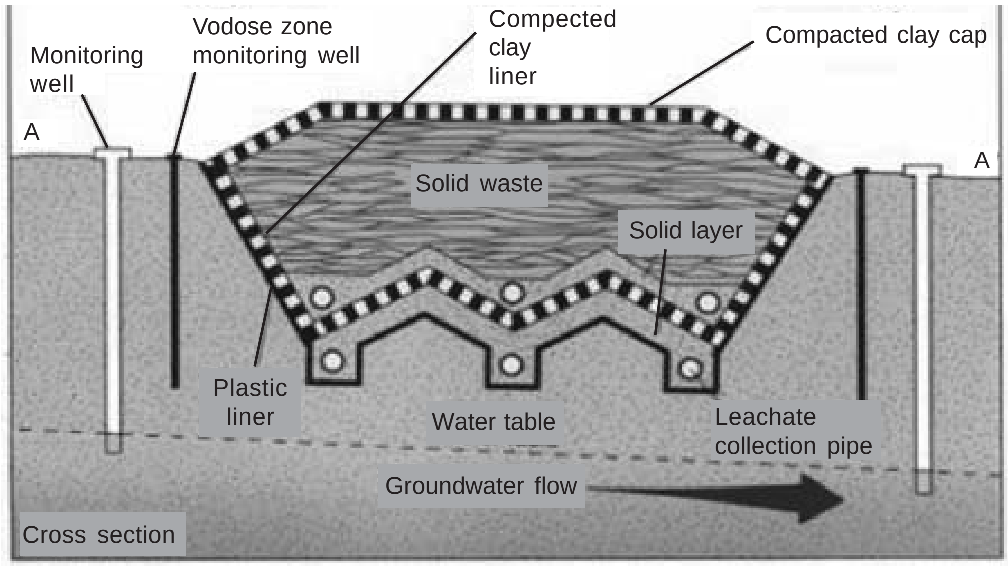


Figure 4.34: Secure Landfill

4.8 BIO MEDICAL WASTE MANAGEMENT

With the increase in population and the subsequent augmentation of health care facilities such as hospitals, nursing homes, dental institutes, veterinary and animal husbandry facilities diagnostic and research laboratories, blood banks the generation of biomedical waste is on the increase. The biomedical waste has been broadly divided into 10 categories as listed below in Table 4.8.

Category	Type of Waste	Treatment and Disposal Options
Category 1	Human Anatomical Waste (Human tissues, organs, body parts)	Incineration/Deep Burial
Category 2	Animal waste (Animal tissues, organs, body parts, carcasses, bleeding parts, blood and experimental animals used in research)	Incineration/Deep Burial
Category 3	Microbiology and biotechnology waste (waste from lab culture, specimens from microorganisms, vaccines, cell cultures, toxins, dishes, devices used to transfer cultures)	Local Autoclaving/ Microwaving/Incineration
Category 4	Waste Sharps (Needles, Syringes, scalpels, blades, glass)	Chemical Disinfection Autoclaving/Microwaving, Mutilation and Shredding
Category 5	Discarded medicines and cytotoxic drugs (outdated, contaminated, discarded drugs)	Incineration/Destruction and disposal in land fills
Category 6	Soiled waste (contaminated with blood and body fluids including cotton, dressings, soiled plasters, linen)	Autoclaving/Microwaving/ Incineration

Category 7	Solid waste (tubes, catheters, IV sets)	Chemical Disinfecion/ Autoclaving/Microwaving
Category 8	Liquid waste (Waste generated from laboratory and washing, cleaning, disinfection)	Disinfection by chemical treatment and discharge into the drains
Category 9	Incineration ash	Land fills
Category 10	Chemical waste	Chemical disinfection and discharge into the drains

Figure 4.8

The biomedical waste has become a health and environmental hazard due to the indiscriminate dumping of medical waste like human and animal body parts, body fluids, rags and linen, discarded dressing materials, medicines and sharp objects like knifes, needles and broken glass and porcelain ware. All this contain pathogens which infects humans and animals leading to spread of dreaded diseases.

It is not only the waste handlers who are at risk, since the infection can spread beyond through vectors. In developing countries and poor societies children and woman are highly prone to such infections. In addition unscrupulous elements in the society recondition these materials and sell them for reuse which is extremely dangerous. Medical waste also gets mixed with municipal solid waste and contaminates the same with pathogens. Indiscriminate burning or uncontrolled incineration results in the release of air pollutants like dioxins and furans. Medical waste also can contaminate soil, surface and ground waters.

Handling and Disposal of Biomedical Waste

Suitable collection facilities like plastic bags, cans, etc with proper identification and labeling should be provided at the points of generation like operation theaters, wards, intensive care units, laboratories, and blood and organ banks.

Different types of containers with proper color coding are to be used for different categories of medical waste. From the generation points medical waste should be removed immediately and disposed off within 48 hours. Medical waste should be transported in prescribed and approved vehicles only. Sharp objects like needles scalpels, and syringes is a safety problem to the waste handler. Hence the waste handler should use proper need based personal protective equipment such as gloves, gum boots, face masks etc.

A suggested list of type of containers for disposal of biomedical waste is given in Table 4.9.

Table 4.9

Type of Container	Waste Category	Treatment Options
Plastic Bags	Human and animal wastes, Microbial and Biological wastes and soiled wastes	Incineration/Deep Burial
Disinfected container/Plastic bags	Microbiological and Biological wastes, Soiled wastes, Solid wastes	Autoclave/Microwave/Chemical Treatment

Plastic bag, Puncture proof container	Waste sharps and solid waste	Autoclave/Microwave/Chemical Treatment Destruction
Plastic bag	Discarded medicines, Cytotoxic drugs, Incineration ash and chemical waste	Disposal in secured land fills
Plastic Container	General waste such as office waste, food waste and garden waste	Disposed in secured landfills

Medical Waste Treatment Techniques

Medical waste Treatment Techniques include

- Incineration
- Sterilization
- Disinfection
- Thermal deactivation
- Irradiation and microwave treatment

Incineration is a process of controlled combustion in the presence of excess air which is explained in chapter. Incineration completely destroys pathogens and oxidizes all organic carbon. The reduction in the volume of the waste is around 80%. The residue may be categorized as hazardous waste and can be disposed off in a secured landfill. The excess heat generated from incineration can be commercially exploited. Different types of incinerators are in use for depending on quantity and nature of medical waste generated. Hospital incinerators are grouped into three types namely multiple chamber, controlled air, rotary incinerators.

Steam sterilization is also known as autoclaving . The waste is placed in a sealed chamber and exposed to steam at a preset temperature and pressure for a specified time. Normally for hospital sterilization a temperature of 121°C is used with processing time of around 12 minutes there is no volume reduction of the waste and generation of an extremely offensive odor and toxic emissions are also possible. For large volumes of waste continuous sterilization units have been developed.

Chemical disinfection process involves treating the medical wastes with liquid chemical disinfectant. The wastes have to be prepared by grinding them therefore the chemical disinfectant can penetrate and disinfect the entire mass. Particle size, porosity and permeability will affect the process of disinfection. The ground waste materials are thoroughly mixed with the disinfectant after holding for a specified length of time, the solid residues are separated and are disposed in a landfill. The liquid portion along with the disinfectant is normally released in to the sewer. There is some reduction in the volume of solid waste because of grinding.

Thermal deactivation involves raising the temperature of the waste to such a level that all infectious agents are destroyed. This process is used mainly in treating liquid waste which is heated to a preset temperature for a specified period and then is disposed. Dry oven heating for non-liquid waste are also adopted.

Irradiation is a process in which ultraviolet or ionizing radiation is used for destroying infectious agents. The advantage of the process is that the power consumption is very less and thermally untreatable materials also can be treated. However the process suffers from the fact that ionizing radiation source and UV radiation can be a potential health hazard. Microwave radiation systems are used for treatment of hazardous medical waste. The waste is first ground and shredded and sprayed with water. The mass is then heated with microwave radiation with high temperature. Toxic gaseous emissions are possible during this treatment.

4.9 MANAGEMENT AND DISPOSAL OF ELECTRONIC WASTE

Obsolete, dysfunctional and discarded computers and computer peripherals, televisions, VCRs, DVD players, stereo equipment, and cell phones and other electronic and instrumentation gadgetry are commonly referred to as electronic waste or e-waste. Management and disposal of e-waste has become a serious problem in recent times due to a surge in the use of these items and the rate at which they become obsolete. Electronic waste in addition to occupying valuable landfill space is also hazardous in nature.

One of the major pollutant in the electronic waste is lead which may cause lead poisoning and can be especially harmful to young children. It is estimated that around 1.6 billion pounds of lead associated waste from discarded computers will be generated between 1997 to 2007. Much of the focus on managing e-waste revolves around Cathode Ray Tubes (CRTs), often called “picture tubes,” which convert an electronic signal into a visual image. Computer monitors, televisions, some camcorders, and other electronic devices contain CRTs. A typical CRT contains between two and five pounds of lead.

E–Waste Management and Disposal Options

E-waste can be managed in various ways, depending upon its continued usability, availability of reprocessing facilities, where it is generated, and other factors. Here are some options:

Reuse

Preventing waste in the first place is the preferred management option. Consider repairing or upgrading your used electronic equipment so you can continue to use it. In some cases, for example, adding memory to a computer or upgrading software can improve the units’ performance and extend its usefulness. Instead of purchasing a new digital television, consider purchasing a converter box to receive and reformat DTV signals.

Donate

Donating reusable electronic equipment to schools or other nonprofit organizations.

Recycle

In response to consumer concerns, several electronics manufacturing companies have implemented take-back programs. Some programs allow the purchaser to pay a fee at the time of sale to cover shipping to a reprocessing facility when the unit becomes unwanted or obsolete. Others allow owners to ship e-waste to their facilities for a nominal fee or will provide owners with a rebate when the unit is shipped to a participating recycling center. Some waste management companies also offer similar management options to households and businesses.

Units may be reused or dismantled for recycling. The silver, gold, lead and other heavy metals as well as some of the plastics and glass are recycled. Some companies guarantee 100% of the unit is recycled while others recycle as much as possible and then dispose of the rest.

Dispose

E wastes are disposed as secure landfill since the waste is considered to be as hazardous due to the presence of heavy metals. Pretreatment of the waste is necessary to reduce volume occupied. Size reduction techniques like crushing and grinding or mechanical compaction is used. The compacted waste is encased in synthetic membrane containers and are placed inside a secure landfill.

5

WASTE MINIMIZATION AND CLEANER TECHNOLOGY OPTIONS

5.1 WASTE MINIMIZATION

5.1.1 Introduction

Waste minimization is aimed at reducing the generation of waste through education and improved production process rather than attempting to enhance technology to improve treatment of waste. The idea of minimization is not centered on technological advances, but is a method of managing existing resources and technology in order to maximize the efficiency of available resources. Minimizing waste generation has the potential to reduce costs and increase profits by maximizing the use of resources and reducing the amount of waste to be disposed and hence the cost of waste management.

Waste minimization thus involves changing production, consumption and disposal activities so that resources can be used more efficiently, less wastes are generated.

The term '**waste minimization'** has a variety of meanings. As an overall management strategy, it is associated with a range of techniques and/or process activities targeted at different points in the production chain. As such, it involves resource use, production techniques and product design.

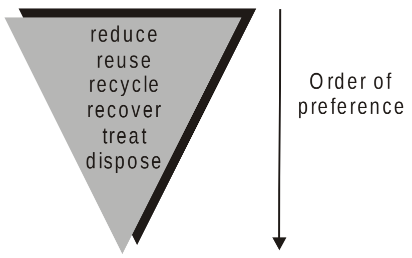
A comprehensive **working definition** for waste minimization reads as under:

"Prevention and/or reducing the generation of waste, improving the quality of waste generated by reduction of hazard, and encouraging re-use, recycling and recovery".

5.1.2 Waste Minimization Techniques

Waste can be minimized by any one of the following approaches/Techniques

- Waste prevention/Waste reduction at source
- Re-use
- Materials recycling
- Recovery
  - Incineration with energy recovery
  - Incineration without energy recovery



- Landfill with energy recovery
- Landfill without energy recovery

5.1.3 Waste Prevention In Manufacturing

The most preferred waste minimization technique is source reduction which involves either completely prevent the formation of waste or reduce the quantity of waste formed at the point of production/manufacturing process itself.

The following approaches can be adopted in manufacturing industries

- **Source control/resource management**
  - Using less and/or more homogeneous raw materials for the same output,
  - Using higher quality raw materials.
  - Using different materials, i.e. input substitution related to prices and/or process modifications.
  - Using less hazardous or toxic materials as inputs.
  - Using input materials which are more easily recyclable.
  - Improve material receiving, storage, and handling practices.
- **Improving operations and processes**
  - Usage of optimum process conditions, reactions and raw materials.
  - Improve housekeeping: Avoid leaks and spills.
  - Implement standard operating practices and preventive maintenance procedures.
  - Segregate wastes by its type.
  - Processing and/or sale of waste as by-products.
- **Modification of production equipment and machinery**
  - Select and install manufacturing/production equipment that produce less or no waste.
  - Improve the operating efficiency of the equipment by redesign.
  - Enhance recovery or recycling options by modifying the equipment.
- **Improving Managerial Practices**
  - Train the employees for improving technical skills.
  - Conduct awareness program and motivate the employees to participate in the waste minimization activity.
  - Create a strategic planning, implement and monitor.
  - Create waste minimization circles.
- **Product Changes: "product management and marketing"**
  - Light weighting, better quality longer life and more reliable products.
  - Product substitution.
  - Single material construction as opposed to multiple component products.
  - Larger containers, economy-size items, bulk purchases.

- Less packaging, multiple packaging.
- Ease of disassembly and segregation.
- Re-usable, returnable products.

5.1.4 Waste Reuse

Reuse involves reuse of a material in its original form, possibly after refurbishment (including cleaning), but not including waste separation and materials reprocessing. The reuse of materials is important for the conservation and recovery of resources. As a consequence of this the overall cost of production may be significantly reduced.

Examples of reuse initiatives include:

- Product reuse–retreading of tyres, recovery of demolition materials, reuse of plastic bags, second hand clothing, reconditioning and repair of furniture and appliances.
- Durable packaging, e.g. milk and egg crates, bread trays, string or calico shopping bags.

5.1.5 Waste Recycling

The waste recycling involves processing of materials from waste streams, which are broken down into raw materials and reprocessed either into the same material (closed loop) or a new product (open loop). Waste recycling includes waste separation and material reprocessing.

There are various materials that are capable of being recycled, and technology is available for recycling of more and more materials. However, in many cases, due to health and technological considerations, it has not been possible to use a material, which is fully recycled.

The benefits of recycling do not lie solely in diversion of waste away from disposal but, even more importantly, in the reduction of the amount of virgin resources that need to be harvested and processed for the manufacture of new products.

The main categories of recyclables are: Paper, PET and HDPE plastics, Liquid paperboard, Aluminium and Steel cans, Glass bottles and Food containers. Waste oil and car batteries are also recycled in many Countries. There are many more materials that are recyclable than materials that are actually recycled. The reason for this is that quite often the recycled product has no established market or the market is not viable due to low commodity prices. It is hence not viable for such products to be recycled. Examples of this are: Some types of Plastics and Crushed glass.

5.1.6 Waste Recovery

Waste recovery or Secondary Resource Recovery (SRR) is the range of activities characterized by the treatment and use of materials or energy from waste through thermal, chemical, or biological means.

Generally, there are two main groups of SRR processes.

Biological processes such as

- Composting
- Anaerobic digestion
- Vermiculture.

Thermal and chemical processes such as

- Incineration
- Gasification

SRR allows for the recovery of significant volumes of wastes, much higher than traditional Primary Resource Recovery processes such as green waste mulching. This allows communities to move towards resource recovery that fulfils social, environmental and economic goals, which constitutes sustainable, Integrated Resource Recovery.

Examples include: Cow dung can be used as manure and for production of biogas. Agricultural waste biomass can be utilized in gasification process and thus for electricity generation. Kitchen wastes and garbage can be used for making composites.

5.2 ESTABLISHING A WASTE MINIMIZATION PROGRAM

Waste minimization is a continuous organizational effort. It needs thorough process understanding to get an insight about the true cause for waste generation in order to select a waste minimization technique/alternative. Thorough process observation and sampling also provides information on whether wastes are generated due to process chemistry, equipment used, operating procedure or poor house keeping.

A waste minimization program comprises several phases like, planning and organizing, assessment, feasibility analysis, implementation and evaluation (Figure). Such a step-by-step waste minimization approach is primarily aimed at an existing manufacturing process. When dealing with new processes the waste reduction concept should be applied starting from the early stages of process development or planning phase itself. Emphasis should be given for raw material substitution, process modification and recycle/reuse of waste since they are less expensive to implement.

Planning and Organizing Phase

- Setting goals
- Defining objectives
- Making procedures
- Establihsing techniques

Assessment Phase

- Collecting of process and equipment/facility data
- Prioritizing and selecting of assessment targets
- Selecting people for assessment teams
- Review of collected data
- Inspecting the site where the program is to be implemented
- Generation of options
- Screening and selection of options for further study

Feasiblity Analysis Phase

- Technical evaluation of the program
- Economical evaluation of the program

- Implementation phase
- Justification of the project
- Obtaining the funding
- Installation of equipment
- Implementation and evaluation procedure

Evaluation Phase

- Repeating the previous steps
- How much waste minimized ?
- Other necessary modifications

5.3 BENEFITS AND BARRIERS FOR WASTE MINIMIZATION

Benefits

- Conservation of natural resources and reduced disposal infrastructure such as land fill
- Financial return
- Environmental improvement
- Staff motivation
- Reducing risk and contingent liabilities
- Company/country image

Barriers

- Initial cost
- Other priorities
- Quality worries
- Existing initiatives
- Management overload
- Re-organisation
- Proposed plant/process changes
- New normal products
- New normal system(s)
- Perception (compliance vs cost saving)

5.4 CLEAN TECHNOLOGY

A clean technology aims at source reduction or recycling method to eliminate or significantly reduce hazardous waste generation. Hence it is concerned with the design, operation and management of activities, which minimize or avoid creating environmental impacts at source. It is also essential that final product quality be reliably controlled to meet acceptability standards. In addition, the cost of applying the new technology relative to the cost of similar technologies should be considered.

Introduction of clean technologies can be made by:

- Incorporating the principles of clean technology and "benign design" into the decision making process.
- Systematic review of processes using environmental operability studies.
- Ranking of technology options.
- Feasibility analysis.

Some Examples of technological options where there is very nominal or nil pollution are:

1. Fuel cells for power generation
2. Environmentally degradable plastics
3. Bio diesel as an alternate fuel
4. Alternatives to chlorinated solvents
5. Biofertilizers.

5.4.1 Fuel Cells

The fuel cell is an electrochemical devise, which converts chemical energy of the fuel to electricity by combining gaseous hydrogen with air in the absence of combustion. A fuel cell provides a DC (direct current) voltage that can be used to power motors, lights or any number of electrical appliances The basic principles of operation of the fuel cell is similar to that of the electrolyser in that the fuel cell is constructed with two electrodes with a conducting electrolyte between them.

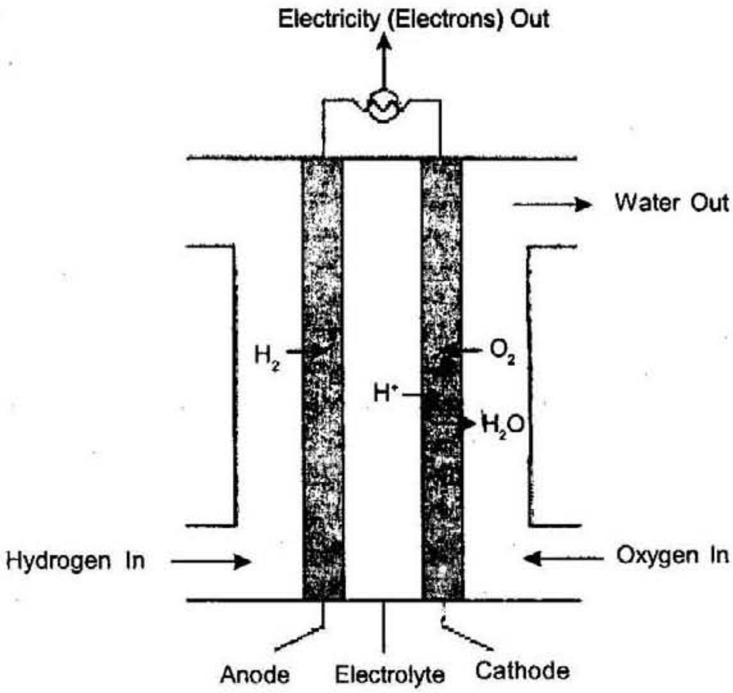


Figure 5.1: A simple representation of a fuel cell

For example consider the **Proton Exchange Membrane (PEM)** fuel cell .The heart of the cell is the proton conducting solid **PEM**. It is surrounded by two layers, a diffusion layer and a reaction layer. Under constant supply of hydrogen and oxygen, the hydrogen diffuses through the anode and the diffusion layer up to the platinum catalyst. The reason for the diffusion current is the tendency of hydrogen oxygen reaction.

Two main electrochemical reactions occur in the fuel cell. One at the anode and one at the cathode.

At the anode, the reaction releases hydrogen ions and electrons whose transport is crucial to energy production.

$$H_2 \rightarrow 2H^+ + 2e^-$$

The hydrogen ion on its way to the cathode passes through the polymer membrane while the only possible way for the electrons is though an outer circuit. The hydrogen ions together with the electrons of the outer electric circuit and the oxygen which has diffused through the porous cathode react to produce water.

$$2H^+ + ½\ O_2 + 2e^- \rightarrow H_2O$$

The water resulting from this reaction is extracted from the system by the excess air flow. The overall reaction is:

$$H_2 + ½\ O_2 \rightarrow H_2O$$

This process occurs in all types of fuel cells.

Types of fuel cells

There are several types of fuel cells, each using different chemistry. Fuel cells are usually classified by the type of electrolyte they use. Some types of fuel cells show promise for use in power generation plants. Others may be useful for small portable applications or for powering cars. Some of the important types are:

Solid Oxide Fuel Cell (SOFC): They operate at high temperatures (1000–1100°C) with a practical efficiency of 50-60%. They are not the most reactive because of the low conductivity of its ionic conducting electrolyte (yttria-stabilised zirconia). Because of their conductivity and heat, they have been used in large power plants, which can use the cogeneration of steam for additional power. The primary drawback to this type of fuel cell is the cost of containment, which requires ceramics, which are difficult to fabricate in forms, and shapes that can accommodate the high thermal stresses. They can be used in power backs for outdoor recreation (small tubular system) and in micro CHP systems in residences.

Molten Carbonate Fuel Cell (MCFC): They operate at 600°C and can use CO as a fuel input on the cathode side but need hydrogen on the anode. The temperature is high enough to be used for additional power production through cogeneration of steam. The efficiency of these types of fuel cells has risen to 50% in a combined (electrical and steam) cycle. They can also be used in mega-watt size power plants because of their heat.

Phosphoric Acid Fuel Cell (PAFC): PAFCs have an operating temperature of 200°C. The efficiency of this system is much lower than that of the other systems at 40%. It is the FC that has mostly been exploited, mainly due to its high grade heat, which can be used in small-scale CHP especially at military sites and UPS systems fuelled with hydrogen, natural gas, LPG and methane from waste water purification plants. The power output varies from 200 kW to

20 MW. The main disadvantage is that it has no self-starting capability, because at lower temperatures (40–50°C) freezing of concentrated Phosphoric Acid occurs. In order to reduce losses, the cathode catalyst and the reformer need to be improved.

Proton Exchange Membrane or Solid Polymer Membrane Fuel Cell (PEMFC or SPMFC): PEM fuel cells operate at around 80°C and a practical efficiency of 60%. Power output is in the range of 5–200 kW. They are ideal for transportation and portable power. Additional advantages are their high response, small size and low cost. An attractive future development is the Direct Methanol Fuel Cell (DMFC). This uses methanol as a fuel for fuel cells by reforming it into hydrogen because of the capacity of safe storage and transportation that methanol provides. DMFC is basically used in transportation.

Alkaline Fuel Cell (AFC): The operating temperature of AFCs is about 70°C and their power output is 10-100 kW. They have been widely used for space and defense applications, where pure hydrogen is used. Their excessive cost and sensitivity to CO_2, have restricted their research and development, no matter their high efficiency and power density.

Advantages of Fuel Cells

- *High efficiency of conversion*: Fuel cells convert chemical energy directly into electricity without the combustion process. As a result, a fuel cell is not governed by thermodynamic laws, such as the Carnot efficiency associated with heat engines, currently used for power generation. Fuel cells can achieve high efficiencies in energy conversion terms, especially where the waste heat from the cell is utilized in cogeneration situation.
- *High power density*: A high power density allows fuel cells to be relatively compact source of electric power, beneficial in application with space constraints.
- *Quiet operation*: Fuel cells, due to their nature of operation, are extremely quiet in operation. This allows fuel cells to be used in residential or built-up areas where the noise pollution is undesirable.

Disadvantage of Fuel Cells

The main disadvantage of the fuel cells is associated with the cost. The two basic reasons are: (i) High costs compared to other energy systems technology (ii) Operation requires replicable fuel supply.

5.4.2 Environmentally Degradable Plastics

Polymeric Materials that undergo significant structural modifications (mainly reduction of molecular weights) when placed in suitable environments are called Environmentally degradable polymers. These natural raw materials are abundant, renewable, and biodegradable, making them attractive feed stock for bioplastic, a new generation of environmentally friendly plastics.

Biodegradable materials: Materials that by action of microorganisms gets quantitatively converted either to CO_2 and H_2O or CH_4 and H_2O under aerobic or anaerobic conditions.

Hydrolytically degradable materials: Materials that undergo degradation by hydrolytic process.

Photodegradable materials: Materials that undergo degradation by combined action of light and oxygen.

Oxidative degradable materials: Materials that undergo an oxidation degradation process.

Bioplastics are a new generation of biodegradable materials , whose components are derived entirely or almost entirely from renewable raw materials. Recent advances in research and technology have shown that these plastics can be made from abundant agricultural resources. They preserve nonrenewable resources—petroleum, natural gas, and coal—and contribute little to the already burdensome problems of waste management.

Biopolymers are the polymers that occur in nature. Carbohydrates and proteins, for example, are biopolymers. Some of the biopolymeric materials are :

Cellulose is the most plentiful carbohydrate in the world; 40 percent of all organic matter is cellulose. **Starch** is found in corn (maize), potatoes, wheat, tapioca (cassava), and some other plants. Annual world production of starch is well over 70 billion pounds, with much of it being used for non-food purposes, like making paper, cardboard, textile sizing, and adhesives. Collagen is the most abundant protein found in mammals. Gelatin is denatured collagen, and is used in sausage casings, capsules for drugs and vitamin preparations, and other miscellaneous industrial applications including photography. **Casein**, commercially produced mainly from cow's skimmed milk, is used in adhesives, binders, protective coatings, and other products. **Soya protein** and **zein** (from corn) are abundant plant proteins. They are used for making adhesives and coatings for paper and cardboard.

A number of other natural materials can be made into polymers that are biodegradable. For example:

Lactic acid is now commercially produced on large scales through the fermentation of sugar feedstocks obtained from sugar beets or sugar cane, or from the conversion of starch from corn, potato peels, or other starch source. It can be polymerized to produce poly (lactic acid), which has become a significant commercial polymer. Its clarity makes it useful for recyclable and biodegradable packaging, such as bottles, yogurt cups, and candy wrappers. It has also been used for food service ware, lawn and food waste bags, coatings for paper and cardboard, and fibers-for clothing, carpets, sheets and towels, and wall coverings. In biomedical applications, it is used for sutures, prosthetic materials, and materials for drug delivery.

Triglycerides can also be polymerized. Triglycerides make up a large part of the storage lipids in animal and plant cells. Triglycerides are mainly produced from soybean, flax, and rapeseed. They are another family of promising raw material for producing plastics and sturdy composites. With glass fiber reinforcement they can be made into long-lasting durable materials with applications in the manufacture of agricultural equipment, the automotive industry, construction, and other areas. Fibers other than glass can also be used in the process, like fibers from jute, hemp, flax, wood, and even straw or hay. If straw could replace wood in composites now used in the construction industry, it would provide a new use for an abundant, rapidly renewable agricultural commodity and at the same time conserve less rapidly renewable wood fiber.

Starch-based bioplastics are important not only because they are less expensive biopolymers but also they can be processed by all of the methods used for synthetic polymers, like film extrusion and injection molding etc. Eating utensils, plates, cups and other products have been made with starch-based plastics.

Research has shown that soya protein, with and without cellulose extenders, can be processed with modern extrusion and injection molding methods. Many water soluble biopolymers such as starch, gelatin, soy protein, and casein form flexible films when properly plasticized. Although such films are regarded mainly as food coatings, it is recognized that they have potential use as non supported stand-alone sheeting for food packaging and other purposes.

Starch-protein compositions have the characteristics of meeting nutritional requirements for farm animals. Hog feed, for example, is recommended to contain 13-24% protein, complemented with starch. If starch-protein plastics were commercialized, used food containers and serviceware collected from fast food restaurants could be pasteurized and turned into animal feed.

Polyesters are now produced from natural resources-like starch and sugars-through large-scale fermentation processes, and used to manufacture water-resistant bottles, eating utensils, and other products.

The widespread use of these new plastics will depend on developing technologies that can be successful in the marketplace. That in turn will partly depend on how strongly society is committed to the concepts of resource conservation, environmental preservation, and sustainable technologies. There are growing signs that people indeed want to live in greater harmony with nature and leave future generations a healthy planet. If so, bioplastics will find a place in the current age of plastics.

5.4.3 Biodiesel

Biodiesel is the name of a clean burning alternative fuel, produced from domestic, renewable resources. Biodiesel is not derived from petroleum sources, but it can be blended at any level with petroleum diesel to create a biodiesel blend. It can be used in compression-ignition (diesel) engines with little or no modifications. Biodiesel is simple to use, biodegradable, nontoxic, and essentially free from sulfur and aromatics.

Biodiesel is made through a chemical process called transesterification whereby the glycerin is separated from the fat or vegetable oil. The process leaves behind two products — methyl esters (the chemical name for biodiesel) and glycerin (a valuable byproduct usually used in soaps and other products. Basic transesterification technology is given in the flowsheet.

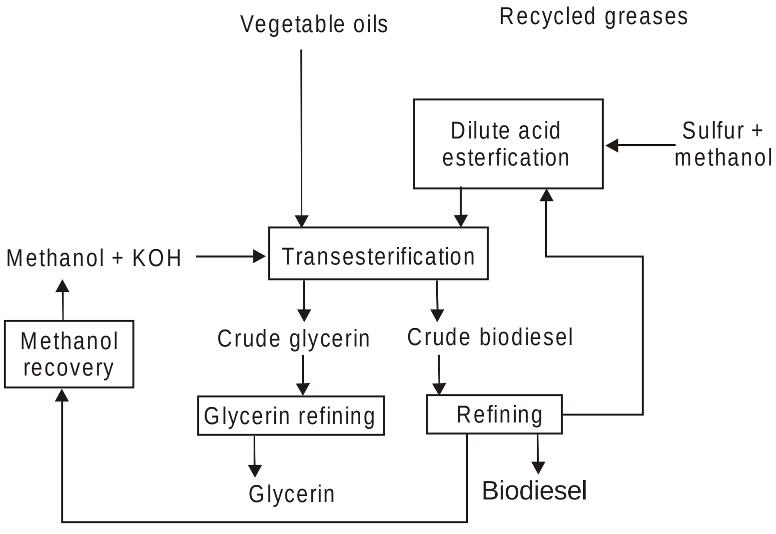


Figure 5.2

Advantages

- Safer to use than petroleum diesel
- It can be made from domestically produced, renewable oilseed crops such as soybeans
- Operates in conventional engines.
- Reduces the amount of harmful substances let into the air.
- Biodegradable
- Does not require special storage.

6

ENVIRONMENT AND DEVELOPMENT

6.1 ENVIRONMENT AND DEVELOPMENT

The very essence of human existence is growth and development and this feature of humanity distinguishes him from all other living species on the earth. Till recently humans existed in small numbers with limited use of technology and hence the environmental impact of his existence was well within the environment's capacity to absorb them. In the last two and a half centuries several events took place, which has created environmental stresses beyond nature's ability to absorb the same. Broadly speaking these events can be summarized as below:

(a) Population Explosion

(b) Industrialization

(c) Urbanization

(d) Growth in energy use

(e) Repeated high tech war fare.

All these events have a negative impact on the environment. The developed nations had huge economic success due to industrialization, which led to high standards of living accompanied by a spending culture or consumerism. Industrialization increased the air, land and water pollution. Industrialization also led to exploitation of cheap labor and resources in less developed nations and the gap between the rich and poor nations increased. New products were developed and mass-produced. Use of synthetic fertilizers and pesticides were on the increase. Synthetic products replaced many of the environmentally friendly materials. Replacement of cotton and wool by synthetic fibers or animal wastes by synthetic fertilizers are good examples. Synthetic products needed more energy to produce and this had a cascading effect on the energy demands. Quantum jump in energy generation led to further pollution leading to a vicious circle.

Urbanization was a natural off shoot of industrialization. Due to the availability of employment opportunities and other infrastructural facilities migration of labor towards cities resulted leading to increase of population densities in relatively smaller land areas. This increased stresses in land use, transportation, sanitation and services. Massive quantities of CO_2, Oxides of sulfur and Nitrogen dust and particulate matter were released into the atmosphere from these cities. Photochemical smog resulting from interaction between the various pollutants and the air became a health hazard.

Urbanization is a global phenomenon, which has affected both the developed as well as developing nations. The problem is acute in our country where one fourth of the city population lives in slums and one third of the population have no safe drinking water.

On the other side developing and underdeveloped countries encountered the stress of unprecedented **population growth**. To meet the increased demands of humanity indiscriminate depletion on natural resources took place at a rate that cannot be sustained without serious environmental impacts. At the current levels of population increase, the world population will double in less than 100 years. To provide the basic requirements like food, water, clothing, shelter and livelihood for all will further stress the existing resources.

In this context it is urgently necessary to balance the twin issues of development and environment so that the current generation hands over the earth to their future generation without any further damage. Hence any development process needs to be innovative in reducing per capita or per unit of production impact on the environment. In other words, the development process should be sustainable.

6.2 SUSTAINABLE DEVELOPMENT

6.2.1 Introduction

Sustainable development is a recent concept that has become important for a wide range of people and industries. It involves maintaining the current rate of development leaving suitable resources behind for later generations to continue to develop. Sustainable development involves the dual issues of environment and society.

The **Brundtland Report** released by the **United Nations** in the 1980s defines sustainable development as **'development, which meets the needs of the present without compromising the ability of future generations to meet their own needs.'**

In order to achieve sustainable development, strategies of resource conservation, energy efficiency and improved transport methods are needed. Changes in attitudes among the public and Government are also a must.

6.2.2 Principles of Sustainable Development

Agenda 21, established at the 1992 **United Nations** Conference on Environment and Development, or **Earth Summit** in Rio de Janeiro, Brazil, is the blueprint for sustainability in the 21st century. Agenda 21 was agreed by many of the world's governments that are monitored by the International Commission on Sustainable Development. This agenda addresses the development of societies and economies by focusing on the conservation and preservation of our environments and natural resources.

The principles outlined in the famous RIO Declaration on Environment and Development is enumerated below:

Principle 1

Human beings are at the center of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.

Principle 2

States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states or of areas beyond the limits of national jurisdiction.

Principle 3

The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.

Principle 4

In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.

Principle 5

All States and all people shall cooperate in the essential task of eradicating poverty as an indispensable requirement for sustainable development, in order to decrease the disparities in standards of living and better meet the needs of the majority of the people of the world.

Principle 6

The special situation and needs of developing countries, particularly the least developed and those most environmentally vulnerable, shall be given special priority. International actions in the field of environment and development should also address the interests and needs of all countries.

Principle 7

States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit to sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.

Principle 8

To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies.

Principle 9

States should cooperate to strengthen endogenous capacity building for sustainable development by improving scientific understanding through exchanges of scientific and technological knowledge, and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies.

Principle 10

Environmental issues are best handled with participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.

Principle 11

States shall enact effective environmental legislation. Environmental standards, management objectives and priorities should reflect the environmental and development context to which they apply. Standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries.

Principle 12

States should cooperate to promote a supportive and open international economic system that would lead to economic growth and sustainable development in all countries, to better address the problems of environmental degradation. Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade. Unilateral actions to deal with environmental challenges outside the jurisdiction of the importing country should be avoided. Environmental measures addressing transboundary or global environmental problems should, as far as possible, be based on an international consensus.

Principle 13

States shall develop national law regarding liability and compensation for the victims of pollution and other environmental damage. States shall also cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction.

Principle 14

States should effectively cooperate to discourage or prevent the relocation and transfer to other States of any activities and substances that cause severe environmental degradation or are found to be harmful to human health.

Principle 15

In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Principle 16

National authorities should endeavor to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.

Principle 17

Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.

Principle 18

States shall immediately notify other States of any natural disasters or other emergencies that are likely to produce sudden harmful effects on the environment of those States. Every effort shall be made by the international community to help States so afflicted.

Principle 19

States shall provide prior and timely notification and relevant information to potentially affected States on activities that may have a significant adverse transboundary environmental effect and shall consult with those States at an early stage and in good faith.

Principle 20

Women have a vital role in environmental management and development. Their full participation is therefore essential to achieve sustainable development.

Principle 21

The creativity, ideals and courage of the youth of the world should be mobilized to forge a global partnership in order to achieve sustainable development and ensure a better future for all.

Principle 22

Indigenous people and their communities and other local communities have a vital role in environmental management and development because of their knowledge and traditional practices. States should recognize and duly support their identity, culture and interests and enable their effective participation in the achievement of sustainable development.

Principle 23

The environment and natural resources of people under oppression, domination and occupation shall be protected.

Principle 24

Warfare is inherently destructive of sustainable development. States shall therefore respect international law providing protection for the environment in times of armed conflict and cooperate in its further development, as necessary.

Principle 25

Peace, development and environmental protection are interdependent and indivisible.

Principle 26

States shall resolve all their environmental disputes peacefully and by appropriate means in accordance with the Charter of the United Nations.

Principle 27

States and people shall cooperate in good faith and in a spirit of partnership in the fulfillment of the principles embodied in this Declaration and in the further development of international law in the field of sustainable development.

Source: Earth Summit Agenda 21, United Nations Conference on Environment and Development.

In a broad sense sustainable development should incorporate (but not limited to) the following features.

- Reduce Population growth.
- Minimize/Avoid dependence on fossil fuels.
- Improve efficiencies of all processes.

- Eliminate poverty in developing nations and moderate consumerism in affluent nations.
- Restore/preserve biodiversity.
- Create legislative mechanisms and governance institutions compatible with global environmental aims.
- Develop individual and collective culture of participating in local, regional and global efforts in maintaining sustainability.

6.2.3 Major Issues Addressed in Sustainable Development

1. Societies and Economies
   - Energy
   - Transport
   - Poverty and health
   - Populations
   - Business and industry
   - Consumption and waste.
2. Conservation and Preservation
   - Atmospheric protection
   - Climate change
   - Ozone depletion.
3. Eco System
   - Agriculture
   - Forestry
   - Biodiversity.
4. Oceans and Fresh Water
   - Fishing
   - Water quality.

(1) Societies and Economies

Energy

Industrialized countries consume more per capita energy than those in the developing world. For example the per capita energy consumption in the UK is 35 times more as compared to the consumption in India. Most of this energy comes from non-renewable sources such as **fossil fuels** (coal, oil and gas). The consumption of fossil fuels are far higher than the rate at which they are generated. Hence these fuels will be unavailable to future generations. In addition, the environmental impacts of energy production from fossil fuels are harmful resulting in generation **greenhouse gases,** which cause **global warming**. Emission of **sulfur dioxide** and **oxides of nitrogen** leads to **acid rain**.

It is imperative that some of these fuels are preserved for the future, and **renewable energy** sources are introduced. Renewable energy sources include solar power, wind power, tidal power and hydroelectric power. These are known as **green fuels** because they generate less pollution and are not likely to be exhausted. Agenda 21 requires countries to increase the proportion of energy from these sources.

Transport

The growth of transport industry has adverse effects on our environment. Current methods of transport are unsustainable. Pollutants emitted from vehicles lead to human health problems, **acid rain** and **global warming** in addition to **noise pollution.** Agenda 21 urges nations to take steps to reduce the rate of traffic growth and to improve the performance and efficiency of road vehicles at the producer and user level. The environmental impacts of road traffic, and the benefits of using public transport should be publicized among users to create awareness.

Poverty and Health

Poverty is an international problem, requiring specific programs to tackle in different countries. Improving educational infrastructure, job opportunities, increasing autonomy of local and community groups to control their resources and providing the poor with access to fresh water, sanitation are some of the methods to overcome poverty. The world's poor should be allowed to create their own wealth rather than simply providing aid at times of crisis. Wealth needs to be distributed equally around the world.

Health and poverty are closely connected. Poor societies are more prone to poor health due to diseases caused by malnutrition or starvation. In developing countries public health suffers from lack of sanitation, polluted drinking water, and lack of timely and quality health care. In western societies affluence related health problems like heart disease and obesity are encountered. Sickness prevention is a more sustainable option than treatment and cure, mainly because of the costs. Agenda 21 promotes reducing the risks to health caused by environmental pollution and hazards.

Population

By the year 2025 the population of the world could exceed eight billion, which is double the population in 1975. Most of this increase will be in the developing world. Such a large population can be sustained only if food resources are properly managed and distributed, and the environmental impacts of food production and housing are minimized. Population growth can be sustained by using sensible planning and suitable modern technology.

Business and Industry

Business and industry have a huge responsibility in achieving worldwide sustainable development. They can reduce impacts on the environment and resources by using more efficient manufacturing processes and minimizing waste. Introduction of systems in which the prices of goods and services partly reflect the environmental costs of their production, use and disposal will be a deterrent against use of environmentally unfriendly products. Less harmful goods would be cheaper than those that cause more environmental damage. Introduction of **Environment tax** on products causing pollution will generate funds for restoring habitats and cleaning up.

Consumption and Waste

The current patterns of consumption are unsustainable. Developed countries consume more resources than countries in the developing world, where basic needs for food, healthcare and education are often not met. Agenda 21 promotes changes in patterns of consumption and production that reduce environmental stress and cater for the basic needs of all humanity. Developed countries are encouraged to help other countries to achieve more sustainable consumption patterns by providing suitable technology. They should also lead by example by using fewer resources and producing less waste.

At the moment, the amount of waste produced in the developed world is not sustainable. For example, 99% of the material used to make goods in the USA becomes waste within 6 weeks of sale, including the goods themselves. Most waste is buried underground in landfill sites. Agenda 21 requires Governments, industry and the public to make efforts to reduce the amount of wastes by recycling, reducing wasteful packaging of products, introducing products that are more environmentally sound.

Agenda 21 covers waste that is hazardous to health or toxic separately. The main aim is to minimize the production of these wastes by changing manufacturing methods. Cleaning up land that's been contaminated by hazardous waste is also a priority.

(2) Conservation and Preservation

Atmospheric Protection

Recently, levels of some greenhouse gases have begun to increase. This occurs as a result of the burning of **fossil fuels**, which release a great deal of carbon dioxide into the air. This will lead to **global climate change** or **global warming**, which could have adverse effects such as rising sea levels and the extinction of plant and animal species that cannot cope with the change. Reducing carbon dioxide emissions is an important part of the United Nations sustainable Development Program.

Ozone Depletion

In the stratosphere, around 25 km above the Earth's surface, there is a layer of ozone that absorbs **ultraviolet** light from the Sun. The ozone layer acts as a protective shield around the Earth Ultra-violet light causes skin cancer in humans, and damages plants. Life on the planet will not be sustainable if the ozone layer is destroyed, since damage caused to plants will severely reduce the global food supply. In the 1970s a hole started appearing in the ozone layer over Antarctica. This was due to the build-up of **chlorofluorocarbons (CFCs)** chemicals used in aerosol sprays, air conditioners and refrigerators. One molecule of CFC can remove up to 100,000 ozone molecules. In the 1987 Montreal Protocol it was agreed that countries would take steps to eliminate CFCs and other substances, which cause ozone depletion. The ozone layer will probably fully repair itself by around 2050 if adequate steps are taken as planned. Agenda 21 suggests that the ozone layer can be viewed as a vital resource for life, and should be protected for sustainable development to be achieved.

(3) Ecosystems

Agriculture

Farming in the near future faces the daunting task of feeding a growing population using sustainable methods. Many current agricultural practices are not sustainable because they damage the soil and other parts of the environment due to the use of increased amounts of fertilizers and large quantities of toxic pesticides. Destruction of **Ecosystems** to provide land for agriculture can cause the widespread extinction of plant and animal species. Loss of the **gene pool** variation in some crop species is yet another problem. The United Nations promotes sustainable agriculture through efficient storage and distribution methods and responsible land management. Techniques for increasing production and conserving soil and water resources need to be applied.

Forestry

Forests are important resources. They provide wood for fuel, building and paper and serve as habitats for a variety of wildlife. Forestry practices can be sustainable if felled trees are replanted and the wildlife is improved. Forests are often not well managed and are threatened by agricultural expansion, commercial logging, forest fires and overgrazing. This can lead to extinction of wildlife species and **soil erosion.** Replanting, conservation and protection from fire, disease and pollution are the strategies for sustainable forestry. Commercial forests should be made up of different tree species–and a layer of smaller plants to promote refuges for wildlife.

Biodiversity

Biodiversity is the total variety of life on Earth. It is range of species at a site, the size of the **gene pool**, or the number of different **ecosystems.** It is important for sustainable development because it represents the wealth of biological resources available to future generations and us. Biodiversity is being reduced by habitat destruction, pollution and the introduction of foreign plants and animals. Reducing habitat destruction and promoting co-operation are the strategies of preserving the biodiversity that exists.

(4) Oceans and Freshwater

Fishing

Fish are the main source of animal protein for about a quarter of the world's population in addition to being a large job provider. The fishing industry has certain negative impacts on the environment. Some fish stocks are being over-exploited and some species (e.g. dolphins and seabirds) are affected by problems caused by fishing such as discarded nets, which trap them under water. Over-fishing affects the **marine ecosystem**. Pollution also has a significant impact on the aquatic environment. One of the policies suggested by Agenda 21 is to reduce the amount of fish caught by each country. This is known as the 'quota.' Licensing fishing boats and banning fishing in parts of the sea which have been over-exploited in the past, should allow fish stocks to recover.

Water Quality

Sustainable development requires suitable supplies of clean water for drinking and cleaning. The main use of fresh water (70-80%) is for irrigation schemes. A great deal of water is lost through evaporation. Hence downstream populations often have very little water, which lead to disputes. Other uses of inland water include hydroelectric schemes industrial and human requirements. Groundwater is also used for similar purposes. When groundwater is over-exploited it is contaminated with saltwater, which makes it unsuitable for use. The river and lake water get polluted, making it harmful to plants, animals and people. The cost of treatment of water is usually much cheaper than the cost of treating disease and illness. This makes water treatment a more sustainable option. Proper sanitation needs a good quality water supply. The Agenda 21 urges that the sustainable use of the world's water resources will be achieved through co-operation between countries that share a source of water, efficient water use, and a reduction in pollution and contamination.

6.2.4 Indices of Sustainable Development

The indicators of sustainable Development are many. These indicators serve as quantifiable tools to assess, monitor and take corrective action in this regard. Some of the useful indicators for different sectors are listed below:

- **Economy:** Employment, inflation, government borrowing and debt
- **Transport:** Car use, number of short journeys, freight traffic
- **Land Use:** Use of derelict land, urban development, green spaces
- **Water Resources:** Demand and Supply of Fresh Water, Rainfall
- **Forestry:** Forest Cover, Tree Health
- **Climate Change:** Global Temperature Changes, Greenhouse Gas Emissions
- **Ozone Layer Depletion:** Measured Ozone Concentrations, CFC Consumption.
- **Acid Deposition:** SO_2 and NO_2 Emissions
- **Air Quality:** Pollutants Emissions, Expenditure on Air Pollution Reduction
- **Fresh Water Quality:** Chemical and Biological pollutants levels, Pollution incidents, Expenditure on sewage treatment)
- **Marine Water Quality:** Oil Spills and Discharges, Contaminants in Fish)
- **Wild Life and Habitats**: Habitat Fragmentation, Animals and Bird Population and Distribution
- **Agriculture:** Productivity, Use of Fertilizers and Pesticides
- **Soil:** Soil Quality, Heavy Metals in soil
- **Waste Generation:** Household and Industrial Waste, Recycling, Landfill Waste
- **Radio activity:** Population Exposure To Radiation, Nuclear Power Station Discharges).

6.3 ENVIRONMENTAL QUALITY OBJECTIVES AND GOALS

Organizations of all kinds (including governments) irrespective of their size and nature of activity are becoming increasingly concerned with the on going damage to the environment and want to demonstrate that the products and services being offered by them are environment friendly. This has become more relevant in the contemporary context of increasingly stringent legislations, developmental policies and the increased environmental awareness among general public.

6.3.1 Environmental Quality Standards

Traditionally the most common approach to environmental pollution control has been the use of standards. A standard is a level of performance that is enforced by law. An emission standard, for example, is the maximum rate of emissions that is legally allowed. The enforcing authorities can punish an organization not complying with the standard. Several types of standards have evolved for dealing with different kinds of situations. Policy making bodies like Governments and Pollution control boards enforced standards like Emission Standard, Ambient Standard, Technology based standard, Performance based standard etc. The major difficulty in the standard based approach was the high cost of monitoring compliance. In addition these standards are looked at as externally enforced rather than internally evolved. Organizations like to rather willfully follow and ensure an internal objective and this gave way to the concept Environmental Quality Objectives and goals. Organizations hence spell out their envisaged levels of performance in this form. These objectives serve as an index for evaluating the environmental performance of organizations both by themselves as well as by the external stakeholders.

6.3.2 Environmental Quality Objectives

An Environmental Quality Objectives (or EQO) is generally a non-enforceable goal, which specifies a target for environmental quality, which, it is envisaged, will be met in a specific environment, such as a river, beach or industrial site. EQOs are generally not a set of regulations. Unlike Environmental Quality Standards EQOs are not usually expressed in quantitative terms and cannot be enforced legally.

From the point of view of the highest governing body in a country viz. the government, the overall environmental policy should be to hand over to the next generation a society in which the major environmental problems currently facing the country have been solved. To work towards this goal, environmental quality objectives and goals are framed which create a transparent and stable framework for environmental programmes and initiatives, and serve to guide such efforts at various levels in society. These objectives and goals are further split into interim objectives and action plans.

A typical list of EQOs of an apex administrative body (viz. Government) can be as under:

(1) Reduce climate impact due to pollution

(2) Clean Air

(3) No Acid Rain (only Natural Acidification)

(4) Protect Ozone Layer

(5) Non Toxic Environment

(6) Total freedom from Nuclear Radiation

(7) No Eutrofication

(8) Pollution free water bodies (Surface, Ground and Marine)

(9) Sustainable forests and agriculture.

Every sector of the society must assume its share of responsibility to implement these goals. Public agencies, organizations, enterprises and individuals must devote more attention to environmental issues and sustainable development. Many small decisions affect the environment, and information, education and evaluation are therefore increasingly necessary. This new framework of objectives is aimed at making it possible to pursue environmental issues dynamically and specify what needs to be done, as well as to raise awareness and monitor progress. Legislation and economic instruments are parallely implemented with voluntary agreements and dialogues between government and industry. The Non Governmental Organizations (NGOs) are important stakeholders in this process.

6.3.3 Environmental System Standards–ISO 14000

EOQs can be evolved for different organizations in their sphere of activity. The evolution of **ISO 14000** series of standards is a step in this direction. These set of standards are evolved by the International Organization for Standardization (ISO) based at Geneva, Switzerland. These standards deal with Environmental Management Systems (EMS) and are voluntary in nature.

The main aim of the ISO 14000 standards is to encourage effective and efficient environmental management. The standard provides the necessary tools for organizations to implement actions for achieving continual improvement in environmental performance. During the Earth Summit in Rio-de-Janeiro in 1992 the basis for these standards was laid. The essential ingredients of the ISO 14000 implementation are

- Management Commitment
- Preliminary Review and Audit
- Framing of Environmental Policy
- Create Organization structure and allocate Resources
- **Set objectives and Targets and establish Review Programmes**
- Prepare Standard Operating Procedures (SOP) manuals
- Train all Concerned.
- Implement SOPs and Document Control
- Carry Out Internal Audits and correct non-conformances
- EMS certification by accredited certifying agencies
- Continuous Improvement by regular monitoring and review of objectives

The critical areas of the standard involving the EQOs are the framing of the environmental policy and setting objectives and targets.

6.3.4 Oroganizational Environmental Policy

This is a written document expressing the management's commitment for environment protection as a business goal. Environmental policy of an organization should incorporate their commitments to:

- Comply with all Regional, National and International Legislations applicable
- Document and monitor environmental impact
- Set quantifiable performance goals with continuous Improvement plan
- Move towards Sustainable development.

Objectives and Targets

The objectives and targets evolved should be consistent with the environmental policy. They should be quantifiable, measurable and achievable with sufficient effort. Unrealistic, vague and non-measurable targets will not be taken seriously for implementation across the organization. Given below are some of the sample parameters for measuring Environmental Performance of a manufacturing organization.

- Yield on product (Output/Input)
- Waste/Emission Generated (Kgs of Waste/Kgs of Product)
- Energy Consumed (KWH/Kg of Product)
- Water Consumption (Cu.M/Kg of Product)
- Compliance to Effluent Discharge standards (Quantity and Concentration)
- Recovery Targets (By Products, Recycle, Reuse)

The organization should identify and prioritize the parameters in specific areas of environmental performance improvement and provide adequate resources in terms of equipment, manpower, technology and funds. Review programmes should be established to monitor progress, resource requirement and utilization and most critically monitor performance level gaps between targeted goals and actuals achieved. Implementation of corrective and preventive actions for closing the performance gaps should be in place. Improvement targets consistent with the technology have to be evolved and implemented.

In order to achieve targeted levels of performance the managements of the organizations should demonstrate commitment to the objectives and goals and should ensure acceptance of the objectives and goals by everyone concerned. This is best done through awareness programmes and involving all in the target setting process. Interest groups like employee associations, unions etc should be taken into confidence to ensure their full cooperation.

6.4 POLICIES ON DEVELOPMENTAL PROJECTS

Many governments all over the world have become increasingly aware of the environmental impacts of development and have put in place policies for stopping further environmental damage due to on going and future developmental projects. These policies are all also aimed at repairing the damage already done to the environment. The term policy means a set of principles and directives that guide the decisions of an organization. Some of the common features of a Developmental Policy include:

- Activities that an organization decides to do, or not do
- Interrelated decisions, and identifying the objectives and tools to achieve them
- A plan of action
- A set of principles and directives that guide the decisions of an organization.

In the environmental context a Government's task is to provide the platform and ensure the implementation of, sound and sustainable environmental management practices. A practicable, consistent and acceptable national policy on environment provides several benefits such as

- Reduced pollution levels and preservation of natural resources
- Healthier human, animal and plant population and decrease in expenditure of resources in dealing with after effects like diseases, environmental emergencies etc.
- Contribution to minimizing/repairing Global Environmental problems like Climate change, Ozone layer Depletion, Acid rain etc.
- Enhanced economic competitiveness of the industry
- Preservation of Bio Diversity
- Move towards Sustainable Development.

6.4.1 The Developmental Policy Cycle

A societal compulsion eventually takes the shape of a public policy. The evolution of policy from a public opinion to a full-fledged, documented governmental policy involves several steps. This can be called as a policy cycle. The problem needs to be identified and debated widely in public. A set of agenda is made followed by policy proposals. In order to get acceptability among the different sections of the society, the proposals are disseminated to all the stakeholders and support is built up. It is now time for the policy to be enacted as a law so that it becomes mandatory for the stakeholders to abide by it. The policy is then implemented under the watchful eyes of the government .The difficulties in implementing the law, impacts of the law including negative fallouts, if any are closely monitored. The results are evaluated and changes and improvements are made and implemented. The policy cycle is pictorially represented in Fig. 6.1.

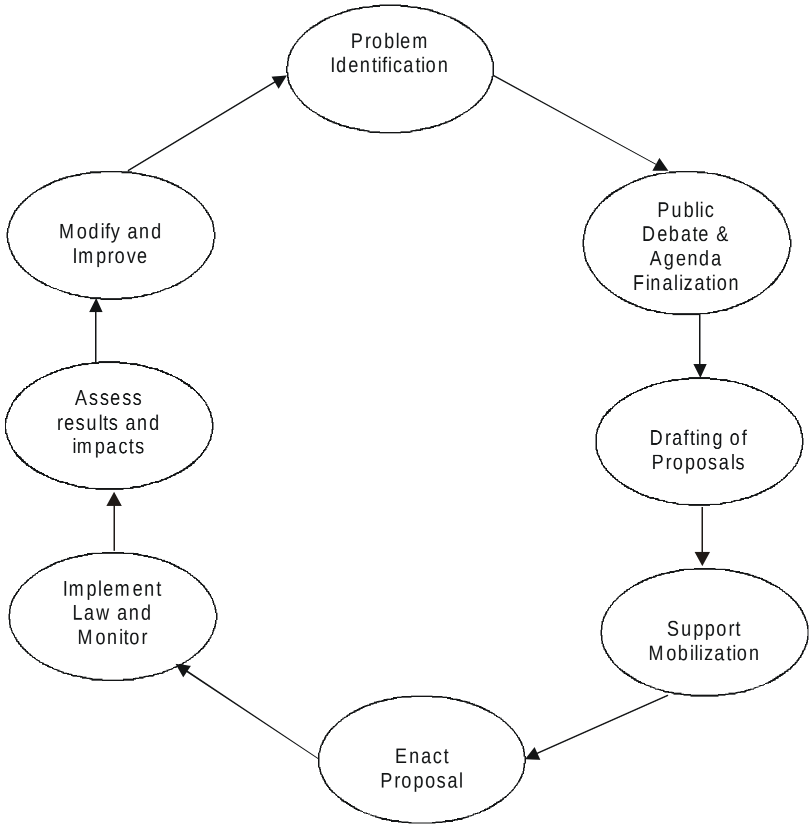


Figure 6.1

6.4.2 Policy Strategies For Developmental Projects

The survival and well-being of the nations depend on sustainable development. It is a process of social and economic betterment that satisfies the needs and values of all interest groups without foreclosing future options. To this end, we must ensure that the demand on the environment from which we derive our resources does not exceed its carrying capacity for the present as well as future generations.

Agenda for Action

- Sustainable and equitable use of resources for meeting the basic needs of the present and future generations without causing damage to the environment.
- Control and prevent future deterioration in land, water and air.
- Locate developmental projects in correct sites so as to minimize their adverse environmental consequences.
- Conserve and nurture the biological diversity and gene pool.

Instruments for Action

- Environmental impact assessment for all development projects starting from the planning stage and combine it with their economic considerations. Environmental safeguards would form an integral part of the projects.
- All projects above a certain size, proposed to be located in ecologically sensitive areas should require compulsory prior environmental clearance.
- Research, development and adoption of environmentally compatible technologies.
- Involvement of people in programmes.
- for environmental improvement.
- Environmental awareness through education and mass contact programmes.
- Moderation of demand triggered by the developmental process.
- Measures to recycle waste materials and natural resources, conserve energy.
- Organizational structures and a professional body of experts to serve as the cadre for environmental management service.
- Implement the various environmental laws and regulations for environmental protection through creation or strengthening of the requisite enforcement machinery.

Priorities for Action

- **Population Control**

  Uncontrolled population growth adds to the economic burden for all developmental activities and also reduces the impact of economic growth. A comprehensive programme for Population control should be implemented. Stern measures such as legislative control and better incentives are needed. The following policy guidelines will be useful in this regard.

  - Increased female education, female employment, and of social security programmes.
  - Easier access to the means of family planning and health care facilities.
  - Additional incentives in terms of taxation and other benefits for family planning.
  - Improved sanitation, prevention and control of communicable diseases.

Conservation of Natural Resources

Atmosphere, Land and Water

For prevention and control of atmospheric pollution the thrust areas identified are as follows:

- Use of clean fuels and clean technologies, energy efficient devices and air and noise pollution control systems.
- Setting up of appropriate air quality standards and time bound plans to prevent and control pollution.
- Correct location of projects to minimize the adverse environmental impact.
- Incentives for use of eco friendly substitutes, technologies and energy conservation.
- Promotion of green belts.
- Develop action plans to cope with future climatic changes due to global warming and ill effects due to ozone depletion and other gaseous pollutants in the atmosphere.

An integrated land and water management is a must. The steps to be taken in this direction should include the following:

- Classification, zoning and apportionment of land for designated uses such as, agriculture, forestry, grassland, green areas, industrial activities, catchment areas and human settlements Laws to protect the soil from erosion, pollution and degradation are to be enacted.
- Social forestry programmes, land use planning, afforestation.
- Restoration and reclamation of degraded areas including weed infested areas, mined areas, grazing lands and salt affected soils.
- Infrastructure for assessment and monitoring of soil and water (surface and ground water) quality.
- Measures for water conservation, recycling and optimal conjunctive use of surface and ground water for specific uses; Check over exploitation.
- Incentives for traditional methods of rainwater harvesting and storage.
- Stringent measures for prevention and control of pollution due to indiscriminate disposal of solid wastes, effluents and hazardous substances in land and water courses by industries and municipalities.

Biodiversity

Action for conservation must include the following steps:

- Inventorisation of biological resources in different parts .The survey should include information on distribution pattern of particular species/population/communities and the status of important groups.
- Conservation of biodiversity through a network of protected areas including Biosphere Reserves, Marine Reserves, National Parks, Sanctuaries, Gene Conservation Centers, Wetlands, Coral Reefs and such other natural habitats of biodiversity.
- Protection and sustainable use of plant and animal genetic resources through appropriate laws and practices.
- Multiply, breed and conserve the threatened and endangered species.

Sectorwise Developmental Policies from Environmental Perspective

The process of development should be integrated with the needs of the environment. For environmental protection and sustainable development, the steps to be taken in some of the key sectors of developmental activities are outlined below:

Agriculture and Irrigation

- Development of sustainable farming, especially organic and natural farming including integrated pest management and nutrient supply system.
- Efficient use of inputs including agro-chemicals with minimal degradation of environment and minimize use of toxic pesticides. Promotion of environmentally compatible cropping practices, bio-fertilizers and biopesticides.
- Restriction on diversion of prime agricultural land for other purposes.
- Cost effective methods of water conservation and use.

- Incentives for cultivation of crops with high nutritive value and those with lesser demands on water and energy inputs.
- Mechanisms to deal with disasters such as drought, flood and climate change.
- Priority to small projects to meet the requirements of irrigation without causing significant alteration in the environmental conditions. Revival of traditional water management systems and development of alternate irrigation systems such as harvesting and conservation of run-off rain water.
- Critical assessment of irrigation projects and delivery systems.

Energy

- Environmental impact assessment and correct choice of project site, adoption of clean technologies.
- Waste utilization, treatment and disposal of solid wastes, effluents and emissions.
- Decentralized small projects for meeting the rural energy needs.
- Incentives for use of non-conventional energy sources and renewable energy sources like bio fuels.
- Incentives and punitive measures (including proper pricing) to prevent abuse and to promote the use of energy efficient devices in the production and distribution systems and for energy conservation in all sectors including households, agriculture, industry, power and transportation.

Industrial Development

- Environmental impact assessment and correct choice of project site, adoption of clean technologies.
- Encourage recycle and reuse of wastes and conservation of natural resources.
- Implementation of 'polluter pays principle' by introducing effluent tax, resource cess for industry and implementation of standards based on resource consumption and production capacity.
- Enforcement of pollution control norms in various types of industrial units.
- Installation and operation of common effluent treatment facilities in industrial estates and in areas with a cluster of industries.
- Introduction of 'Environmental Audit'.
- Public awareness on environmental safety aspects and stringent measures to ensure safety of workers and general population against hazardous substances and processes.
- On-site and off-site emergency plans for hazardous industries.
- Public liability insurance against loss or injury to life or property.

Mining and Quarrying

- Environmental impact assessment prior to selection of sites for mining and quarrying activities.
- Mined area rehabilitation and implementation of the environmental management plans.

- Stipulations for mining leases regarding tenure, size, shape and disposition with reference to geological boundaries and other mining conditions to ensure systematic extraction of minerals along with environmental conservation.
- Reduce indiscriminate extraction.
- Up gradation and beneficiation of minerals at the source, in order to ensure utilization of low-grade mineral resources and to reduce the cost of transportation, processing and utilization.
- Environmentally safe disposal of the by-products of mining.
- Restriction on mining and quarrying activities in sensitive areas.

Tourism

- Promotion of tourism based on careful assessment of the use infrastructural facilities such as transport, fuel, water and sanitation and their impact.
- Development without affecting the lifestyles of local people, and the plants and animals of the spot.
- Restriction on indiscriminate growth of tourism and strict regulation of the tourist activities in sensitive areas such as hill slopes, islands, coastal stretches, National Parks and Sanctuaries.

Transportation

- Improvement in public transport system to reduce consumption of fuel, traffic congestion and pollution.
- Transport system based on bio and other non-polluting energy sources.
- Rail transport and pipeline transport instead of road transport, where ever possible.
- Transportation of hazardous substances through pipelines.
- Proper maintenance of roads, updated traffic regulation and strict enforcement of prescribed standards.
- Enforcement of smoke emission standards for containing vehicular exhausts, at the manufacturer and user level.
- Phasing out the use of lead in motor spirit.
- Regulations for environmental safety in transportation of hazardous substances.

Human Settlements/Urbanization

- Creation of employment opportunities and better facilities like communications, entertainment, healthcare and schooling in rural areas.
- Establishment of secondary cities and towns with requisite infra-structural services.
- Disincentives for industrial and job location in existing urban centers.
- Integrated development of infra-structural facilities such as water supply, sewerage, solid waste disposal, energy recovery systems and transportation.
- Conservation of heritage sites and buildings, through regulations.
- Development of greenery and tree cover and provide gardens, parks and open spaces in the towns and cities for public use and for promotion of environmental consciousness.

- Environmental appraisal of projects related to urban development.
- Educating people on personal hygiene, sanitation and use of potable water.

International Cooperation

It is well documented that developed nations are contributing more to the transboundary and global environmental damage than the developing nations mainly due to high standards of living and consumerism. The responsibility is clearly established and also the need for urgent and effective action, by the developed world, to prevent global disaster. This includes not only direct action, but also indirect measures such as creation of an economic order, which helps developing countries to exert less pressure on their own natural resources. The developed economies can also extend financial assistances and provide technical inputs such as cleaner technology.

7

TOOLS FOR ENVIRONMENTAL MANAGEMENT

7.1 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Environmental Impact Assessment is a widely accepted tool for Environment Management. It is being increasingly adopted in several countries. The aim of EIA is to identify and subsequently predict the impacts of Commercial, Industrial and Legislative proposals, Policies and Operational procedures and interpret and communicate information to all stake holders about these impacts.

7.1.1 Background

Any developmental activity in the form of new project proposals (e.g. setting up of chemical/ petrochemical complexes, Metallurgical plants like Iron and Steel mills, Mining activities, Atomic and Conventional Power Generating stations and research facilities, construction of a dam/railway line, introduction new regulations etc.) is likely to affect Environmental quality and hence calls for the carrying out of an EIA. In many countries EIA has become mandatory before allowing such project activities to start.

In the US the National Environmental Policy Act (NEPA), which came into force in 1970, was the pioneering effort in introducing EIA as a mandatory requirement. Canada inducted this process in 1973. Today EIA is being increasingly adopted in many industrialized countries and developing countries like Australia, Japan, Netherlands, India, etc. In India the Ministry of Environment and Forests (MoEF) has made EIA a statutory requirement in 1994 for 29 specific activities in different sectors like industries, mining, irrigation, power, transport, tourism etc. The details of such projects is listed below.

List of Projects Requiring Environmental Clearance from the Central Government

1. Nuclear Power and related projects such as heavy water plants, nuclear fuel complex, rare earths.
2. River valley projects including hydel power, major irrigation and their combination including flood control.
3. Ports, harbors, airports (except minor ports and harbors).
4. Petroleum Refineries including crude and product pipelines.
5. Chemical fertilizers (nitrogenous and phosphatic other than single super phosphate).

6. Pesticides (technical).
7. Petrochemical complexes (both olefinic and aromatic) and Petro-chemical intermediates such as DMT, Caprolactam, LAB etc. and production of basic plastics such as LLDPE, HDPE, PP, PVC.
8. Bulk drugs and pharmaceuticals.
9. Exploration for oil and gas and their production, transportation and storage.
10. Synthetic rubber.
11. Asbestos and asbestos products.
12. Hydro cyanic acid and its derivatives.
13. (a) Primary metallurgical industries (such as production of Iron and Steel, Aluminium, Copper, Zinc, Lead and Ferro Alloys). (b) Electric arc furnaces (Mini Steel Plants).
14. Chlor alkali industry.
15. Integrated paint complex including manufacture of resins and basic raw materials required in the manufacture of paints.
16. Viscose staple fiber and filament yarn.
17. Storage batteries integrated with manufacture of oxides of lead and lead antimony alloys.
18. All tourism projects between 200–500 meters of high water line and at locations with an elevation of more than 1000 meters with investment of more than Rs. 5 crores.
19. Thermal Power Plants.
20. Mining projects (major minerals) with leases more than 5 hectares.
21. Highway Projects except projects relating to improvement work including widening and strengthening of roads with marginal land acquisition along the existing alignments provided it does not pass through ecologically sensitive areas such as National Parks, Sanctuaries, Tiger Reserves, Reserve Forests.
22. Tarred Roads in the Himalayas and or Forest areas.
23. Distilleries.
24. Raw Skins and Hides.
25. Pulp, paper and newsprint.
26. Dyes.
27. Cement.
28. Foundries.
29. Electroplating.
30. Meta amino phenol.

The EIA process during the initial phases of introduction laid emphasis on the study of the adverse/beneficial impacts of the proposals on physical factors viz. Air, Water quality, Solid waste Disposal. With the passage of time the scope of EIA was widened to include Biological, Ecological and Socio Economic factors.

7.1.2 The EIA Process

The various steps involved in the EIA process is enumerated below:

- Identification and Selection of a competent coordinator for the EIA and the collection of all relevant background information. This is done immediately after a project is identified.
- Broad analysis of the impacts of project activities with a view to focus on issues needing a detailed study.
- Collection of detailed data on the current environmental status of the project site and surroundings (prior to the project implementation) and preparation of the **environmental inventory** describing comprehensively all the components of the environment existing in the area where the proposed project is being considered to be implemented.
- Quantitative Impact evaluation terms including potential mitigation measures. Project alternatives should be kept ready before the impact evaluation.
- Impact Assessment taking into account environmental losses and gains as well as economic costs and benefits for each alternative proposed and preparation of an **Environmental Impact Statement (EIS)** which will be a formatted public document specified by authorized national, state and/or local agencies.
- Public scrutiny of the EIS and review at public hearings.
- Detailed documentation of the work done in the EIA with specific recommendations about the proposed project and alternatives with comments on the environmental and economic impacts of each.
- Decision-making process by the decision maker. The decisions normally fall into any one of the following categories.
  (a) Proposal accepted
  (b) Proposal accepted with amendments
  (c) Alternate proposal accepted
  (d) Proposal is rejected
  (e) Further study of the proposal.
- Follow up and monitoring of the project activities during installation and operation phases and conduct audits to compare actual performance with the EIA predictions and suggest improvement measures.

7.1.3 Stakeholders/Participants of the EIA Process

The different agencies involved in the EIA process are broadly listed below:

Agency	Description
Proposer	Organization/individual (Govt. or private) initiating the project.
Decision making Authority	Designated Govt. agency/Ministry/individual/Head of state.
Assessor	Organization/individual vested with the responsibility of preparing the EIS.
Reviewing Agency	Organization/individual vested with the responsibility of reviewing the EIS and ensuring compliance of regulations.

Other Govt. Agencies	Mainly local governmental bodies like provincial Govt., Municipalities/village administration etc.
Experts	Persons with special knowledge about the project and matters of environment who are required to evaluate the proposal.
Members of the Public/ society/community	Citizens who are affected by the project.
Media	Print/electronic media which reflect and review the opinions of all concerned and report factual happenings.
Special Interest Groups	Governmental and Non-Governmental Organizations, Professional bodies, Labor Unions.

7.1.4 Contents of the EIS

(1) Details of the proposed project/action and alternates including all phases of action (Construction, Operation, Shutdown).

(2) Nature and magnitude of the predicted impacts of the proposed action under the following three categories.

   (a) *Physical*: Air, water and land pollution, natural disasters like flood, earthquakes etc.

   (b) *Biological*: Flora and fauna, biodiversity, endangered species.

   (c) Socioeconomic.

(3) Identification of human concerns.

(4) Measurement criteria of the significance of the predicted environmental changes.

(5) Estimate the significance of the impacts of the environmental changes.

(6) Recommendations about the acceptability or otherwise of the proposed projects and alternates.

(7) Monitoring procedures during and after implementation of the project.

To quantitatively estimate the impacts of different factors the technique of LEOPOLD MATRIX is often used.

7.1.5 Benefits of EIA

- Cost and time saving in project implementation due avoidance of mid course design changes or corrections.
- Increases acceptability of the project among all stakeholders.
- Laws and regulations of the country/society is fully complied and hence no future conflicts.
- Improves project performance by decreased pollutant emissions, effective resource utilization and minimization of treatment and cleanup costs.
- A healthy environment (flora, fauna, biodiversity, clean air, water and land).
- Improved human health.
- Paves way for sustainable development.

7.2 PRECAUTIONARY PRINCIPLE

7.2.1 Background

Scientific and technological research and Innovations can bring great benefits to human beings. However they can also result in unexpected or accidental adverse effects. The society should take adequate precautions about introducing innovations that have potential to affect human health and the environment. For the last several decades "risk analysis'' model was widely adopted for arriving at the negative impacts of new technologies or products. Calculating the mathematical likelihood of their harm to public was used to assess new technologies.

A competing new idea evolved in Europe as an alternate to the risk analysis model .The problem with the risk analysis model (which came out of the world of engineering and which was very popular during the late 70s) is that it was not very reliable in predicting the ecological and health effects of many new technologies. It was very good at measuring impacts of easily quantifiable things but was inadequate in calculating subtler, less quantifiable risks. Whatever that was not quantified was out of the risk analyst's purview and hence in the absence of demonstrated, measurable harms, technologies are simply allowed to go forward.

The Precautionary Principle approach was developed in Germany. The term Precautionary Principle is a translation of the German term ***Vorsorgeprinzip Vorsorge*** that literally means, "fore caring." It means a sense of foresight and preparation, not just "caution."

This Principle can be summarized as follows:

When an activity raises threats of harm to the environment or human health, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. When the health of humans and the environment is at stake, it may not be necessary to wait for scientific certainty to take protective action.

This idea appeared in the preamble of the UN Treaty on Biodiversity.

7.2.2 Reasons for Adopting Precautionary Principle

The adverse l impacts of uncontrolled developmental activities of human beings have accumulated over the years on the earth and beyond. There are several warning signals indicating that human beings and environment are not able to cope with the ill effects of these developments. Some of them are listed below:

1. Chronic diseases and conditions like cancer, asthma, Alzheimer's disease, autism, birth defects, developmental disabilities, diabetes, endometriosis, infertility, multiple sclerosis, and Parkinson's disease are on the increase.
2. Loss of biodiversity, destruction of ecosystems, the depletion of ozone layer, the global warming, climate change etc.

Scientific proof about the origin of all these from a single or group of causes may be difficult to establish since causes and outcomes are multiple. If we wait for a scientific proof it may be too late. Scientific standards for demonstrating cause and effect are very high. For example, there was strong suspicion that smoking was causing lung cancer but by the time it was conclusively proved many smokers had died of lung cancer. But many others had already quit smoking because of the growing evidence that smoking was linked to lung cancer. Despite scientific proof regarding the link between lung cancer and smoking these persons were operating the precautionary principle.

When we have reasonable evidence to believe that an activity, technology, or substance may be harmful, we should act to prevent harm. If we always wait for scientific certainty society will suffer and there can be irreversible damage.

Many of the current legislations are reactive and not proactive. They are aimed at cleaning up pollution and controlling the amount released into the environment rather than preventing the use and production of toxic substances. This is based on the assumption that humans and ecosystems can absorb a certain amount of contamination without being harmed. We are now becoming aware that it is difficult to know levels of safe contamination.

The greatest weakness in most of the policies is that they are based on the expectation that scientific proof is a must about the harm before protective action is taken. This assumption gives the benefit of the doubt to products, technologies, and development projects, even those that are likely to have harmful side effects.

7.2.3 Methods of Implementing the Precautionary Principle

The precautionary principle is an effective and powerful tool since it serves as a guide to making correct decisions in the background of scientific uncertainty about the outcome any new product/service/technology. It cannot be successful if it is used as a last resort alone and results only in bans or moratoriums. The correct methods of implementing the principle will be as under.

- Develop **alternatives** to possible harmful actions, like adopting "clean" technologies that eliminate waste and toxic substances.
- Place the **responsibility of proof** on the agency initiating an activity and not on potential victims of the activity.
- Set and work toward **goals** that protect health and the environment.
- Bring **democracy and transparency** to decisions affecting health and the environment.

The precautionary principle should become the basis for reforming environmental laws and regulations. It can also be applied in industrial practices, science, consumer choices, education, city planning and legal practice.

7.2.4 Arguments Against the Precautionary Principle

It is argued that the precautionary principle poses a stiff challenge to business development in a modern, technological society. If made into a law the precautionary principle would fundamentally shift the responsibility of proof to the initiator of an activity and many new technologies/products will not be allowed to automatically operate. This will increase the cost and time overruns in implementation of any project or introduction of any new product or technology. Scientific uncertainty would no longer argue for freedom of action but for precaution and alternatives.

The precautionary principle is also argued to be "antiscientific" in the sense that scientists and technologists alone have the competence to tell the society about the environmental outcome of any new or current product or technology.

7.2.5 Benefits of the Precautionary Principle

This principle encourages the exploration of better, safer, and in many cases cheaper alternatives and the development of cleaner products and technologies. These practices not only make good ethics but also are also economically favorable in the long run. The future markets will be more and more environmentally conscious and increasingly demand safe products and sustainable technologies. Society and future generations receive more benefits in the form of lower cost and reduced suffering.

7.3 POLLUTER PAYS PRINCIPLE

7.3.1 Background

The Polluter Pays Principle (PPP) implies that those who pollute the environment and destroy its biodiversity should pay the costs of the adverse effects of pollution and loss of biodiversity created by them. The justification behind PPP is that polluters will try to reduce their emissions if they have to pay for them. By making polluters pay, society also generates funds to compensate those affected by the negative effects of pollution. Implementation of Polluter pays Principles hence may result in a cleaner environment improved economic efficiency and better social welfare.

Pollution abatement legislation in many countries provides objectives and establishes the basic principles of environmental management and sustainable development. Such principles set forth the actions required to be taken by both the industry and environmental management authorities. Principles once incorporated in law, provide protection of environmental rights and define individual and collective duties. One such principle is the commonly known "polluter-pays" principle.

The polluter-pays principle is the [legal] requirement that the person responsible for polluting should bear the costs for causing the pollution and consequential costs.

According to this principle the polluters must pay for:

- The cost of pollution abatement
- The cost of environment repair
- The compensation costs for victims of environmental damages.

We tend to waste things that are cheap or under priced. It is hence not surprising that producers of toxic pollution and consumers of products that generate toxic pollution have overused and wasted the free air, water, and land and have converted them into receptacles of pollutants. Industries have to pay for machinery, construction costs, labor, pollution control equipment But they are not billed for the use of the environment viz. rivers, lakes, oceans air and land. To encourage efficient use of resources, the society must adopt the rule that the polluter or user pays for this damage. Whoever causes environmental degradation or resource depletion should bear the full cost.

7.3.2 Implementation Strategies

The Polluters can be made to pay in several ways. Some of the implementation methods of the 'polluter pays principle' are listed below:

- An **emission charge** system for industrial effluents.
- A system of **product taxes** to ensure that the market price of products/services includes costs that they impose on the environment during their production, use and disposal.
- A **deposit/refund system** to ensure the return of products containing toxic materials.
- Manufacturers, distributors and retailers take **direct responsibility** for disposal of products containing toxic materials.

- **Civil liability** of toxic polluters.
- Mandatory **insurance** and/or **security** requirements for polluters.
- A **government purchasing policy** that gives routine preference to products produced with clean technology.
- A review of all **government subsidy programs**, and elimination of non-environmental subsidies for industries that create toxic pollution.

7.3.3 Obstacles/Problems in Implementing the Polluter Pays Principle

- Accurately assessing the economic effects of pollution
- Setting the level of the charge to achieve the desired level of pollution reduction
- Identifying polluters
- Enforcement and control
- Trade and competitiveness issues
- Political acceptability.

7.3.4 Benefits of the Polluter Pays Principle

- Greener environment
- Economic efficiency
- Incentives to reduce pollution.
- Generate funds for green investments or for compensation payments.

7.4 CONSTITUTIONAL PROVISIONS FOR ENVIRONMENTAL MANAGEMENT

The Indian Constitution is amongst the few in the world that contains specific provisions on environmental protection. The directive principles of state policy and the chapters on fundamental duties explicitly enunciate the national commitment to protect and improve the environment. Judicial interpretation has strengthened this constitutional mandate. Table 7.1 gives an overview of the constitutional provisions for environmental management. The following provisions in the constitution of India confers the basic right in every Indian citizen for obtaining a clean environment to live.

Table 1

OVERVIEW OF THE CONSTITUTIONAL PROVISIONS

UNDER PART III – FUNDAMENTAL RIGHTS	
Article 21	Right to Freedom—Protection of life and personal liberty
Article 32	Right to Constitutional Remedies
UNDER PART IV – DIRECTIVE PRINCIPLES OF STATE POLICY	
Article 47	Duty of the State to raise the level of nutrition and the standard of living and to improve public health
UNDER PART IV – DIRECTIVE PRINCIPLES OF STATE POLICY	
Article 48A	Protection and improvement of environment and safeguarding of forests and wild life

UNDER PART IVa – FUNDAMENTAL DUTIES	
Article 45-51A	Fundamental Duties
UNDER PART V – THE UNION CHAPTER IV – THE UNION JUDICIARY	
Article 136	Special leave to appeal by the Supreme Court
UNDER PART VI – THE STATES CHAPTER III—THE STATE LEGISLATURE GENERAL	
Article 172	Duration of State Legislatures
UNDER PART VI – THE STATES	
Article 226	Power of High Courts to issue certain writs

Article 21 of the constitution of India, deals with protection of life and personal liberty "**No person shall be deprived of his life or personal liberty except according to procedure established by Law**". The Supreme Court of India in numerous matters elaborated the scope of Article 21. Example: In the matter of Rural Litigation and Entitlement Kendra Vs State of U.P. the Hon'ble Supreme court held that the right to unpolluted environment and preservation and protection of nature's gifts has also been conceded under Article 21 of the Constitution of India.

Article 32 of the constitution of India provides remedies for enforcement of rights.

(1) The right to move the Supreme Court by appropriate proceedings for the enforcement of the rights conferred by this Part is guaranteed.

(2) The Supreme Court shall have power to issue directions or orders or writs, including writs in the nature of habeas corpus, mandamus, prohibition, quo warrant and certiorari, whichever may be appropriate, for the enforcement of any of the rights.

(3) Without prejudice to the powers conferred on the Supreme Court by clauses (1) and (2), Parliament may by law empower any other court to exercise within the local limits of its jurisdiction all or any of the powers exercisable by the Supreme Court under clause (2).

(4) The right guaranteed by this article shall not be suspended except as otherwise provided for by this Constitution.

This article orders that the central government to direct all educational institutions throughout India to set aside one hour per week for environmental education. This is important to educating the children on the importance of keeping the environment clean.

Under Part IV–Directive Principles of State Policy, **Article 47** deals with Duty of the State to raise the level of nutrition and the standard of living and to improve public health. "The State shall regard the raising of the level of nutrition and the standard of living of its people and the improvement of public health as among its primary duties and, in particular, **the State shall endeavour to bring about prohibition of the consumption except for medicinal purposes of intoxicating drinks and of drugs which are injurious to health**".

Under Part IVa Paricularly, **Article 48-A** of the Constitution deals with the Protection and Improvement of Environment and Safeguarding of Forests and Wildlife–"***The State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country***". Under Part IV–A of the Directive Principles of State Policy, Fundamental Duties have been added under **Article 51–A** by the 42nd Amendment of the Constitution in 1976. Under Article 51–A(g) provides the Fundamental Duties with respect to the environment which includes. "***To protect***

and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures".

Under part V–The Union Chapter IV–The Union Judiciary, Article 136 deals with Special leave to appeal by the Supreme Court

(1) Notwithstanding anything in this Chapter, the Supreme Court may, in its discretion, grant special leave to appeal from any judgment, decree, determination, sentence or order in any cause or matter passed or made by any court or tribunal in the territory of India.

(2) Nothing in clause (1) shall apply to any judgment, determination, sentence or order passed or made by any court or tribunal constituted by or under any law relating to the Armed Forces.

This article gives the Supreme Court a discretionary power to grant special leave to appeal from any judicial order, judgment or decree in the land.

Under Part VI—The States Chapter III—The State Legislature General, **Article 172** deals with Duration Of State Legislatures

The Constitution of India has basic features in respect of the power of judicial review by the Supreme Court. Under Part III of the Constitution, which guarantees fundamental rights to the people and under Part IV, the State is under obligation to implement the Directive Principles. Article 39-A of the Constitution provides "Right of Access to Courts" to the citizens. In exercise of its powers of judicial review, the Court enforces the constitutional and legal rights of the underprivileged by transforming the right to life under Article 21 of the Constitution and by interpretating the Articles 48-A and 51 A (g) of the Constitution. The Hon'ble Supreme Court of India has given a new dimension to the environmental jurisprudence in India with a view to meeting the problems in the environmental field.

7.5 POLLUTION CONTROL BOARDS

7.5.1 The Central Pollution Control Board

The Central Pollution Control Board (CPCB) a statutory organization, was constituted in September, 1974 under the Water (Prevention and Control of Pollution) Act, 1974.

It serves as a source of information and also provides technical services to the Ministry of Environment and Forests based on the provisions of the Environment (Protection) Act, 1986. Principal functions of the CPCB, as spelt out in the Water (Prevention and Control of Pollution) Act, 1974, and the Air (Prevention and Control of Pollution) Act, 1981, are:

(*i*) To promote cleanliness of streams and wells in different areas of the States by prevention, control and abatement of water pollution, and

(*ii*) To improve the quality of air and to prevent, control or abate air pollution in the country.

One of the mandates of CPCB is to collect, collate and disseminate technical and statistical data relating to water, air and land pollution.

7.5.2 Functions of the Central Pollution Control Board

- One em Advise the Central Government on any matter concerning prevention and control of water and air pollution and improvement of the quality of air.

- Plan and cause to be executed a nation-wide programme for the prevention, control or abatement of water and air pollution;
- Co-ordinate the activities of the State Board and resolve disputes among them;
- Provide technical assistance and guidance to the State Boards, carry out and sponsor investigation and research relating to problems of water and air pollution, and for their prevention, control or abatement;
- Plan and organize training of persons engaged in programme on the prevention, control or abatement of water and air pollution;
- Organize through mass media, a comprehensive mass awareness programme on the prevention, control or abatement of water and air pollution;
- Collect, compile and publish technical and statistical data relating to water and air pollution and the measures devised for their effective prevention, control or abatement;
- Prepare manuals, codes and guidelines relating to treatment and disposal of sewage and trade effluents as well as for stack gas cleaning devices, stacks and ducts;
- Disseminate information in respect of matters relating to water and air pollution and their prevention and control.
- Lay down, modify or annul, in consultation with the State Governments concerned, the standards for the quality of air and water.

7.5.3 State Pollution Control Boards

At state level individual pollution control boards have been constituted which has A Chairman nominated by the state government who has special kno wledge and practical experience in respect of matters relating to environmental protection. The board also consists of members representing government, local authorities and members from interest groups representing agriculture, industry, fishery, trade and labour.

7.5.4 Functions of State Boards

The functions of state board include

- To plan a comprehensive programme for the prevention, control or abatement of pollution and to implement the same.
- To advise the State Government on any matter concerning the prevention, control or abatement of pollution.
- To collect and disseminate information relating to pollution.
- To collaborate with the Central Board in organizing training programs and mass education programmes.
- To inspect control equipment, industrial plant or manufacturing process and to issue directions to take steps for the prevention, control or abatement of pollution.
- To inspect air pollution control areas at such intervals to assess the quality of air take steps for the prevention, control or abatement of air pollution.
- To lay down, in consultation with the Central Board, standards for emission of air pollutants from industrial plants and automobiles and for the discharge of any air pollutant into the atmosphere from any other source.

- Advise the State Government with respect to the suitability of any premises or location for carrying on any industry which is likely to cause air pollution.
- Establish or recognize laboratories to perform its functions efficiently.

7.6 LEGAL AND REGULATORY INSTRUMENTS FOR ENVIRONMENTAL PROTECTION

Even before India's independence in 1947, several environmental legislations existed but the real impetus for bringing about a well-developed framework came only after the UN Conference on the Human Environment (Stockholm, 1972). Under the influence of this declaration, the National Council for Environmental Policy and Planning in the Department of Science and Technology was set up in 1972. This Council later evolved into a full-fledged Ministry of Environment and Forests (MoEF) in 1985 which today is the apex administrative body in the country for regulating and ensuring environmental protection. After the Stockholm Conference, constitutional sanction was given to environmental concerns through the 42nd Amendment, which incorporated them into the Directive Principles of State Policy and Fundamental Rights and Duties.

Since the 1970s an extensive network of environmental legislation has grown in the country. The MoEF and the pollution control boards together form the regulatory and administrative core of the environmental sector. A policy framework has also been developed to complement the legislative provisions.

Some of the major environmental enactments which have been passed by the Parliament are as follows:

- The Wildlife (Protection) Act, 1972, Amendment 1991.
- The Water (Prevention and Control of Pollution) Act, 1974.
- The Water(Prevention and Control of Pollution) Cess Act, 1977.
- The Forest (Conservation) Act, 1980.
- The Air (Prevention and Control of Pollution) Act, 1981.
- The Environment (Protection) Act, 1986.
- The Public Liability Insurance Act, 1991.
- The National Environment Tribunal Act, 1995.
- The National Environment Appellate Authority Act, 1997.

In addition to these Acts, several Rules have also been incorporated under the Environment (Protection) Act, 1986. These Acts and Rules are important guidelines to sort out the environmental problems. Some of the major Rules notified are:

- The Manufacture, Use, Import, Export and Storage of Hazardous Micro-Organism Genetically Engineered or Cells Rules, 1989.
- The Hazardous Wastes (Management and Handling) Rules, 1989.
- The Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989.
- The Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996.
- The Bio-Medical Waste (Management and Handling) Rules, 1998.

- The Recycled Plastics Manufacture and Usage Rules, 1999.
- The Municipal Solid Wastes (Management and Handling) Rules, 2000.
- The Noise Pollution (Regulation and Control) Rules, 2000.
- The Ozone Depleting Substances (Regulation) Rules, 2000.
- The Batteries (Management and Handling) Rules, 2001.

Other measures have also been taken by the government to protect and preserve the environment. Several sector-specific policies have evolved.

Water (Prevention and Control of Pollution) Act, 1974

This Act represents India's first attempt to comprehensively deal with environmental issues. The Act prohibits the discharge of pollutants into water bodies beyond a given standard, and lays down penalties for non-compliance. The Act was amended in 1988 to conform closely to the provisions of the EPA, 1986. It set up the CPCB (Central Pollution Control Board), which lays down standards for the prevention and control of water pollution. At the State level, the SPCBs (State Pollution Control Board) function under the direction of the CPCB and the state government.

Water (Prevention and Control of Pollution) Cess Act, 1977

This Act provides for a levy and collection of a cess on water consumed by industries and local authorities. It aims at augmenting the resources of the central and state boards for prevention and control of water pollution. Following this Act, The Water (Prevention and Control of Pollution) Cess Rules were formulated in 1978.

Air (Prevention and Control of Pollution) Act, 1981

To counter the problems associated with air pollution, ambient air quality standards were established, under the 1981 Act. The Act provides means for the control and abatement of air pollution. The Act seeks to combat air pollution by prohibiting the use of polluting fuels and substances, as well as by regulating appliances that give rise to air pollution. Under the Act establishing or operating of any industrial plant in the pollution control area requires consent from state boards. The boards are also expected to test the air in air pollution control areas, inspect pollution control equipment, and manufacturing processes.

National Ambient Air Quality Standards (NAAQS) for major pollutants were notified by the CPCB in April 1994. These are deemed to be levels of air quality necessary with an adequate margin of safety, to protect public health, vegetation and property. The NAAQS prescribe specific standards for industrial, residential, rural and other sensitive areas. Industry-specific emission standards have also been developed for iron and steel plants, cement plants, fertilizer plants, oil refineries and the aluminium industry. The ambient quality standards prescribed in India are similar to those prevailing in many developed and developing countries.

To empower the central and state pollution boards to meet grave emergencies, the Air (Prevention and Control of Pollution) Amendment Act, 1987, was enacted. The boards were authorized to take immediate measures to tackle such emergencies and recover the expenses incurred from the offenders. The power to cancel consent for non-fulfillment of the conditions prescribed has also been emphasized in the Air Act Amendment.

The Air (Prevention and Control of Pollution) Rules

The Air (Prevention and Control of Pollution) Rules formulated in 1982, defined the procedures for conducting meetings of the boards, the powers of the presiding officers, decision-making, the quorum; manner in which the records of the meeting were to be set etc. They also prescribed the manner and the purpose of seeking assistance from specialists and the fee to be paid to them.

Complementing the above Acts is the **Atomic Energy Act of 1982**, which was introduced to deal with radioactive waste. In 1988, **the Motor Vehicles Act**, was enacted to regulate vehicular traffic, besides ensuring proper packaging, labeling and transportation of the hazardous wastes. Various aspects of vehicular pollution have also been notified under the EPA of 1986. Mass emission standards were notified in 1990, which were made more stringent in 1996. In 2000 these standards were revised yet again and for the first time separate obligations for vehicle owners, manufacturers and enforcing agencies were stipulated. In addition, fairly stringent **Euro I and II emission norms** were notified by the Supreme Court on April 29, 1999 for the city of Delhi. The notification made it mandatory for car manufacturers to conform to the Euro I and Euro II norms by May 1999 and April 2000, respectively, for new non-commercial vehicle sold in Delhi.

The Wildlife (Protection) Act, 1972, Amendment 1991

The WPA (Wildlife Protection Act), 1972, provides for protection to listed species of flora and fauna and establishes a network of ecologically-important protected areas. The WPA empowers the central and state governments to declare any area a wildlife sanctuary, national park or closed area. There is a blanket ban on carrying out any industrial activity inside these protected areas. It provides for authorities to administer and implement the Act; regulate the hunting of wild animals; protect specified plants, sanctuaries, national parks and closed areas; restrict trade or commerce in wild animals or animal articles; and miscellaneous matters. The Act prohibits hunting of animals except with permission of authorized officer when an animal has become dangerous to human life or property or so disabled or diseased as to be beyond recovery (WWF-India, 1999). The near-total prohibition on hunting was made more effective by the Amendment Act of 1991.

The Forest (Conservation) Act, 1980

This Act was adopted to protect and conserve forests. The Act restricts the powers of the state in respect of de-reservation of forests and use of forestland for non-forest purposes (the term 'non-forest purpose' includes clearing any forestland for cultivation of cash crops, plantation crops, horticulture or any purpose other than re-afforestation).

Environment (Protection) Act, 1986 (EPA)

This Act is an umbrella legislation designed to provide a framework for the co-ordination of central and state authorities established under the Water (Prevention and Control) Act, 1974 and Air (Prevention and Control) Act, 1981. Under this Act, the central government is empowered to take measures necessary to protect and improve the quality of the environment by setting standards for emissions and discharges; regulating the location of industries; management of hazardous wastes, and protection of public health and welfare. From time to time the central government issues notifications under the EPA for the protection of ecologically sensitive areas or issues guidelines for matters under the EPA.

Some of the important notifications issued under this Act are:

- **Doon Valley Notification** (1989), which prohibits the setting up of an industry in which the daily consumption of coal/fuel is more than 24 MT (million tonnes) per day in the Doon Valley.
- **Coastal Regulation Zone Notification** (1991), which regulates activities along coastal stretches. As per this notification, dumping ash or any other waste in the CRZ is prohibited. The thermal power plants (only foreshore facilities for transport of raw materials, facilities for intake of cooling water and outfall for discharge of treated waste water/cooling water) require clearance from the MoEF.
- **The Environmental Impact Assessment** of Development Projects Notification, (1994 and as amended in 1997). As per this notification: (Also refer chapter 7.1)
- **Ash Content Notification** (1997), required the use of beneficiated coal with ash content not exceeding 34% with effect from June 2001. This applies to all thermal plants located beyond one thousand kilometers from the pithead and any thermal plant located in an urban area or, sensitive area irrespective of the distance from the pithead except any pithead power plant.
- **Taj Trapezium Notification** (1998), provided that no power plant could be set up within the geographical limit of the Taj Trapezium assigned by the Taj Trapezium Zone Pollution (Prevention and Control) Authority.
- **Disposal of Fly Ash Notification** (1999) the main objective of which is to conserve the topsoil, protect the environment and prevent the dumping and disposal of fly ash discharged from lignite-based power plants. The salient feature of this notification is that no person within a radius of 50 km from a coal-or lignite-based power plant shall manufacture clay bricks or tiles without mixing at least 25% of ash with soil on a weight-to-weight basis.
- **Rules for the Manufacture, Use, Import, Export and Storage of Hazardous Micro-organisms/Genetically Engineered Organisms or Cell** were introduced in 1989 with the view to protect the environment, nature and health in connection with gene technology and microorganisms, under the Environmental Protection Act, 1986. The government in 1991 further decided to institute a national label scheme for environmentally friendly products called the 'ECOMARK'. The scheme attempts to provide incentives to manufactures and importers to reduce adverse environmental impacts, reward genuine initiatives by companies, and improve the quality of the environment and sustainability of available resources. Besides the above attempts, notifications pertaining to Recycled Plastics Manufacture and Usage Rules, 1999 were also incorporated under the Environment (Protection) Act of 1986.

The Environment (Protection) Rules, 1986

These rules lay down the procedures for setting standards of emission or discharge of environmental pollutants. The Rules prescribe the parameters for the Central Government, under which it can issue orders of prohibition and restrictions on the location and operation of industries in different areas. The Rules lay down the procedure for taking samples, serving notice, submitting samples for analysis and laboratory reports. The functions of the laboratories are also described under the Rules along with the qualifications of the concerned analysts.

The National Environment Appellate Authority Act, 1997

This Act provided for the establishment of a National Environment Appellate Authority to hear appeals with respect to restriction of areas in which any industry operation or process or class of industries, operations or processes could not carry out or would be allowed to carry out subject to certain safeguards under the Environment (Protection) Act, 1986.

In addition to these, various Acts specific to the coal sector have been enacted. The first attempts in this direction can be traced back to the Mines Act, 1952, which promoted health and safety standards in coalmines. Later the Coal Mines (Conservation and Development) Act (1974) came up for conservation of coal during mining operations. For conservation and development of oil and natural gas resources a similar legislation was enacted in 1959.

Legislation for Hazardous Wastes

There are several legislations that directly or indirectly deal with hazardous waste. The relevant legislations are the Factories Act, 1948, the Public Liability Insurance Act, 1991, the National Environment Tribunal Act, 1995. Under the EPA 1986, the MoEF has issued several notifications to tackle the problem of hazardous waste. These include:

- **Hazardous Wastes (Management and Handling) Rules**, 1989, which brought out a guide for manufacture, storage and import of hazardous chemicals and for management of hazardous wastes.
- **Biomedical Waste (Management and Handling) Rules**, 1998, were formulated along parallel lines, for proper disposal, segregation, transport etc. of infectious wastes.
- **Municipal Wastes (Management and Handling) Rules**, 2000, whose aim was to enable municipalities to dispose municipal solid waste in a scientific manner.
- **Hazardous Wastes (Management and Handling) Amendment Rules, 2000**, a recent notification issued with the view to providing guidelines for the import and export of hazardous waste in the country.

Factories Act, 1948 and its Amendment in 1987

The Factories Act, 1948 was a post-independence statute that explicitly showed concern for the environment. The primary aim of the 1948 Act has been to ensure the welfare of workers not only in their working conditions in the factories but also their employment benefits. While ensuring the safety and health of the workers, the Act contributes to environmental protection. The Act contains a comprehensive list of 29 categories of industries involving hazardous processes.

Public Liability Insurance Act (PLIA), 1991

The Act covers accidents involving hazardous substances and insurance coverage for these. Where death or injury results from an accident, this Act makes the owner liable to provide relief as is specified in the Schedule of the Act. The PLIA was amended in 1992, and the Central Government was authorized to establish the Environmental Relief Fund, for making relief payments.

National Environment Tribunal Act, 1995

The Act provided strict liability for damages arising out of any accident occurring while handling any hazardous substance and for the establishment of a National Environment Tribunal for effective and expeditious disposal of cases arising from such accident, with a view to give relief and compensation for damages to persons, property and the environment.

7.7 THE PUBLIC INTEREST LITIGATIONS (PIL)

The Public Interest Litigations (PIL) in India initiated by the Hon'ble Supreme Court emerged through human rights jurisprudence and environmental jurisprudence. PIL in Indian Law has been introduced by the Hon'ble judges. The traditional concept of Locus Standi is no longer a bar for the community oriented Public Interest Litigations. Though not an aggrieved party, environmentally conscious individuals, groups or NGOs may have access to the Supreme Court/ High Courts by way of PIL. The Hon'ble Supreme Court while taking cognizance on the petitions has further relaxed the requirement of a formal writ to seek redressal before the Court. Any citizen can invoke the jurisdiction of the Court, especially in human rights and environmental matters even by writing a simple postcard.

The Courts have to interpret the Constitution keeping in view the needs of the present generation. Some of the leading public interest litigations in the environmental area are Taj Mahal case.

Hazardous industries matter in Delhi, Vellore Citizen's Welfare Forum case and Rural litigation and Entitlement Kendra case relating to lime stone queries in Dehradun.

7.8 ECONOMIC INSTRUMENTS FOR ENVIRONMENTAL MANAGEMENT

Environmental economic instruments (e.g. packaging taxes, CO_2/energy taxes, road user charges, eco-labels) are a market mechanism in contrast to regulatory instruments, which work by command and control and have no element of market choice. The current move away from command and control to more market-based approaches is generally supported by industry, provided the measures respect certain criteria. The term "economic instruments" will be used to identify all instruments which, by means of affecting price structures, impact positively upon the environment. The term "economic instruments" thus also includes subsidies, grants, and tax allowances that have a positive environmental impact.

- OECD's (Organization for Economic Co-operation and Development) definition on this is as follows:

  'Those policy instruments which may influence environmental outcomes by changing the cost and benefits of alternative actions open to economic agents. They aim to do so by making the environmentally preferred action financially more attractive.'

- The main accomplishments from applying economic instruments are illustrated in Table 7.1.

Table 7.1

Incorporates the cost of environmental services, and pollution directly into the costs of goods, services and activities
Economic efficiency
Provides incentives for consumers and producers to change their behavior.
Stimulates innovation
Tackles environmental priorities from 'diffuse' pollution sources.
Raises revenues for, among other things, environmental expenditures.

- The basic rationale behind economic instruments is to improve the state of the environment through a voluntary participation of rational, economic agents.
- Economic instruments take their effect through the impact that they have on price structures.
  - An environmental levy on a specific item (such as an article or a service) increases the relative price of that item. Rational and economic agents (consumers and/or producers) will, as a consequence, reduce their demand of this item, as it has become relatively more expensive.
  - Furthermore, the argument is to internalize economic externalities, and in this sense, increase the overall economic efficiency. The levy would ideally reflect costs that are not internalized. This would, in particular, include the costs to society of the environmental and health effects in question.
  - The price, including the levy, would thereby be a more correct reflection of the total costs of the production and/or use of the item in question.

7.8.1 Categorization of Economical Instruments

Taxes are compulsory unrequited payments to the government. The specific benefits provided by government are normally not related to the specific payments of the taxpayers.

Charges are compulsory requited payments. These are proportionally related to the services provided. Charges can also be paid into specific funds and earmarked for specific environmental purposes, without necessarily having a direct proportionality to the service rendered.

In addition, there exist a number of other economic instruments used in environmental protection: deposit-refund systems, subsidies, and enforcement incentives together with market creating instruments. Table 7.2 provides an overview of the various categories of instruments and of the specific types within each category.

Table 7.2

Charges/Taxes	**Subsidies**	**Deposit-refund systems**	**Market creation**	**Enforcement incentives**
Product taxes and charges	Grants	Reusable items	Emission Trading	Non-compliance fees
Tax differentiation	Soft Loans	Disposals	Market intervention	Performance bonds
Effluent taxes and charges	Tax Allowances		Liability Insurance	
User fees				
Administrative charges				

Product Taxes and Charges

The purpose of product taxes and charges is to impose a levy on products that cause environmental damage through their extraction, production, use, or disposal. Typically, companies that trade or produce goods must keep accounts of their production, sales, and purchase, e.g. for VAT collection purposes. Thus, the collection and enforcement of product taxes may be directly related to such already existing registers and procedures.

While this substantially eases the calculation and collection procedures, the environmental effects may be more difficult to foresee. This is, because product taxes and charges typically only have an indirect relation to the emissions, as opposed to effluent charges that are more directly related to the actual emissions. As a consequence, it may also be argued that emission charges, in many cases, provide a much stronger incentive to reduce emissions.

Tax Differentiation

Tax differentiation aims to stimulate the use of less harmful substitute products or inputs at the expense of more harmful products or inputs. Differentiated taxes on vehicle fuels thus are widely applied to stimulate, for example, the use of low-sulphur diesel, and the use of unleaded petrol and/or petrol with low contents of benzene.

Effluent charges/taxes

Effluent charges and taxes are based on the quantity and/or quality of discharged pollutants. Ideally, their level would reflect the costs to society of the discharge in question. For all practical purposes, the level is, however, established more pragmatically, because the costs to society are extremely difficult to assess. This difficulty includes, i.e. the uncertainties or lack of knowledge on current and/or future effects from the discharges; and the lack of complete knowledge on available technologies to reduce discharges. Consequently, effluent charges are mainly applied vis-à-vis sectors where the number of factors are limited, and where there is fairly good knowledge on the mentioned relations.

User fees

User fees are payments for specific environmental services, such as waste disposal or sewage treatment. The intention is that payments for such services will reflect the costs of providing the service. User fees include the costs of complying with the environmental requirements imposed on the plants. The size of the user fees should not exceed the full cost recovery. User fee levels are, among other things, determined by the environmental requirements imposed on the plants providing the service in question. User fees are typically calculated and collected by the units that own and operate the plants in question.

Administrative Taxes

Administrative taxes are payments for authority services that are associated with the administration of related environmental regulation. Administrative taxes can, in a sense, be considered as a user fee.

Subsidies

Subsidies provide the opportunity for financial assistance to motivate individuals or enterprises to act more environmental-friendly per se. Subsidies may also be used to reduce compliance costs in relation to specific environmental regulations. Subsidies may be in terms of **grants, soft loans,** or **tax allowances**. Subsidies may be financed through the general budget, or through earmarked revenues.

Earmarked revenues

Earmarked revenues may constitute the financing source for specific subsidy schemes. Thus, revenues collected from one specific or from several charges may be re-allocated for specific environmental purposes. This subsequent use may relate directly to the source of the revenue, or it may relate to any environmental purpose. While it is argued that the economic rationale for such schemes is weak, they may nevertheless play an important role in enhancing the acceptability of the taxes and charges in question, and in providing funds for the environmental expenditures.

The latter argument is particularly justified in cases where public financial resources are very scarce. In these cases, suitably designed environmental funds can be effective mechanisms for channeling earmarked revenues to help tackle serious environmental problems. By the standard of market economies though, the continued use of subsidies and the reliance on earmarked funds is a second-best solution. Earmarking sets aside economic resources outside the general process of financial and economic policy, thereby, reducing the economic resources available for other necessary expenditures. There is also a danger that over the longer term, resources may be channeled to problems that are no longer high priority. Further, the level of public services financed through earmarking may have to adjust to changes in revenue, rather than to changes in demand and needs.

Impacts from other Subsidies

Subsidies that are applied for other reasons than environmental may also have an effect on the environment. For example, subsidies may aim to enhance the mobility of the work force, in terms of, e.g. tax allowances for cost of transportation to and from the workplace. Subsidies are also provided to agriculture through the EU, in order to support the competitiveness of European agriculture. Although such subsidies have been implemented for other reasons, their effect on environment may be negative. In other words, these subsidies may be counterproductive to the effects from using economic instruments in environmental protection, as for example, in terms of providing an incentive to intensive agriculture production. While this illustrates the importance of applying a highly integrated approach in assessing economic instruments in environmental protection, such instruments are nevertheless considered to be beyond the scope of the present report, and therefore will not be considered.

Deposit-Refund Systems

Reusable items and Disposals: This measure adds a surcharge to the price of a product. The surcharge is refunded when the product, its residual, or packaging is returned to a collection system instead of conventional disposal. A distinction can be made between reusable items and items for disposal. The former has a value to the producer, whereas the latter has no value. The latter types thus call for public intervention to promote the establishment of deposit-refund systems.

Market Creation

Market creation renders it easier to control the overall levels of pollution, assuming, among other things, well-functioning financial markets.

Enforcement Incentives

Enforcement incentives are actually at the border between administrative regulations and economic instruments. Enforcement incentives provide an economic incentive for compliance. They are particularly relevant in cases where non-compliance or postponement is an immediate alternative. Non-compliance fees are the most used instruments in this category.

7.8.2 Overcoming the Limitations to Economic Instruments

Each type of economic instrument has its own limitations. They can be difficult to design in some cases, and may engender political opposition from stakeholders concerned about pricing hitherto free environmental resources or, from the other perspective, about establishing a "license to pollute."

Without regulatory baselines, some types of economic instruments will not provide a sufficiently predictable response to be acceptable as the primary mechanism for managing certain risks.

In many cases, however, the barriers are not significantly different from those that confront the use of other policy instruments.

Lack of Awareness

Many barriers to the use of economic instruments relate to lack of awareness and institutional inertia. Efforts to overcome these barriers includes the Initiatives by academics, environmental agencies and various NGOs to raise awareness of the overall importance of correcting market signals as well as awareness-raising efforts to ensure support for a particular instrument.

Resistance to "New Taxes"

One of the main barriers to the introduction of economic instruments has been opposition to "new taxes." To overcome this:

1. Any new economic instrument must be clearly defined and well-understood.
2. Another approach has been to introduce environmental taxes in stages and to incorporate temporary relief packages.
3. Utilizing rebates to overcome anti-tax resistance and concerns about competitiveness.

Competitiveness Concerns

Concerns about the effects of economic instruments on the competitiveness of exporting industries are particularly significant for an open economy nations.

7.9 ROLE OF NON-GOVERNMENT ORGANISATIONS (NGOS) IN ENVIRONMENTAL MANAGEMENT

7.9.1 Background and Definition

The organizations, which do not represent the government, are one of the nation's greatest resources for developing and implementing environmental laws and policies. In fact, some of the tasks for social renewal and progress have had to be performed by NGOs (Non-Governmental Organizations).

In many countries, NGOs were established in the early seventies. The adverse effects of a seemingly unlimited economic growth which started after World War II led to polluted air and water, acid rain, and dying forests. The concern caused by these phenomena was the reason why a new social movement called the Environmental Movement arose. This resulted in many initiatives by citizens. Local residents began to organize and oppose some activities like the construction of a highway, an industrial site, a runway, pollution of a river or the disruption of a nature reserve. As all these initiatives were addressed to the government, it soon became apparent that actions would be more successful when properly coordinated than when started individually. A group can achieve more and collect more data so as to be well prepared when confronting the opposition. In this way a lot of new organizations were founded which can be classified under the name NGO. All those citizen initiatives made the environmental problem in to a political problem. It appeared on the political agenda of the respective governments and the NGOs gained power and influence and became an important political factor

In this context an NGO can be defined as:

(1) A group of citizens organizing grassroots activities to oppose a proposed government/ private project which is expected to have an adverse impact on the environment.

(2) An association of scientific experts providing the government with neutral non-partisan advice on a topic related to control and prevention of Pollution and safeguarding of Environment

(3) A coalition of industry, communicating their companies' view to the government.

7.9.2 Categories of NGOs

As far as the conservation of nature and environmental protection are concerned, the NGOs range from groups with a vague and loose structure to ultramodern, organized institutes with national and international branches. There are also several possible strategies of working. On the basis of these strategies NGOs can be roughly distinguished into three categories:

1. Groups and organizations that mainly engage in propagating and helping in the process of implementing the environmental policy of the governments. Through different activities, they try to influence official policy and, if necessary, to alter it. These groups represent a direct form of public participation.
2. Groups and organizations that mainly engage in information and educational activities. They pursue broad-based public awareness activities and a change in mentality with regard to nature and the environment. They influence the political decision making process and the official policy in an indirect way.
3. Groups and organizations applying themselves to an environmentally aware and ecologically sound way of life. By setting an example they try to convince others and pursue a change in the collective mentality.

7.9.3 Important Roles of NGOs

In rural areas, these NGOs have often complemented the **work of government** agencies– filling in the gaps where necessary.

In other cases, they have helped **monitor** (and hence improve) the functioning of local government bodies.

They have also played a part in the **rehabilitation** of victims of natural disasters or communal riots.

They have also succeeded in raising **public awareness and consciousness** on issues where no one else was paying any attention by taking up neglected or unpopular causes. Such NGOs have played a vanguard role in championing the necessity of clean air and water. It is largely due to the work of such dedicated NGOs that the Supreme Court has passed new injunctions against air and water pollution, banned smoking in public places, or correctly brought attention to violations of urban noise ordinances.

In recent times, some useful and interesting work has been performed by NGOs fighting to make public records more readily accessible, and make public undertakings (such as those responsible for electricity, water supply and municipal works) more transparent in their functioning, and more responsible to the public interest.

Some of these NGOs have won important legal victories through effectively framed **Public Interest Litigations** (PILs). To this extent, public support and backing for such NGOs is essential to ensure that the legal gains translate into real changes in society. Only when the work of such NGOs begins to have a widespread impact–affecting political parties, administrative agencies and public and private corporations will their work translate into real and effective victories. It is important that the good work done by small groups of valiant individuals not go waste.

Enactment of statutes on Pollution Control and the experience gained in implementation of the various provisions of these Acts in the past more than two decades had indicated that Govt. machinery alone couldn't effectively cope-up with the task of pollution control until supported by the masses. The need for participation of masses in achieving the targets committed in the Policy Statements for Abatement of Pollution has been felt strongly. Public interest litigations have successfully demonstrated that responsible and concerned NGOs and public spirited individuals can bring about significant pressure on polluting industries for adopting pollution control measures.

NGO being one of the most effective media to reach the people these days may play a significant role in this regard. NGOs are assisting the State Pollution Control Boards to a greater extent in providing first hand information and generating mass awareness with regard to control of pollution and can better function in this field in the following ways:

- By conducting preliminary river surveys and survey in air pollution control area for identification of any pollution source.
- By keeping vigil on withdrawal of water/discharge of sewage or trade effluent by any industry.
- By conducting sampling and analysis of river/well water to ascertain the quality of river/well water.
- By providing information regarding poisonous, noxious or polluting matter in any stream or well or on land or in air.
- By keeping vigil in the surrounding area, river, well, land and air against pollution and reporting to State Board/Central Board.
- By providing information whether any river stretch requires prohibition on use for disposal of polluting matters.
- By providing information regarding violation of consent such as discharges in odd hours etc.
- By providing information on fish kill or other sudden damage to the environment not noticed by the State Board.

7.9.4 NGOs–An Indian Perspective

The NGOs have achieved several important victories for the people of India. Their work has been of crucial importance in the past. Few of the non-government organizations working for betterment of environment in India are as follows:

- Bombay Environmental Action Group (BEAG), Mumbai
- Centre for Environment Education (CEE), Ahmedabad
- Centre for Himalayan Environment and Development, Chamoli
- Centre for Science and Environment (CSE), New Delhi

- Environment Society of India, Chandigarh
- Environmental Resources Research Centre (ERRC), Thiruvananthapuram
- Environmental Society of Tirupati
- Green Ray Foundation, Panaji Indian Environmental Society (IES), New Delhi
- Indian Society for Nature Volunteer, Sonepat
- Jammu & Kashmir Environment and Wasteland Development Society, Jammu
- Nilgiri Wildlife and Environment Association, Otacamand
- Orissa Environmental Society (OES), Bhubaneshwar
- Rajasthan Environment Preservation Society, Jaipur
- Research in Environment, Education and Development Society (REEDS), Hyderabad
- Sheratgarh Environmental Society (SES), Shehratgarh,
- Society for Conservation of Forest and Wildlife, Pune
- Society for Promotion of Wastelands Development (SPWD) New Delhi

7.9.5 International NGOs

Few of the International Non-governmental organizations are as follows :

- Center for International Environmental Law
- Conservation International
- Earth Action
- Earth Times
- EcoNet Acid Rain Resources
- EnviroLink
- Global Environment Facility
- Greenpeace
- International Institute for Sustainable Development (IISD): Linkages
- IISD–International Forest Policy
- Natural Heritage Network
- United National Environmental Program
- World Conservation Monitoring Centre
- The World Conservation Union
- World Resources Institute
- World Wildlife Fund

7.9.6 Advantages and Disadvantages

The benefits from NGOs are as under

- They are flexible in adapting to local situations and responding to local needs and therefore able to develop integrated as well as sectoral projects.

- They have the ability to experiment freely with innovative approaches and, if necessary, to take risks.
- They enjoy good rapport with people and can render micro-assistance to very poor people.
- They have the ability to communicate at all levels, from the neighborhood to the top levels of government.
- They are able to recruit both experts and highly motivated staff with fewer restrictions than the government.

The disadvantages could be :

- Paternalistic attitudes restrict the degree of participation in programme/project design.
- Restricted/constrained ways of approach to a problem or area.
- Reduced replicability of an idea, due to non-representativeness of the project or selected area, relatively small project coverage, dependence on outside financial resources, etc.
- "Territorial possessiveness" of an area or project reduces cooperation between agencies, seen as threatening or competitive.

7.10 COMMUNITY PARTICIPATION IN ENVIRONMENTAL MANAGEMENT

7.10.1 Need And Benefits Of Community Participation in Environmental Protection

Environmental protection is a cooperative process, requiring concerted action by government, individual citizens, and industry. The public is one of a nation's greatest resources for developing and implementing environmental laws and policies. They know the country's land and natural attributes more intimately than a government ever will. Their number makes them more pervasive than the largest government agency. And because the public works, plays, and travels in the environment, each has a personal stake in its beauty, health, and permanence. The involvement of the public is crucial to the establishment and implementation of a fair and effective environmental protection regime. The opportunities for and the benefits from public involvement are many and wide-ranging.

Participation in the environmental protection process **benefits the public** because it allows individuals to have a greater impact on the environmental decision making process. It also enables people to learn about the environmental risks to which they, their families, and their communities are exposed and to adjust their activities accordingly. In addition, public participation also empowers citizens and helps them to feel that they can have a positive effect and influence on concrete conditions in their countries.

Public participation can also **assist industry** by increasing its knowledge of the impacts of its own operations on the environment. Mechanisms for public involvement in environmental decisions often require companies to engage in detailed assessments of their pollution-producing processes or activities. These comprehensive evaluations can lead companies to discover inefficiencies in production methods, raw material use, or energy consumption that can actually reduce operating costs and eliminate the need to install expensive pollution control equipment. These cost savings may be especially important when difficult economic times threaten industry's ability to attain compliance with environmental regulations. Public participation also increases industry's understanding of consumers' concerns and teaches industry how to market its products more effectively. Finally, because industry itself is a non-governmental institution, legal and other avenues for input from non-governmental sources can also allow companies to have a voice in governmental decisions that affect them directly.

Significant **benefits to the government** can also result from public involvement in the environmental protection process. Citizens have direct, immediate knowledge about environmental conditions in their communities. Encouraging them to share this knowledge with the government can create more informed government decisions and can reduce the likelihood that significant environmental impacts of proposed actions or policies will be overlooked. The sheer number of the citizenry can also supplement scarce government monitoring, inspection, and enforcement resources, thus saving money and time for the government. Members of the public can act as the government's "eyes and ears," identifying and taking action against environmental threats or violations of applicable laws. In addition, significant public involvement in an environmental issue can strengthen the position of the Environment Ministry in relation to other government interests and ministries—the public can reinforce the environment ministry's views and ensure that the government as a whole does not ignore environmental concerns.

Giving the public an opportunity to **influence government decisions** from the outset also defuses opposition to particular government actions and builds broad-based consensus for environmental programs as a whole. If the public is involved in the full decision making process, their concerns may be met early on in the planning process when changes may be easier to make, rather than late in the process when even small changes may cost both time and money. In addition, by being involved in the full decision making process, the public is exposed to the multiple factors involved in each decision. Even if the public does not agree with the final decision, they are more likely to understand why the decision was made and thus may not oppose it. Thus, even though allowing for public input into an environmental decision may delay the decision making process in the short term, it can save valuable time and money in the long run by avoiding lengthy and divisive disputes after the decision is made.

Although public participation makes a valuable contribution in each of these separate spheres, the overall value to society of public involvement may be even greater than the sum of these various individual benefits. Actually applying democratic ideas to improving environmental conditions reinforces basic principles and practices of self-governance, thus strengthening the legitimacy of a country's environmental protection regime. And acceptance of the public as a valued partner in the environmental protection process can inspire the cooperation between citizens, their government, and industries that is crucial to the success of a regulatory system.

7.10.2 Instruments for Community Participation

(1) Notice and Comment Procedures

To make the process of public participation work effectively in a satisfactory way for the public, whatever instrument is being used, a sufficient preparation is more or less a prerequisite. This requires for instance the government (or other official authorities) to provide broad public notice of proposed decisions and adequate time for the public to educate themselves about the issue before "the floor is open" for discussion, either orally or in writing. In addition, the government should be required to respond in writing to the comments, explaining their final decisions and, if they did not adopt all of the changes recommended during, e.g., a hearing, they have to explain why. As stated several times before, these are very important and effective procedures. They indicate that the government has actually listened to written and oral comments and help the public to better understand the final decision and to feel they have been listened to .

(2) Public Hearings

Whenever a measure has to be taken, a public hearing can be organized before the final decision is made. During the hearing the initiators (usually the government) give information on the plans, after which the participating citizens can give their opinion. These hearings can be exclusively informative, which means that information is only given. There are also hearings in which the participating citizens can express their complaints and opinions. The most successful hearings, however, are those where both parties have their say, and where a discussion takes place between the initiators and the participating citizens.

As said before, the hearings are generally organized by the authority who wants to take the measure. This can be a national government, but also regional or local authorities. In many cases the authorities are legally obliged to organize a hearing before making a final decision. The report of the hearing is an important document in the decision making process.

(3) Advisory Committees

An increasingly occurring phenomenon is the establishment of advisory committees. Usually this is done on a national level and these bodies give advice to the government on (environmental) measures or laws. The government is obliged to ask for advice before making final decisions. In such advisory committees, seats are made available for all sorts of social groups, such as those from the environmental movement. Therefore, the environmental movement has to be well organized so as to be able to send a representative delegation to these advisory committees. Of course, we have to consider that before accepting a seat on advisory committees or the like, two basic conditions must be met: (1) the public nature of the sessions, and (2) compulsory recording of minority opinions. These conditions are to prevent matters from being settled and engineered behind closed doors, and/or a group from being overruled by a majority. That is exactly why it is of major importance in situations where citizens are involved in the decision making process by representatives that every group can see or check what is being done on behalf of them.

(4) International Treaties

A special form of public participation is the international treaty. This is an agreement worked out between two or more States, i.e., an agreement between governments. Regarding nature and the environment, many international agreements were adopted during the past twenty years. As pollution disregards boundaries, many environmental problems can actually only be solved at an international level. This applies especially for water and air pollution, radioactivity, indigenous animal trading, protection of vast transboundary conservation areas, and wildlife.

As treaties are agreements between governments in the first place, individual citizens cannot directly appeal to them. Nevertheless, they can be involved in a few ways. Once an international treaty is concluded and signed by a government, it has to be ratified by the Parliament. Only then does it become effective and is the government liable to observe the agreement. When the treaty is discussed in the parliament, the opportunity is open for public discussion.

The public may also become directly involved in the conclusion of a treaty through the secretariat of the treaty. Every treaty has its own secretariat, which checks the observance with the rules and in this quality organizes regular meetings of the countries joining the agreement. At these meetings citizens and/or organizations can make their voices heard. More and more treaties include a provision that NGOs may be admitted as observers to these meetings. On the principle that speaking, writing and asking is free, the citizen can directly appeal to these secretariats and the periodical conferences with questions and comments.

The treaties which usually contain all information about the secretariats and the data of the periodical meetings are freely accessible to the public, like other laws and policy documents. There is a growing tendency to order governments to involve their citizens in the implementation of the international agreements.

(5) Environmental Impact Assessments

More and more countries are legally bound to make Environmental Impact Assessments (EIAs). This is a statutorily required analysis of the effects of a certain activity on the environment. Final decisions may only be made after a thorough study of the facts. This kind of study is not always required. The EIA laws indicate exactly for which activities a study is required, who has to conduct it, when it has to be conducted and within what period of time, and which aspects have to be given special attention. The set-up of an EIA, the draft and final reports can then be discussed in public.

(6) Ombudsman

Some countries have an independent complaint committee: the ombudsman. Citizens can lodge their complaints there whenever they disagree with any measure taken by the government. The institution is independent of the government and is competent to deal with complaints on the basis of statutory rules. The law requiring an ombudsman also regulates what kinds of complaints are included. In general, these are not matters that can be taken to court. If one, nevertheless, decides to go to the ombudsman, the ombudsman will explain the available options. In this respect the ombudsman has an important informative function. Specific complaints in a certain field of policy can be dealt with by a special ombudsman. Thus, a social ombudsman may be appointed for social matters, a consumer ombudsman for consumer affairs, or an environmental ombudsman for environmental affairs

7.10.3 Examples of a Few Community Actions to Abate Pollution

Solid Waste Pollution Control

1. Provide separate containers for organic material, plastics, metals and paper.
2. Avoid/minimize the usage of non-biodegradable materials.
3. Segregate and Recycle paper, plastics and metals.
4. Utilize vegetable waste for gardening.
5. Promote the usage of edible dishes, bowls and minimize domestic waste.

Liquid Waste Pollution Control

1. Control/minimize the water consumption
2. Replace the leaking taps
3. Provide covers on open gutters

Gaseous Waste Pollution Control

1. Avoid smoking at public places
2. Minimize use of crackers/wood burning during the festivals like Deepavali/Holi

3. Promote usage of solar energy
4. Save energy and fuel whenever possible

Noise Pollution Control

1. Avoid using Loudspeakers at meetings, shops etc.
2. Avoid using Air-Horns in vehicles
3. Keep the Volume of T.V., Radio, Audio tapes etc low
4. Use enclosures for the high noise generating equipments.

General

1. Cleanliness:
   (a) Make use of toilets and latrines instead of using open space
   (b) Don't spit in public
   (c) Always keep the surroundings, road, parks clean
2. Educate public through print and electronic media
3. Carry out regular maintenance of vehicles
4. Minimize or avoid the usage insecticides/pesticides.

7.11 INTERNATIONAL CONVENTIONS AND PROTOCOLS

7.11.1 Background and Definition

Environmental problems are not new to the world. But for many decades, environmental problems were characterized by issues of local pollution like effluent pipes discharging to rivers or low-level chimneys creating atmospheric problems or hazardous waste dumped at land site. These problems generally do not require very sophisticated science to establish a solution and rarely involved more than one political jurisdiction in developing the enforcing the appropriate regulations.

Since the late 1960s, however, environmental issues have taken on a more global and complex nature. Issues such as stratospheric ozone depletion, acid rain, or global warming are large-scale issues necessitating the involvement of several nations in defining their cause and effects, and in implementing management actions. These issues are also scientifically more complex. Consequently, they require a greater understanding of global ecological systems (e.g. the global carbon cycle), of longer time-scales (sometimes centuries), and of integrated ecological processes.

It is necessary to develop new scientific and political mechanisms that could operate at the international level in order to deal with regional and global environmental change. While there are many variations of the theme, the concept of developing an International Convention as a first step in addressing problems has become well established, frequently under the general guidance of the United Nations Environmental Programme.

7.11.2 Important International Conventions and Associated Protocols Related to Environmental Protection

- United nations conference on human environment, June 1972
- United nations General assembly regulation, December 15, 1972

- Charter of Economic rights and duties of states 1974
- The convention on international trade in endangered species CITES, 1975
- UN habitat conference on human settlement of 1976 and water conference of 1977
- Environmental education conference
- Control of transboundry movement and disposal of hazardous waste (Basel Convention)
- Earth summit–1992 (Rio–Declarations on Environment and development)
- The Vienna Convention on Ozone Layer Depletion–Montreal protocol
- United Nations Climate Change Control Convention (UNCCC)–Climate of Greenhouse control convention
- Manila Declaration on Green productivity
- United Nations Framework Convention On Climate Change Kyoto Protocol.

7.11.2.1 United Nations Conference on Human Environment, 1972

The United Nations Conference on the Human Environment was held at Stockholm from 5 to 16 June 1972 considered the need for a common outlook and for common principles to inspire and guide the peoples of the world in the preservation and enhancement of the human environment.

The Conference called upon Governments and peoples to exert common efforts for the preservation and improvement of the human environment, for the benefit of all the people and for their posterity. Some of the principles are:

- Man has the fundamental right to freedom, equality and adequate conditions of life, in an environment of a quality that permits a life of dignity and well being, and he bears a solemn responsibility to protect and improve the environment for present and future generations. In this respect, policies promoting or perpetuating apartheid, racial segregation, discrimination, colonial and other forms of oppression and foreign domination stand condemned and must be eliminated.
- Man has a special responsibility to safeguard and wisely manage the heritage of wildlife and its habitat, which are now gravely imperiled by a combination of adverse factors. Nature conservation, including wildlife, must therefore receive importance in planning for economic development.
- The discharge of toxic substances or of other substances and the release of heat, in such quantities or concentrations as to exceed the capacity of the environment to render them harmless, must be halted in order to ensure that serious or irreversible damage is not inflicted upon ecosystems. The just struggle of the peoples of ill countries against pollution should be supported.
- Scientific research and development in the context of environmental problems, both national and multinational, must be promoted in all countries, especially the developing countries. In this connection, the free flow of up-to-date scientific information and transfer of experience must be supported and assisted, to facilitate the solution of environmental problems; environmental technologies should be made available to developing countries on terms which would encourage their wide dissemination without constituting an economic burden on the developing countries.

Many speakers supported the proposed Environment Fund. Several delegations announced their intention of making contributions to the Fund. Concern was expressed by some representatives of developing countries that the Fund might be regarded by some developed countries as an alternative to development assistance. Some speakers emphasized the need to use the Fund to help developing countries meet the additional environmental costs incurred in their development programmes. Several speakers endorsed the argument that "the polluter must pay".

This was followed by the United Nations General Assembly regulation on December 15, 1972, emphasizing the need of active cooperation among the states in the field of human environment. The resolution has designated **June 5 as the world environment day** and has urged governments and organizations in the U.N. System to undertake on that date every year worldwide activities reaffirming their concern for the preservation and enhancement of the environment.

7.11.2.2 Charter of Economic Rights and Duties of States 1974

Charter of Economic Rights and Duties of States was framed in the UN General Assembly Resolution in 1974. According to this the protection, prevention and enhancement of the environment for the present and future generation is the responsibility of all states. All the states have the responsibility to ensure that the activities within their jurisdiction or control do not cause damage to the environment of the other states or of areas beyond the limits of national jurisdiction. All states should co-operate in evolving international norms and regulations in the field of Environment.

7.11.2.3. The Convention on International Trade in Endangered Species CITES, 1975

CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is an international agreement between Governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival.

Widespread information nowadays about the endangered status of many prominent species, such as the tiger and elephants, might make the need for such a convention seem obvious. But at the time when the ideas for CITES were first formed, in the 1960s, international discussion of the regulation of wildlife trade for conservation purposes was something relatively new. With hindsight, the need for CITES is clear. Annually, international wildlife trade is estimated to be worth billions of dollars and to include hundreds of millions of plant and animal specimens. The trade is diverse, ranging from live animals and plants to a vast array of wildlife products derived from them, including food products, exotic leather goods, wooden musical instruments, timber, tourist curios and medicines. Levels of exploitation of some animal and plant species are high and the trade in them, together with other factors, such as habitat loss, is capable of heavily depleting their populations and even bringing some species close to extinction. Many wildlife species in trade are not endangered, but the existence of an agreement to ensure the sustainability of the trade is important in order to safeguard these resources for the future.

Because the trade in wild animals and plants crosses borders between countries, the effort to regulate it requires international cooperation to safeguard certain species from over-exploitation. CITES was conceived in the spirit of such cooperation. Today, it accords varying degrees of protection to more than 30,000 species of animals and plants, whether they are traded as live specimens, fur coats or dried herbs.

CITES was drafted as a result of a resolution adopted in 1963 at a meeting of members of The World Conservation Union. The text of the Convention was finally agreed at a meeting of representatives of 80 countries in Washington DC., United States of America, on 3 March 1973, and on 1 July 1975 CITES entered in force.

CITES is an international agreement to which States (countries) adhere voluntarily. States that have agreed to be bound by the Convention ('joined' CITES) are known as Parties. Although CITES is legally binding on the Parties – in other words they have to implement the Convention– it does not take the place of national laws. Rather it provides a framework to be respected by each Party, which has to adopt its own domestic legislation to make sure that CITES is implemented at the national level.

Not one species protected by CITES has become extinct as a result of trade since the convention entered into force and, for many years, CITES has been among the largest conservation agreements in existence, with now 166 parties.

7.11.2.4 Un Habitat Conference On Human Settlement

UN-HABITAT is mandated by the UN General Assembly to promote socially and environmentally sustainable towns and cities with the goal of providing adequate shelter for all. The main documents outlining the mandate of the organization are:

The Vancouver Declaration on Human Settlements, known as the Habitat I conference when the agency was created at the first major United Nations conference on human settlements in Vancouver, Canada, 31 May–11 June 1976.

The Habitat Agenda is the main political document that came out of the Habitat II conference in Istanbul, Turkey 3 to 14 June 1996. Adopted by 171 countries, at what was called the City Summit it contains over 100 commitments and 600 recommendations on human settlements issues.

The Istanbul Declaration on Human Settlements of 1996 is a reaffirmation of the Habitat Agenda agreed separately at the Habitat II conference. It notably reaffirms the commitment of world governments to better standards of living in larger freedom for all humankind.

Declaration on Cities and Other Human Settlements in the New Millennium, is the United Nations General Assembly Resolution of 9 June 2001 reaffirming that the Istanbul Declaration and the Habitat Agenda will remain the basic framework for sustainable human settlements development in the years to come.

Resolution A/56/206 of 1 January 2002, is the UN General Assembly resolution in which governments strengthened the agency by transforming the United Nations Commission on Human Settlements (Habitat) into a full fledged programme renamed as the United Nations Human Settlements Programme (UN-HABITAT), under the Economic and Social Council which coordinates the work of all the United Nations 14 specialized agencies.

7.11.2.5 Water Conference of 1977

The United Nations Water Conference held at Mar del Plata, Argentina, from 14 to 25 March 1977 reviewed the general world water situation, and adopted the Mar del Plata Action Plan directed to solving the water problems facing the international community, as well as specific resolutions on the role of water in combating desertification and on drought loss management. These recommendations include *inter alia* some measures relating to specific problems of dry lands and drought-prone areas subject to desertification.

7.11.2.6 Control of Transboundry Movement and Disposal Of Hazardous Waste (Basel Convention)

In the late 1980s, a tightening of environmental regulations in industrialized countries led to a dramatic rise in the cost of hazardous waste disposal. Searching for cheaper ways to get rid of the wastes, “toxic traders” began shipping hazardous waste to developing countries and to Eastern Europe. When this activity was revealed, international outrage led to the drafting and adoption of the Basel Convention.

During its first Decade (1989–1999), the Convention was principally devoted to setting up a framework for controlling the “transboundary” movements of hazardous wastes, that is, the movement of hazardous wastes across international frontiers. It also developed the criteria for “environmentally sound management”. A Control System, based on prior written notification, was also put into place.

During The Next Decade (2000-2010), the Convention will build on this framework by emphasizing full implementation and enforcement of treaty commitments. The other area of focus will be the minimization of hazardous waste generation. Recognizing that the long-term solution to the stockpiling of hazardous wastes is a reduction in the generation of those wastes–both in terms of quantity and hazardousness – Ministers meeting in December of 1999 set out guidelines for the Convention’s activities during the Next Decade, including:

- Active promotion and use of cleaner technologies and production methods;
- Further reduction of the movement of hazardous and other wastes;
- Prevention and monitoring of illegal traffic;
- Improvement of institutional and technical capabilities -through technology when appropriate–especially for developing countries and countries with economies in transition;
- Further development of regional and sub regional centers for training and technology transfer.

A central goal of the Basel Convention is “environmentally sound management” (ESM), the aim of which is to protect human health and the environment by minimizing hazardous waste production whenever possible. ESM means addressing the issue through an “integrated life-cycle approach”, which involves strong controls from the generation of a hazardous waste to its storage, transport, treatment, reuse, recycling, recovery and final disposal.

The Basel Convention contains specific provisions for the monitoring of implementation and compliance. A number of articles in the Convention oblige Parties (national governments which have acceded to the Convention) to take appropriate measures to implement and enforce its provisions, including measures to prevent and punish conduct in contravention of the Convention.

Because hazardous wastes pose such a potential threat to human health and the environment, one of the guiding principles of the Basel Convention is that, in order to minimize the threat, hazardous wastes should be dealt with as close to where they are produced as possible. Therefore, under the Convention, transboundary movements of hazardous wastes or other wastes can take place only upon prior written notification by the State of export to the competent authorities of the States of import and transit (if appropriate). Each shipment of hazardous waste or other waste must be accompanied by a movement document from the point at which a transboundary movement begins to the point of disposal. Hazardous waste shipments made without such documents are illegal. In addition, there are outright bans on the export of these wastes to certain countries. Transboundary movements can take place, however, if the state of export does not have the capability of managing or disposing of the hazardous waste in an environmentally sound manner. The Basel Convention entered into forces in 1992.

7.11.2.7 Earth Summit–1992

The Earth Summit in Rio de Janeiro was unprecedented for a UN conference, in terms of both its size and the scope of its concerns. Twenty years after the first global environment conference, the UN sought to help Governments rethink economic development and find ways to halt the destruction of irreplaceable natural resources and pollution of the planet. Hundreds of thousands of people from all walks of life were drawn into the Rio process. They persuaded their leaders to go to Rio and join other nations in making the difficult decisions needed to ensure a healthy planet for generations to come.

The Summit's message–that nothing less than a transformation of our attitudes and behavior would bring about the necessary changes–was transmitted by almost 10,000 on-site journalists and heard by millions around the world. The message reflected the complexity of the problems facing us: that poverty as well as excessive consumption by affluent populations place damaging stress on the environment. Governments recognized the need to redirect international and national plans and policies to ensure that all economic decisions fully took into account any environmental impact. And the message has produced results, making eco-efficiency a guiding principle for business and governments alike.

- Patterns of production–particularly the production of toxic components, such as lead in gasoline, or poisonous waste–are being scrutinized in a systematic manner by the UN and Governments alike;
- Alternative sources of energy are being sought to replace the use of fossil fuels which are linked to global climate change;
- New reliance on public transportation systems is being emphasized in order to reduce vehicle emissions, congestion in cities and the health problems caused by polluted air and smog;
- There is much greater awareness of and concern over the growing scarcity of water.

The two-week Earth Summit was the climax of a process, begun in December 1989, of planning, education and negotiations among all Member States of the United Nations, leading to the adoption of Agenda 21, a wide-ranging blueprint for action to achieve sustainable development worldwide. At its close, Maurice Strong, the Conference Secretary-General, called the Summit a "historic moment for humanity". Although Agenda 21 had been weakened by compromise and negotiation, he said, it was still the most comprehensive and, if implemented, effective programme of action ever sanctioned by the international community.

The Earth Summit influenced all subsequent UN conferences, which have examined the relationship between human rights, population, social development, women and human settlements–and the need for environmentally sustainable development. The World Conference on Human Rights, held in Vienna in 1993, for example, underscored the right of people to a healthy environment and the right to development, controversial demands that had met with resistance from some Member States until Rio. (Refer chapter 6.2.2).

7.11.2.8 The Vienna Convention on Ozone Layer Depletion

In 1985, nations agreed in Vienna to take "appropriate measures...to protect human health and the environment against adverse effects resulting or likely to result from human activities which modify or are likely to modify the Ozone Layer", thus the Convention for the Protection of the Ozone Layer was born.

The main thrust of the Convention was to encourage research and overall cooperation among countries and exchange of information. Even so it took four years to prepare and agree. Twenty nations signed it in Vienna, but most did not rush to ratify it. The Convention provided for future protocols and specified procedures for Amendment and dispute settlement.

The Vienna Convention set an important precedent. For the first time nations agreed in principle to tackle a global environmental problem before its effects were felt, or even scientifically proven.

As the experts began to explore for specific measures to be taken, the journal 'Nature' published a paper in May 1985 by British scientists–led by Dr. Joe Farman–about severe ozone depletion in the Antarctic. The paper's findings were confirmed by American satellite observations and offered the first proof of severe ozone depletion and making the need for definite measures more urgent.

As a result, in September 1987, agreement was reached on specific measures to be taken and the Montreal Protocol on substances that Deplete the Ozone Layer was signed. The Vienna Convention entered into force on 22 September 1988.

7.11.2.9 Montreal Protocol

Following the discovery of the Antarctic ozone hole in late 1985, governments recognized the need for stronger measures to reduce the production and consumption of a number of CFCs (CFC 11, 12, 113, 114, and 115) and several Halons (1211, 1301, 2402).

The Montreal Protocol on Substances that Deplete the Ozone Layer was adopted on 16 September 1987 at the Headquarters of the International Civil Aviation Organization in Montreal. The Protocol was designed so that the phase out schedules could be revised on the basis of periodic scientific and technological assessments. Following such assessments, the Protocol was adjusted to accelerate the phase out schedules. It has also been amended to introduce other kinds of control measures and to add new controlled substances to the list.

The Protocol came into force on 1st January 1989.

Amendments to the Protocol:

The London Amendment–1990

The London Amendment was adopted at the Second Meeting of the Parties to the Montreal Protocol held in London in 1990. This amendment introduced control measures for both production and consumption for three new groups of substances, namely other halogenated CFCs, Carbon Tetrachloride and Methyl Chloroform or 1,1,1-trichloroethane. Control measures also included restrictions on trade with non-parties.

The financial mechanism was also established (Article 10 of the Protocol) for providing financial and technical assistance to developing countries to enable their compliance with their obligations under the protocol. The financial mechanism meets the agreed incremental costs of developing countries in order to enable their compliance with the control measures of the Protocol.

The amendment further introduced HCFCs but only required reporting of production and consumption data for the Annex and did not introduce control measures for the Annex Group.

The London Amendment entered into force on 10 August 1992.

Copenhagen Amendment–1992

The Copenhagen Amendment was adopted in 1992 at the Fourth Meeting of the Parties to the Montreal Protocol held in Copenhagen. The amendment introduced control measures for consumption only for HCFCs .The amendment further introduced control measures for both production and consumption for two new groups of substances, namely HBFCs and Methyl

The Copenhagen Amendment entered into force on 14 June1994.

Montreal Amendment–1997

The Montreal Amendment was adopted in 1997 at the Ninth Meeting of the Parties to the Montreal Protocol held in Montreal. This is the only amendment that did not introduce new substances to the protocol. Instead, the amendment introduced the requirement for licensing systems to allow control and monitoring of trade in substances controlled under the protocol.

The Montreal Amendment entered into force on 10 November 1999.

Beijing Amendment–1999

The Beijing Amendment was adopted in 1999 at the eleventh Meeting of the Parties to the Montreal Protocol held in Beijing. The amendment introduced control measures for production for HCFCs and imposed restrictions on trade with non-Parties for these HCFCs. The amendment further introduced control measures for both production and consumption for one new group of substances, namely Bromochloromethane or BCM

The Beijing Amendment entered into force on 25 February 2002.

7.11.2.10 United Nations Climate Change Control Convention (UNCCC)–Climate Of Greenhouse Control Convention

The First World Climate Conference recognized climate change as a serious problem in 1979. This scientific gathering explored how climate change might affect human activities. It issued a declaration calling on the world's governments "to foresee and prevent potential man-made changes in climate that might be adverse to the well-being of humanity". It also endorsed plans to establish a World Climate Programme (WCP) under the joint responsibility of the World Meteorological Organization (WMO), the United Nations Environment Programme (UNEP), and the International Council of Scientific Unions (ICSU).

A number of intergovernmental conferences focusing on climate change were held in the late 1980s and early 1990s. Together with increasing scientific evidence, these conferences helped to raise international concern about the issue. Participants included government policy-makers, scientists, and environmentalists.

The Intergovernmental Panel on Climate Change (IPCC) released its First Assessment Report in 1990. Established in 1988 by UNEP and WMO, the Panel was given a mandate to assess the state of existing knowledge about the climate system and climate change; the environmental, economic, and social impacts of climate change; and the possible response strategies. Approved after a painstaking peer review process, the Report confirmed the scientific evidence for climate change. This had a powerful effect on both policy-makers and the general public and provided the basis for negotiations on the Climate Change Convention.

In December 1990, the UN General Assembly approved the start of treaty negotiations. The Intergovernmental Negotiating Committee for a Framework Convention on Climate Change (INC/CCC) met for five sessions between February 1991 and May 1992. Facing a strict deadline–the June 1992 Rio "Earth Summit"–negotiators from 150 countries finalized the Convention in just 15 months. It was adopted in New York on 9 May 1992.

The 1992 UN Framework Convention on Climate Change was signed by 154 states (plus the EC) at Rio de Janeiro. Twenty years after the 1972 Stockholm Declaration first laid the foundations of contemporary environmental policy, the Earth Summit became the largest-ever gathering of Heads of State. Other agreements adopted at Rio were the Rio Declaration, Agenda 21, the Convention on Biological Diversity, and Forest Principles. The UNFCCC Convention entered into force on 21 March 1994.

7.11.2.11 Manila Declaration on Green Productivity

The Asian Productivity Organization (APO) launched the Green Productivity (GP) program in Asia and the Pacific in 1994, in response to the Rio Earth Summit of 1992, with special funding from the Government of Japan.

The Manila Declaration on Green Productivity was adopted during the First APO World Conference on Green Productivity held in the Philippines in December 1996. The Johannesburg Declaration was adopted during the World Summit on Sustainable Development (WSSD) in the Republic of South Africa in 2002

It was emphasized that sustainable development continues to be a critical issue that must be addressed with a sense of urgency by all and that the Green Productivity program has shown, with its many successful cases, to be a practical and effective means for attaining sustainable development.

Under its Green Productivity program, the APO has extensively and successfully promoted and publicized the Green Productivity concept to all the stakeholders in the government, public, and economic sectors in the region

This Second World Conference on GP

1. **Confirms** that the Green Productivity program should be the driving force to achieve the Millennium Development Goals and sustainable development;
2. **Stresses** that in future plans for the APO's Green Productivity program, the outcome of the WSSD should be given due consideration, especially with regard to issues related to the management of natural resources, sustainable production and consumption, and eradication of poverty;
3. **Agrees** that the Green Productivity concept and practices should be integrated in the industry, agriculture, and service sectors as well as communities;
4. **Urges the governments and businesses as the primary stakeholders in governance** to infuse the Green Productivity concept in development policies and corporate strategies, respectively;
5. **Calls on all stakeholders** to extend, in the spirit of partnership, their assistance and cooperation to the Green Productivity program; and
6. **Recommends** that the APO:

- Encourage all concerned, particularly decision makers in the public and private sectors, to contribute to Green Productivity practices proactively through all possible means including the greening of supply chains with a view to changing unsustainable production and consumption patterns;
- Further strengthen collaboration with national and local governments, enterprises, labor unions, financial institutions, academia, trade and professional associations, media, civil society, and international organizations in implementing the Green Productivity program with shared responsibilities for sustainable development;
- Promote the incorporation of the Green Productivity concept and approaches in the formal and informal education systems;
- Develop indicators at various levels for measuring the results of Green Productivity practices to share with others for effective Green Productivity implementation and promotion;
- Urge the National Productive Organizations to enhance their capabilities and capacity in planning, implementing, monitoring, and evaluating the Green Productivity program, and also in disseminating its successful cases to contribute to national development goals; and
- Contribute to further promotion of the concept and practices of Green Productivity as a key to poverty alleviation in conjunction with the Integrated Community Development program in line with the Partnership Initiative accepted at the WSSD.

7.11.2.12 United Nations Framework Convention on Climate Change

Kyoto Protocol

The Kyoto Protocol was adopted at COP–3 (conference of Parties) in December 1997. Some 10,000 delegates, observers, and journalists participated in this high-profile event from 1–11 December. Because there was not enough time to finalize all the operational details of how the Protocol would work in practice, COP–4, held in Buenos Aires from 2–13 November 1998, agreed a two-year Plan of Action for completing the Kyoto rulebook. The agenda of COP–5, which took place in Bonn from 15 October–5 November 1999, was based on this Plan.

A political agreement on the operational rulebook for the Protocol was reached at COP–6. Meeting from 6 to 25 November 2000, COP–6 made good progress but could not resolve all the issues in the time available. The meeting was suspended and then resumed from 16 to 27 July 2001 in Bonn. The resumed session reached agreement on the political principles of operational rulebook for the Kyoto Protocol. This agreement addressed the emissions trading system, the Clean Development Mechanism, the rules for counting emissions reductions from carbon "sinks", and the compliance regime. It also outlined a package of financial and technological support to help developing countries contribute to global action on climate change. The work of translating the Bonn Agreements into detailed legal texts was finalized at COP–7, which was held in Marrakech, Morocco, from 29 October to 9 November 2001. The Protocol is now ready for implementation.

The Kyoto Protocol would require governments to take even stronger action. In 1997, the Parties to the Convention agreed by consensus that developed countries should accept a legally binding commitment to reduce their collective emissions of six greenhouse gases by at least 5% compared to 1990 levels by the period 2008–2012. The Protocol also establishes emissions trading regime and a "clean development mechanism". However, the Protocol has not yet received enough ratification to enter into force.

Many options for limiting emissions are available in the short- and medium-term. Policymakers can encourage energy efficiency and other climate–friendly trends in both the supply and consumption of energy. Key consumers of energy include industries, homes, offices, vehicles, and farms agriculture. Efficiency can be improved in large part by providing an appropriate economic and regulatory framework for consumers and investors. This framework should promote cost-effective actions, the best current and future technologies, and "no regrets" solutions that make economic and environmental sense irrespective of climate change. Taxes, regulatory standards, tradable emissions permits, information programmes, voluntary programmes, and the phase-out of counterproductive subsidies can all play a role. Changes in practices and lifestyles, from better urban transport planning to personal habits such as turning out the lights, are also important.

Reducing uncertainties about climate change, its impacts, and the costs of various response options is vital. In the meantime, it will be necessary to balance concerns about risks and damages with concerns about economic development. The prudent response to climate change, therefore, is to adopt a portfolio of actions aimed at controlling emissions, adapting to impacts, and encouraging scientific, technological, and socio-economic research.

8

ENVIRONMENTAL PERFORMANCE STANDARDS

8.1 ASBESTOS MANUFACTURING INDUSTRY

	Pollutants	Emission limit
All types of asbestos manufacturing units (including all processes involving the use of asbestos)	Pure asbestos material	4 Fibre*/cc
	Total dust	2 mg/Nm^3

*Fibre of length more than 5 micrometre and diametre less than 3 micrometre with an aspect ratio of 3 or more.

8.2 BATTERY MANUFACTURING INDUSTRY

Lead Acid Manufacturing Industry

Source	Pollutants	Standards	
		Conc. Based, (mg/Nm^3)	**Load based, (kg/tonne of Pb used)**
Grid casting	Lead	10	0.020
	Particulate Matter	25	
Oxide	Lead	10	0.010
Manufacturing	Particulate Matter	25	
Paste mixing	Lead	10	0.025
	Particulate Matter	25	
Assembling	Lead	10	0.010
	Particulate Matter	25	
PVC section	Particulate Matter	150	—

- To comply the respective standards, all the emissions from above mentioned sources shall be routed through stack connected with hood and fan. In addition to above installation of control equipment viz. Bag filter/ventury scrubber is also recommended.
- The minimum stack height shall be 30 m.

Liquid Effluent Discharge Standards:

Pollutant	Value
pH	6.5–8.5
Suspended solids	50 mg/l
Lead	0.1 mg/l

Dry Cell Manufacturing Industry

Pollutant	Standards	
	Concentration based (mg/Nm^3)	Load based (kg/lakh cell)
Particulate Matter	50	1.5
Manganese as Mn	5	0.3

To comply with the respective standards, all the emissions from above mentioned sources shall be routed through stack connected with hood and fan. In addition to above installation of control equipment viz. Bag filter/ventury scrubber is also recommended.

- The minimum stack height shall be 30 m.

Effluent Standards

Pollutant	Value
pH	6.5–8.5
Total suspended solids	100 mg/l
Manganese as Mn	2 mg/l
Mercury as Hg	0.02 mg/l
Zinc as Zn	5 mg/l

8.3 BRICK KILNS : EMISSION STANDARDS

Size	Kiln Capacity	Maximum limit for the concentration of particulate matter. (mg/Nm^3)
Small	Less than 15,000 bricks per day (less than 15 ft trench width)	1000
Medium	15,000–30,000 bricks per day (15–22 ft trench width)	750
Large	More than 30,000 bricks per day (more than 22 ft trench width)	750

Stack Height Regulation: The following stack heights are recommended for optimal dispersion of sulphur dioxide.

Kiln Capacity	Stack Height
Less than 15,000 bricks are day (less than 15 ft trench width)	Minimum stack height of 22 m, or, induced draught fan operating with minimum draught of 50 mm water gauge with 12 m stack height.
15,000–30,000 bricks per day (15–22 ft trench width)	Minimum stack height of 27 m with gravitational settling chamber or induced draught fan operating with minimum draught of 50 mm Water Gauge with 15 m stack height.
More than 30,000 bricks per day (more than 22 ft trench width)	Minimum stack height of 30 m with gravitational settling chamber or Induced draught fan operating with minimum draught of 50 mm Water Gauge with 17 m stack height.

Existing moving chimney Bull's trench kilns shall be dispensed with by December 31, 1987 and no new moving chimney kilns shall be allowed to come up.

Considering the immediate need to protect the top soil and to find ways the safe disposal/utilisation of fly ash, it is provided that from the 1st Jaunary 1997, all brick manufacturing units within a radius of 50 kms from any thermal power plant, shall utilise fly ash in optimal proportion for making bricks.

8.4 BOILER (SMALL)

Steam generation capacity (tph)	Pollutant	Emission limit (mg/Nm^3) (mg/Nm^3)
Less than 2	Particulate Matter	1200*
2 to less than 10	-do-	800*
10 to less than 15	-do-	600*
15 and above	-do-	150**

*	To meet the respective standards, cyclone/multicyclone is recommended as control equipment with the boiler.
**	To meet the standard, bag filter/ESP is recommended as control equipment with the boiler.

Note: I. 12% of CO_2 correction shall be the reference value for particulate matter emission standards for all categories of boilers.

8.5 CEMENT INDUSTRY : EMISSION STANDARDS

Plant Capacity	Pollutants	Emission limit (mg/Nm^3)
200 tonnes per day all less (All Sections)	Particulate Matter	400
More than 200 tonnes per day (All Sections)	Particulate Matter	250

Notes:

(1) The Central and the State pollution control boards may fix stringent standards not exceeding 250 mg/Nm^3 for smaller plants and 150 mg/Nm^3 for larger plant the industry is located in an area which, in their opinion, requires more stringent standards.

(2) Where continuous monitoring equipments are provided on dust emission lines the integrated average values over a period, to be fixed by the central and state boards but not exceeding 72 hours shall be considered instead of momentary dust emission value conformity to standards.

8.6 THERMAL POWER PLANT : STANDARDS FOR LIQUID EFFLUENTS

Source	Parameter	Concentration not to exceed, mg/l (except for pH and Temp.)
Condenser cooling water (once through higher cooling system)	pH	6.5 to 8.5
	Temperature*	Not more than 5°C than the higher intake
Boiler Blowdown	Free available Chlorine	0.5
	Suspended solids	100
	Oil and grease	20
	Copper (Total)	1.0
	Iron 20 (Total)	1.0
Cooling tower blowdown	Free available Chlorine	
	Zinc	1.0
	Chromium (Total)	0.2
	Phosphate	5.0
	Other corrosion inhibiting	Limit to be established on case by case basis by Central Board in case of Union Territories and State Boards in case of States
As pond effluent	pH	6.5 to 8.5
	Suspended solids	100
	Oil and Grease	20

Thermal Power Plant: Emission Standards

Generation Capacity	Pollutant	Emission limit
Generation capacity 210 MW or more	Particulate matter	150 mg/Nm^3
Generation capacity less than 210 MW	Particulate matter	300 mg/Nm^3

- Depending upon the requirement of local situation, such as protected area, the State Pollution Control Boards and other implementing agencies under the Environment (Protection) Act, 1986, may prescribe a limit of 150 mg/Nm3, irrespective of generation capacity of the plant.

8.7 FOOD AND FRUIT PROCESSING INDUSTRY : WASTEWATER DISCHARGE STANDARDS**

Category	Concentration not be exceed				Quantum
	pH	Suspended Solids (mg/l)	Oil and Grease	BOD at 27°C for 3 days (mg/l)	gm/tonne of product (mg/l)
A. Soft drinks	6.5–8.5	100	10	30	
(a) Fruit based synthetic (more than 0.4 tonne/day) Bottles and tetrapack	–	–	–	–	–
(b) Synthetic (<0.4) tonne/day)	disposal via septic tank				
B. Fruits and Vegetables	–	–	–	–	–
(a) Above 0.4 tonne/day	6.5–8.5	50	10	30	–
(b) 0.1–0.4 tonne/day	6.5–8.5	–	–	300*	–
C. Bakery					
(a) Bread and biscuit					
1. Continuous process (more than 20 tonned/ day)	6.5–8.5	–	–	200*	25
2. Noncontinuous Process (less than 20 tonne/day)	disposal via	septic tank			
(b) Biscuit production	–	–	–	–	–
1.10 tonne/day and above	6.5–8.5	–	–	300*	35
2. Below 10 tonne/day	disposal via septic tank				
D. Confenctionaries	–	–	–	–	–
(a) 4 tonne/day and Above	6.5–8.5	50	10	30	–
(b) Below 4 tonne/day	disposal via septic tank				

8.8 FERTILISER INDUSTRY

Urea Plants

Year of Commissioning	Pollutants	Emission Limit
Prilling tower commissioned prior to 1.1.1982	Particulate matter	150 mg/Nm^3 or 2 kg/tonne of Urea
Prilling tower commissioned after 1.1.1982	Particulate matter	50 mg/Nm^3 of 0.5 kg-/tonne of Urea

Straight Nitrogenous Fertiliser Industry : Wastewater Discharge Standards (Excluding the Calcium Ammonium Nitrate and Ammonium Nitrate Fertiliser)

Parameter	Concentration not to exceed, mg/l (except for pH)	
	Plants commissioned	
	January 1, 1982 onwords	Prior to January 1, 1982
pH	6.5 to 8.0	6.5 to 8.0
Ammonical nitrogen	50	75
Total kjeldahl nitrogen (TKN)	100	150
Free ammonical nitrogen	4	4
Nitrate nitrogen	10	10
Cyanide as CN	0.2	0.2
Vanadium as V	0.2	0.2
Arsenic as As	0.2	0.2
Suspended solids	100	100
Oil and grease	10	10
Chromium as Cr		
Hexavalent*	0.1	0.1
Total	2.0	2.0

*To be compiled with at the outlet of chrome removal unit.

Straight Nitrogenous Fertiliser Industry: Wastewater Discharge Standards (Including for Calcium Ammonium Nitrate and Ammonium Nitrate Fertiliser)

Parameter	Concentration not to exceed, mg/l (except for pH) Plant commissioned	
	January 1, 1982 onwords	Prior to January 1, 1982
pH	6.5 to 8.0	6.5 to 8.0
Ammonical nitrogen	50	75
Total kjeldahl nitrogen (TKN)	100	150
Free ammonical nitrogen	4	4
Nitrate nitrogen	10	10

Cyanide as CN	0.2	0.2
Vanadium as V	0.2	0.2
Arsenic as As	0.2	0.2
Suspended solids	100	100
Oil and grease	10	10
Chromium as Cr		
Hexavalent*	0.1	0.1
Total	2.0	2.0

*To be complied with at the outlet of chrome removal unit.

Straight Phosphatic Fertiliser Industry: Wastewater Discharge Standards

Parameter	Concentration and to exceed mg/l (except for pH)
pH	7.0 to 9.0
Phosphate as P	5
Oil and grease	10
Suspended solids	100
Fluorides as F*	10
Chromium as Cr**	
Hexavalent	0.1
Total	2.0

*To be complied with at the outlet of fluoride removal unit, if the recipient system so demands, fluoride as F shall be limited to 1.5 mg/l.

**To be complied with at the outlet of chromate removal unit.

Phosphatic Fertilizer

Parameter	Source	Emission limit, mg/Nm^3
Total fluoride	Phosphoric acid manufacturing unit	25
Particulate Matter	Granulatin, mixing and grinding of rock phosphate	150

Complex Fertiliser Industry: Wastewater Discharge Standards (Including Calcium, Ammonium, nitrate and Ammonium phosphate fertilisers)

Parameter	Concentration not to exceed, mg/l (except for pH)	
	Plants commissioned	
	January 1, 1982 onwords	Prior to January 1, 1982
pH	6.5 to 8.0	6.5 to 8.0
Ammonical nitrogen	50	75
Total kjeldahl nitrogen (TKN)	100	150

Free ammonical nitrogen	4	4
Nitrate nitrogen	10	10
Cyanide as CN	0.2	0.2
Vanadium as V	0.2	0.2
Arsenic as As	0.2	0.2
Phosphate as P	5	5
Oil and grease	10	10
Suspended solids	100	100
Fluoride as F*	10	10
Chromium as Cr**		
hexavalent*	0.1	0.1
Total	2.0	2.0

*To be complied with at the outlet of fluoride removal unit, if the recipient system so demands, fluoride as F shall be limited to 1.5 mg/l.

**To be complied with at the outlet of chromate removal unit.

8.9 COAL MINES

Air Quality Standards

The Suspended Particulate Matter (SPM), Respirable Particulate Matter (RPM), Sulphur dioxide (SO2) and Oxides of Nitrogen (NOx) concentrations at downwind direction, considering predominent wind direction at 500 m from the following dust generating sources shall not exceed the standards given in Tables I, II and III.

Table I

Category	Pollutant	Time wighted Avg.	Concentration in Ambient Air
New Coal Mines (Coal Mines coming up after Dec. 1998)	Suspended Particulated Matter (SPM)	Annual Average* 24 hours**	360 µg/m^3 500 µg/m^3
	Respirable Particulate Matter (size less than 10 mm) RPM	Annual Average* 24 hours**	180 µg/m^3 250 µg/m^3
	Sulphur Dioxide (SO_2)	Annual Average** 24 hours**	80 µg/m^3 120 µg/m^3
	Oxide of Nitrogen as NO_2	Annual Average* 24 hours**	80 µg/m^3 120 µg/m^3

Table II

Category	Pollutant	Time wighted Avg.	Concentration in Ambient Air
Existing coal fields/ mines and Central India Coalifields	Suspended Particualte Matter (SPM)	Annual Average** 24 hours**	430 μg/m^3 600 μg/m^3
	Respirable Particulate Matter (size less than 10 mm) (RPM)	Annual Average* 24 hours**	215 μg/m^3 300 μg/m^3
	Sulphur Dioxide (SO_2)	Annual* Average 24 hours**	80 μg/m^3 120 μg/m^3
	Oxide of Nitrogen as NO_2	Annual Average 24 hours**	80 μg/m^3 120 μg/m^3

Table III

Category	Pollutant	Time wighted Avg.	Concentration in Ambient Air	Method of Measurement
Old Coal Mines	Suspended Particulate Matter (SPM)	Annual Average* 24 hours*	500 μg/m^3 700 μg/m^3	High Volume Sampling (Average flow are not less than 1.1 m^3/min)
	Respirable Particu-late Matter (size less than 10 mm) (RPM)	Annual Average*	250 μg/m^3 300 μg/m^3	Respirable Particulate Matter Sampler
	Sulphur Dioxide (SO_2)	Annual* Average 24 hours**	80 μg/m^3 120 μg/m^3	1. Improved west and Gaeke method 2. Ultraviolet fluorescene
	Oxide of Nitrogen as NO_2	Annual Average* 24 hours**	80 μg/m^3 120 μg/m^3	1. Jacob & Hocchheiser Modified (Na-Aresenic Method) 2. Gas phase Chemi-lumine-scence

Effluent Standards

The standards for effluent discharge into sewer/stream/land, are given below :

PH	-	5.5 to 9.0
Total Suspended Solids	-	100 mg/l
	-	200 mg/l (Land for irrigation)
Oil and Grease	-	10 mg/l
Nitrate Nitrogen	-	10 mg/l

Noise level standards

The proposed standards are as given below :

	6.00 AM – 9.00 PM	9.00 PM – 6.00 AM
Noise level	Leq 75 dB(A)	Leq 70 dB(A)

8.10 HOSPITAL (BIO-MEDICAL) WASTES : ENVIRONMENTAL STANDARDS AND GUIDELINES FOR MANGEMENT

Standards for Incinerators

All incinerators shall meet the following operating and emission standards:

A. Operating Standards

1. Combustion efficiency (CE) shall be at least 99.00%.
2. The Combustion efficiency is computed as follows:

$$C.E. = \frac{\% \ CO_2}{\% \ CO_2 + \% \ CO} \times 100$$

3. The temperature of the primary chamber shall be 800 + 50°C.
4. The secondary chamber gas residence time shall be at least 1 (one) second at 1050 + 50°C, with minimum 3% oxygen in the stack gas.

B. Emission Standards

	Parameters	Concentration mg/Nm^3 at (12% CO_2 correction)
1.	Particulate matter	150
2.	Nitrogen Oxides	450
3.	HCl	50
4.	Minimum stack height shall be 30 metres above ground.	
5.	Volatile organic compounds in ash shall not be more than 0.01%.	

Notes:

- Suitably designed pollution control devices should be installed/retrofitted with the incinerator to achieve the above emission limits, if necessary.
- Wastes to be incinerated shall not be chemically treated with any chlorinated disinfections.

- Chlorinated plastics shall not be incinerated.
- Toxic metals in incineration ash shall be limited within the regulatory quantities as defined under the Hazardous Waste (Management and Handling Rules), 1989.
- Only low sulphur fuel like L.D.O./L.S.H.S./Diesel shall be used as fuel in the incinerator.

Standards for Waste Autoclaving

The autoclave should be dedicated for the purposes of disinfecting and treating bio-medical waste.

1. When operating a gravity flow autoclave, medical waste shall be subjected to
   - (i) A temperature of not less than 121°C and pressure of 15 pounds per square inch (psi) for an autoclave residence time of not less than 60 minutes; or a temperature of not less than 135°C and a pressure of 31 psi for an autoclave residence time of not less than 45 minutes; or
   - (ii) A temperature of not less than 149°C and a pressure of 52 spi for an autoclave residence time of not less than 30 minutes.
2. When operating a vacuum autoclave, medical waste shall be subjected to a minimum of one pre-vacuum pulse to purge the autoclave of all air. The waste shall be subjected to the following:

A temperature of not less than 121°C and pressure of 15 psi per an autoclave residence time of not less than 45 minutes; or

A temperature of not less than 135°C and a pressure of 31 psi for an autoclave residence time of not less than 30 minutes

1. Medical waste shall not be considered properly treated unless the time, temperature and pressure indicators indicate that the required time, temperature and pressure were reached during the autoclave process. If for any reasons, time temperature or pressure indicator indicates that the required temperature, pressure or residence time was not reached, the entire load of medical waste must be autoclaved again until the proper temperature, pressure and residence time were achieved.
2. Recording of operational parameters.
3. Each autoclave shall have graphic or computer recording devices which will automatically and continuously monitor and record dates, time of day, load identification number and operating parameters throughout the entire length of the autoclave cycle.
4. Validation test

Spore Testing

The autoclave should completely and consistently kill the approved biological indicator at the maximum design capacity of each autoclave unit. Biological indicator for autoclave shall be Bacillus stearothermophilus spores using vials or spore strips, with at least 1 × 104 spores per millilitre. Under no circumstances will an autoclave have minimum operating parameters less than a residence time of 30 minutes, regardless of temperature and pressure, a temperature less than 121°C or a pressure less than 15 psi.

Routine Test

A chemical indicator strip/tape that changes colour when a certain temperature is reached can be used to verify that a specific temperature has been achieved. It may be necessary to use more than one strip over the waste package at different location to ensure that the inner content of the package has been adequately autoclaved.

Standards for Liquid Waste

The effluent generated from the hospital should conform to the following limits:

Parameters	Permissible Limits
pH	6.5–9.0
Suspended solids	100 mg/l
Oil and grease	10 mg/l
BOD (3 days at 27°C)	30 mg/l
COD	250 mg/l
Bio-assay test	90% survival of fish after 96 hours in 100% effluent

These limits are applicable to those hospitals which are either connected with sewers without terminal sewage treatment plant or not connected to public sewers. For discharge into public sewers with terminal facilities, the general standards as notified under the Environment (Protection) Act, 1986 shall be applicable.

Standards of Microwaving

1. Microwave treatment shall not be used for cytotoxic, hazardous or radioactive wastes, contaminated animal carcasses, body parts and large metal items.
2. The microwave system shall comply with the efficacy test/routine tests and a performance guarantee may be provided by the supplier before operation of the unit.
3. The microwave should completely and consistently kill the bacteria and other pathogenic organisms that is ensured by approved biological indicator at the maximum design capacity of each microwave unit.
4. Biological indicators for microwave shall be Bacillus subtillis spores using vials or spore strips with at least 1 × 104 spores per millilitre.

Standards for Deep Burial

1. A pit or trench should be dug about meters deep. It should be half filled with waste, then covered with lime within 50 cm of the surface, before filling the rest of the pit with soil.
2. It must be ensured that animals do not have any access to burial sites. Covers of galvanised iron/wire meshes may be used.
3. On each occasion, when wastes are added to the pit, a layer of 10 cm of soil shall be added to cover the wastes.

4. Burial must be performed under close and dedicated supervision.
5. The deep burial site should be relatively impermeable and no shallow well should be close to the site.
6. The pits should be distant from habitation, and sited so as to ensure that no contamination occurs of any surface water or ground water. The area should not be prone to flooding or erosion.
7. The location of the deep burial site will be authorised by the prescribed authority.
8. The institution shall maintain a record of all pits for deep burial.

REVIEW QUESTIONS

1. Define the term environment.
2. Name the two broad classifications of the environment.
3. What are the four segments of the earth's environment?
4. What are the major constituents of earth's atmosphere?
5. Name the four major zones of the atmosphere.
6. Trace the origin of the word Ecology.
7. What are the two important divisions of ecology?
8. Define an ecosystem. Give suitable examples.
9. What are biotic and abiotic components of an ecosystem?
10. What is meant by an ecological factor?
11. What are producers, consumers and decomposers in an ecosystem?
12. What are primary, secondary, tertiary and quaternary consumers?
13. Explain the process of photosynthesis with the generalized photosynthetic reaction equation.
14. Differentiate between a food chain and a food web.
15. Name the six important biogeochemical cycles in the ecosystems.
16. What are the anthropogenic and non-anthropogenic causes of environmental deterioration?
17. List the physical and biological natural hazards.
18. What are the causes of global warming?
19. What are the impacts of acid rain?
20. Explain greenhouse effect.
21. Explain with suitable chemical reactions, the chemistry of ozone layer depletion.
22. What is biodiversity? Name different types of biodiversity.
23. Explain the *ex-situ* and *in-situ* conservation approaches for biodiversity.
24. What is a photochemical smog?
25. What caused the Bhopal gas tragedy?
26. What is minamita disease?
27. List the different physical, chemical and biological water quality parameters.
28. Explain the term pH.
29. Differentiate between temporary hardness and permanent hardness.
30. What are the sources of particulate matter in air?
31. What are bioaerosols? What are their impacts on human health?

32. Classify the different types of rocks on the earth.
33. What are the minerals found on the earth's crust?
34. List the different constituents of the soil.
35. What are the functions, of the soil?
36. What is meant by environmental stress?
37. List the five important environmental issues identified in our country.
38. What are the major global environmental issues?
39. Define air pollution.
40. List the man made and natural causes of air pollution.
41. What are the different ways in which the air pollutants are classified?
42. What are air quality standards?
43. What are the major air pollutants emitted from thermal power plants and petroleum refineries?
44. What are the air pollutants emitted from automobiles?
45. What is meant by source correction in respect of air pollution?
46. List out different air pollution control devices.
47. Define wastewater.
48. What are point and non-point sources of wastewater?
49. Define preliminary, primary, secondary and tertiary treatment of wastewater.
50. Differentiate between equalization and neutralization.
51. List different chemicals used for neutralization of effluents.
52. What is meant by coagulation? Name some coagulants used for treatment of wastewater.
53. Distinguish between aerobic and anaerobic treatment of waste water.
54. What are the different membrane separation operations in wastewater treatment?
55. What is meant by disinfection of wastewater?
56. What are the physical and chemical methods of disinfection?
57. Define waste.
58. What are the various sources of waste?
59. Classify different types of waste.
60. What are the characteristics of hazardous waste?
61. State the objectives of solid waste management in an industry.
62. What are the different methods of disposal of municipal solid waste?
63. What is meant by biomedical waste?
64. Define waste minimization.
65. What are the different waste minimization techniques?

66. What is waste reuse, recycling and recovery?
67. What are the benefits and barriers of waste minimization?
68. What is a clean technology? Give few examples.
69. What is a fuel cell?
70. Define sustainable development.
71. Differentiate between environmental standards and environmental quality objectives.
72. Write a short note on environment system standards (ISO 14000).
73. Define the developmental policy cycle.
74. Explain the term EIA.
75. What is environmental impact statement.
76. What is meant by ECOMARKING?
77. Who are all the stakeholders in the EIA process?
78. State the precautionary principle.
79. State the polluter pays principle.
80. List a few implementation strategies of polluter pays principle.
81. Expand the term CPCB and SPCB.
82. State the major environmental laws in force in India.
83. What is meant by PIL?
84. List a few environment associated PILs in India.
85. What are the different economic instruments for environmental management?
86. Explain the term NGO from an environmental perspective.
87. List a few Indian and international environmental NGOs.
88. List important international conventions and protocols related to environmental protection.
89. Which is the world environment day?
90. Write briefly about Kyoto protocol.

DETAILED ANSWERS

1. Write short notes on:
   (a) Lithosphere
   (b) Hydrosphere
   (c) Atmosphere
   (d) Biosphere.
2. With typical examples explain the interrelationship between the components and subcomponents of the environment
3. Explain with a neat diagram the different zones of the earth's atmosphere and their characteristics.

4. Write a detailed note on abiotic components and biotic components of an ecosystem.
5. Write a detailed note on development and evolution of ecosystem.
6. With a neat diagram explain the different energy levels in an ecosystem. Explain all the parameters involved.
7. With suitable diagrams explain the following biogeochemical cycles.
   (a) Hydrological cycle
   (b) Carbon cycle
   (c) Nitrogen cycle
   (d) Oxygen cycle
   (e) Sulphur cycle
   (f) Phosphorous cycle.
8. Briefly describe about the following natural hazards
   (a) Earthquakes
   (b) Volcanic eruptions
   (c) Floods
   (d) Cyclones, hurricanes, tornadoes
   (e) Tsunamis
   (f) Snow and ice
   (g) Thunderstorms
   (h) Droughts
   (i) El nino and La Nina
   (j) Fog
   (k) Forest and wild fires.
9. Write detailed notes on the following man made impacts on the environment
   (a) Global warming
   (b) Acid rain
   (c) Ozone layer depletion
   (d) Eutrophication
   (e) Loss of biodiversity.
10. Explain why biodiversity is very important for the existence of the human race. What are the different restoration and conservation measures for the repair and revamping of biodiversity.
11. Write a detailed note on
    (a) Suspended matter and turbidity
    (b) Colour, Taste and odour
    (c) pH, hardness
    (d) Pathogens.

12. Write a detailed note on the chemical reactions in the atmosphere involving oxides of sulphur and nitrogen, organic compounds, ozone, and chlorine.
13. Write down the chemical reactions involved in the formation of photochemical smog.
14. Explain the different causes, impacts of environmental stresses.
15. Write a detailed note on causes, identified strategies and remedial steps taken for the following environmental issues in India
    (a) Land degradation
    (b) Biodiversity
    (c) Industrial and vehicular air pollution
    (d) Fresh water resources
    (e) Hazardous and municipal solid waste management.
16. Elaborate on the current the global environmental issues.
17. What are the major air pollutants? What are their sources, characteristics and impact on the environment?
18. Explain the different methods of reducing air pollutants from IC engines.
19. With suitable diagrams, explain the functioning of different pollution control devices like cyclone separator, gravity settling chamber, bag filter, electrostatic precipitator and ventury scrubber.
20. Characterize the wastewater from different industries based on their composition, sources, impacts and treatment methods.
21. Write short notes on
    (a) Screening
    (b) Grit chambers
    (c) Skimmers.
21. Explain with neat diagrams secondary process like activated sludge process, oxidation ditches and trickling filters.
22. With a general schematic flow sheet explain the different stages and processes involved in the treatment of municipal sewage.
23. Briefly explain the wastewater treatment processes for the following industries with the aid of flow sheets
    (a) Petroleum refinery
    (b) Paper and pulp mill
    (c) Cotton textile mill
    (d) Woolen textile mill
    (e) Tannery
    (f) Diary
    (g) Pharmaceutical plant.

24. Explain the process of composting and sanitary landfill.
25. Write a detailed note on incineration and pyrolysis.
26. Explain the physical, chemical and biological disposal methods of hazardous waste.
27. Write an explanatory note on biomedical waste treatment techniques.
28. What are the sources and disposal options of electronic waste?
29. Explain in detail the approaches to be adopted for waste prevention in manufacturing industries.
30. Enumerate the different steps involved in establishing a waste minimization program in an organization.
31. Write an explanatory note on biodegradable plastics and biodiesel.
32. Explain the major issues involved in the sustainable development. Name a few indices.
33. Critically examine the various aspects of organizational environmental policy and policies on developmental projects.
34. Discuss in detail the policy strategies for developmental projects under the following heads:
    (a) Population control
    (b) Conservation of natural resources
    (c) Biodiversity
    (d) Agriculture and irrigation
    (e) Energy
    (d) Industrial development
    (e) Transportation
    (f) Tourism
    (g) Urbanization.
35. Discuss the various steps involved in the EIA. List out the benefits of EIA.
36. Discuss in detail about the precautionary principle elaborating the reasons for adopting, methods of implementing and arguments for and against the same.
37. What are the functions of central and state pollution control boards in India?
38. Characterize the different economic instruments for environmental management. What are the limitations of these economic instruments?
39. Discuss the role of Non-government organizations in environmental management and the need for community participation in environmental management.
40 Write short notes on
    (a) United Nations Conference on Human Environment, 1972.
    (b) United Nations General Assembly Regulation, 1972.
    (c) Charter of Economic Rights and Duties of States, 1974.
    (d) The Convention on International Trade in Endangered Species CITES, 1975

(e) UN Habitat Conference on Human Settlement of 1976 and Water Conference of 1977.

(f) Environmental Education Conference.

(g) Control of Transboundry Movement and Disposal of Hazardous Waste (Basel Convention).

(h) Earth summit-1992 (Rio-Declarations on Environment & development).

(i) The Vienna Convention on Ozone Layer Depletion–Montreal Protocol.

(j) United Nations Climate Change Control Convention (UNCCC)–Climate of Greenhouse Control Convention.

(k) Manila Declaration on Green Productivity.

(l) United Nations Framework Convention on Climate Change–Kyoto Protocol.

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