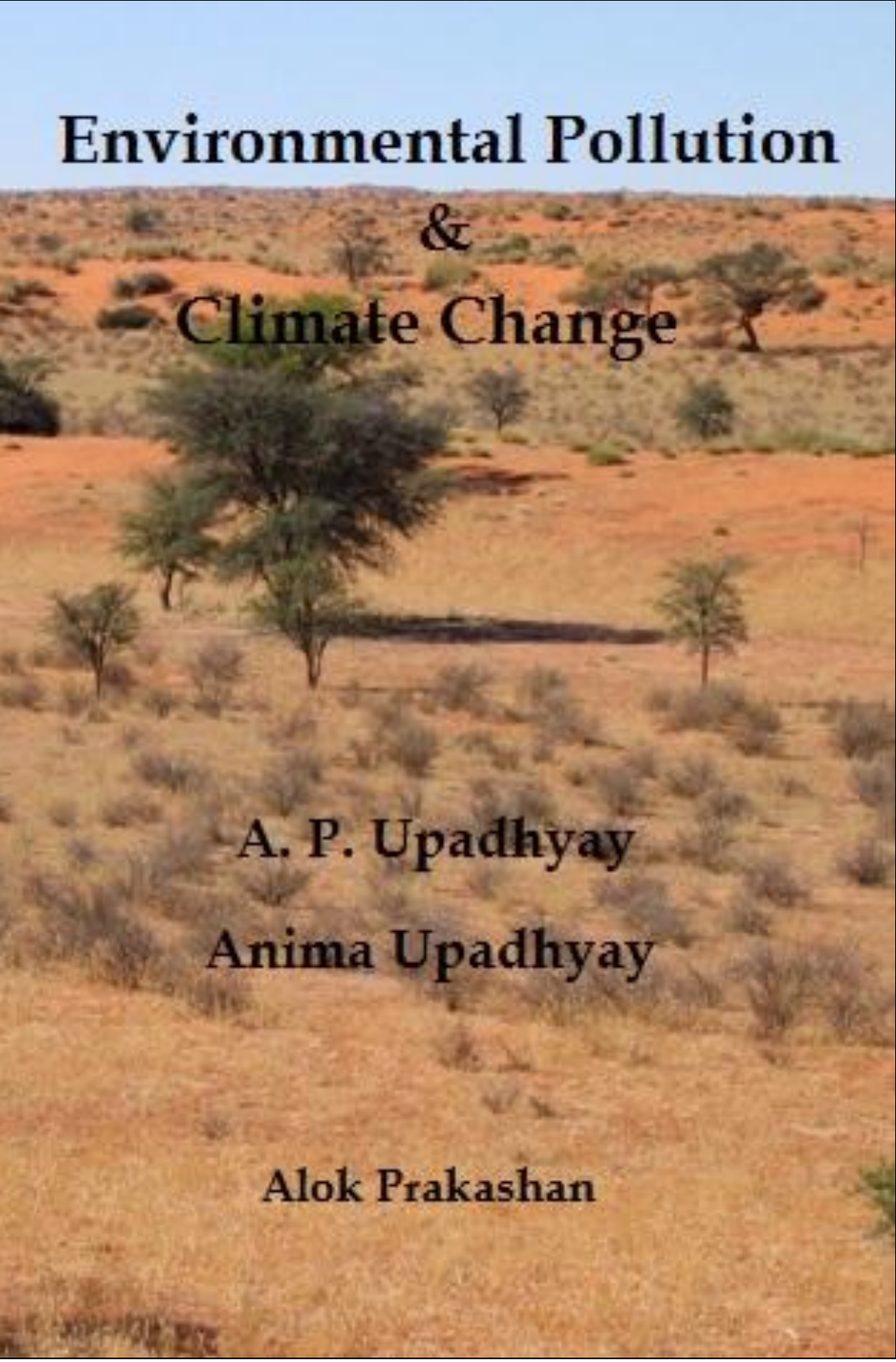
Environmental Pollution
&
Climate Change



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PREFACE

Economic development particularly in the post industrial revolution period has resulted to unprecedented environmental damage. This rapid pace of global environmental degradation is serious cause of concern as this may lead to inhabitability of the Earth. There is also a growing realization that this path of prosperity is not sustainable because of it's over exploitative nature. The scientific facts about the extent of extensive damage and on its consequences are really scary putting the entire humanity at serious risk. However, despite the growing realization of environmental damage, the world community lacks the commitment to address global issues like eminent threat of climate change with its disastrous consequences. Such threats cannot be tackled if some of the most polluting countries are reluctant to act. The environmental degradation is a matter of serious concern for a developing country like India where limited natural resources are already severely constrained to fulfil the legitimate aspiration of its large population. India is on the rapid economic development path and demographic transition. In order to address the economic and social deprivation, country faces a formidable challenge in achieving sustainable growth and protecting the environment. Rapid urbanization, industrialization and large agricultural sector have obvious environmental impact and it is imperative to include environmental concerns in its democratic developmental policies with its commitment of 'Development without Destruction'.

Education and creating awareness about the environmental concerns is one of the effective ways for larger participation of people in promoting clean economic endeavors. The book is an attempt to compile the relevant information in a lucid manner for anyone with genuine concern for environment. It is not just a textbook for class room teaching but a general reference book for any reader. This small compilation of information is not an exhaustive coverage of such a vast topic but an attempt to cover some of the important topics briefly. Authors would greatly appreciate any suggestions for its improvement.

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1. INTRODUCTION

Atmosphere

The gaseous envelope that covers and surrounds the earth is called atmosphere. It is made up of many layers namely troposphere, stratosphere, mesosphere, thermosphere, exosphere and ionosphere. The different layers and their height in kilometres are described below in detail.

Troposphere: It is the innermost layer which is closest to the earth and is about 12 km thick. It is thin at the poles around 8 km and thick at the equator around 12 km. Clouds and weather constitutes this layer. The temperature in this layer decreases with altitude. This layer of earth is region of maximum activity, and is responsible for change of climate and change of seasons. Gaseous pollutants and suspended particles present in the air of troposphere react together and form secondary pollutants which are responsible for greenhouse effect and global warming. The presence of water vapour in the troposphere is responsible for cloud formation. The water vapour condenses on the suspended particles in the air to form the clouds.

Stratosphere: The stratosphere extends from about 12-50 kilometres above the Earth's surface. This is the region where ozone is found hence this is also called as ozone layer region, which absorbs most of the harmful ultraviolet radiations from the Sun, and prevents the earth from harmful radiations and cosmic rays to reach the earth and harm its habitants. The temperature in the stratosphere increases with the altitude. The highest temperature in this region is about 32^{o}F (0^{o}C).

Mesosphere: The region beyond stratosphere is mesosphere. It starts from around 50 kilometres above the earth. Here the atmosphere is rarefied and thin. The temperature decreases with the increase in altitude in the region and is about -130^{o}F (-90^{o}C).

Thermosphere: The thermosphere begins at a height of about 90 kilometres from the earth. This is a very hot region. Temperature in this region is as high as thousands of degrees. The temperature in this

region is not measured by any thermometer but by observing the motion and speed of the rarefied gases.

Exosphere: The penultimate layer or the region beyond thermosphere is called Exosphere. It begins around 700 kilometres from the earth and extends up to 10,000 kilometres.

Ionosphere: The ionosphere is the outermost layer of the atmosphere that overlaps all the atmospheric layers, above the Earth. The air is ionized by the Sun's ultraviolet light. These ionized layers affect the transmittance and reflectance of radio waves. Different ionosphere layers are the D, E (Heaviside-Kennelly), and F (Appleton) regions.
The various layers of atmosphere with altitude are given below in table (1):

Table1. Layers of atmosphere and their height in km

Name of the Layer	**Height in kilometres**
Troposphere	0-12
Stratosphere	12-50
Mesosphere	50-90
Thermosphere	90-700
Exosphere	700-10,000
Ionosphere	10,000 and beyond

Environment

The surroundings or conditions in which living and non-living are associated and interact with each-other in the earth's atmosphere is called environment. In other words, the habitat or abode of an organism is defined as its environment. It includes both living and non-living things and natural forces. It is the environment where the organism grows, develop, propagate and emerge into new species or get extinct. Living things not only live in their environment but also exploit it to the extent of its danger. Story of evolution of humans into modern age has led to the maximum damage of the earth's environment. The environment has a self-cure capacity to repair itself. Reasonable interactions between species and atmosphere bring smaller reversible and reparable changes in the environment. These

changes are negligible and good for its growth. These changes in the environmental is a result of interactions between living and non-living matter in the atmosphere such as plants, animals, soil, water, temperature, light, wind and microorganisms.

Our Earths environment is a thermodynamic system made up of the Earth's crust and layers of gases around the Earth called the *atmosphere.* As we go up from the surface of the earth are the gases as explained above in the atmosphere. Similarly, the surface below the earth is also made up of many layers namely crust, mantle and core. It is the earth's crust where interaction between living and non-living takes pace. Crust is the abode to many animals, most plants and microorganisms.

The layers of earth and the depth of the layers are tabulated below in the table (2).

Table 2. Layers of earth with depth in kilometres

Layer	**Depth (Kilometres)**
Lithosphere	0-60
Crust	0-35
Uppermost part of mantle	35-60
Mantle	35-2890
Upper Mesosphere	210-270
Lower Mesosphere	660-2890
Outer Core	2890-5150
Inner Core	5150-6360

Environmental science: It is the systematic study of the interactions of the biotic and non-biotic factors on the environment. The major areas of study are: The effect of **human activity** on the environment, Pollution including **air**, **water** and **soil pollution**. Effects of **fossil fuels** and **Climate Change** are other important aspects of the environment. Environmental science and study of the various factors disrupting its natural course has become relevant with growing industrialization and urbanization. The study features natural and man-made materials as well the social environment.

Environment Change

A change or disturbance in the environment caused either by human influences or natural ecological processes are termed as environmental change. It includes: Natural disasters such as earth quake, volcanic eruptions, floods, draughts, storms and cloud burst. Human activities, also brings change in environment, such as deforestation, improper cultivation techniques, waste creation and waste disposal, industrialization and urbanization. It not only implies to mere physical changes but it is about the complete extinction of certain species of plants and animals from the planet earth.

Human Interference with Environment

The nature created a variety of species during evolution these were in total harmony until the creation of human beings on the earth. The Stone Age man or the uncivilized man also lived at peace and friendship with the nature. But, with the set in of civilization humans started unreasonable exploitation of earth, and its atmosphere for his selfish motives. Thus, it is the humans whose activities are responsible for the degradation and change of the atmosphere called pollution. Some of the harmful effects on the atmosphere attributed to human activities are as under:

1. Release of untreated effluents in water bodies leading to water pollution.
2. Direct release of flue gases in the atmosphere leading to air pollution.
3. Emission of greenhouse gases by excessive use of excessive fossil fuels.
4. Improper farming and misuse of chemicals in it leading to soil pollution.
5. Excessive mining leading to soil erosion and mineral depletion.
6. Deforestation to get land for cultivation.

Environmental Pollution

Pollution may be defined as the addition of substances that alters the normal composition of the air, water or soil bringing about a permanent and irreparable damage to it. The added substances are called pollutants or contaminants. They may be hazardous or non-hazardous in nature.

Pollutants

Substance or energy that affects the environment adversely is called a pollutant. Pollutants are naturally occurring minerals, synthetic material, gases and radiations. There is an increasing trend in the degree of environmental pollution. The human greed and his lure towards luxury has been major cause of atmospheric pollution and affecting the environment badly. The effect is a permanent change in climate and seasons leading to frequent floods and long and everlasting draughts. Rising sea-levels and melting of polar caps and glaciers are all now a matter of serious concern. The various types of pollutions should be studied and understood in detail in order to control and prevent them. In this book, the major types of pollutions, their sources, effects and control measures are discussed in detail under separate chapters, not ignoring the very important topic of Climate Change, its effect and remedies. The waste management and its disposal methods are also discussed in the end. The various types of pollution discussed in the book are air pollution, water pollution, soil pollution, noise pollution, thermal pollution and radioactive pollution. Climate change is of great significance and without having an understanding of it we cannot do much for the humans in this direction hence it is dealt in detail in a separate chapter in detail about climate change.

2. Air Pollution

It is an inexhaustible natural resource. It is essential for the survival of all the living organisms on earth. In atmosphere, about 95% of the total air is present only up to a height of 20 km above the earth's surface. The region where air is found is called troposphere. The remaining 5% of atmospheric air is present up to a height of about 280 km called, stratosphere. Thus the amount of air decreases as we go far from the earth surface. Composition of air is fixed; it is a mixture of different gases with Nitrogen and Oxygen as the major components of air 78.09% and 20.93% by volume respectively. The remaining 1% is made up of other gases such as Carbon di oxide (0.03%), Argon (0.93%), Neon, Helium, Krypton, Xenon and Radon (0.02%). Thus, the layers of atmosphere beyond stratosphere that is mesosphere, thermosphere and exosphere have no air. The air protects the life on the earth from extra-terrestrial disturbances such as meteorites and harmful UV radiations. It is also responsible in keeping optimum temperature on the earth for the habitats of the earth. It monitors Change of seasons, climate change, cloud formation and water vapour. The composition of the air is given in the table (1).

Table1. Composition of Air

Gas	**Relative %age Volume**
Nitrogen (N_2)	78.09
Oxygen (O_2)	20.93
Argon (A)	0.93
Carbon di oxide (CO_2)	0.03
Miscellaneous	0.02
Total	100.000

Air Pollution

The substances or particles that on mixing with air, alters the composition of air are called *air pollutant*s and this undesired change in the composition of air is referred to as *air pollution*.

Air pollutants: They are usually classified into the following types

- Suspended particulate matter (dusts, fumes, mists, smokes)
- Gaseous pollutants (gases and vapours)
- Odours (Mercaptans)
- Water vapour
- Fossil fuels (coal and petroleum)

The major air pollutants are described in detailed as under:

Suspended particulate matter (SPM): The finely divided solid or liquid particles that may be dispersed through the air from various combustion processes, industrial activities or natural sources are called suspended matter. Their size varies from >3 to 10 microns. Particles that are less than 3 microns if inhaled get deposited in the narrow airways of the lungs and cannot be expelled by coughing. Although particles from 3 to 10 microns are too large to be deposited deep in the lungs, but they are small enough to remain suspended in the atmosphere for days together.

Origin of SPM: SPM is generated by smoking, combustion of fossil fuels, automobile exhaust, fly ash, carbon black, oil smoke, civil and construction works, mineral dust-asbestos and cement, mining, metal dust fumes (e.g., zinc, copper, iron and lead) flue gases, acid mists (sulphuric acid, oxides of nitrogen), paints, varnishes, pigments, pesticide mists, pollen grains, volcanic eruptions, cyclones, natural disasters such as fire hazards, thunder storms, soil erosion etc.

Harmful Effects of SPM: It is responsible for respiratory diseases, cancers in humans. It leads to corrosion and destruction of constructions, buildings and monuments. It reduces plant life by getting deposited on leaves and bark of the plants and trees and interfering with their plant physiology. It also lowers the visibility by forming smog. It interferes with sunlight and leads to formation of haze a scattering phenomenon of light that again lowers the visibility on the highways leading to road accidents.

Gaseous pollutants: The pollutants that are gaseous in nature and alter the composition of the air by getting mixed with it are called gaseous pollutants. There are two types of gaseous pollutants: *Primary gaseous pollutants* and *secondary gaseous pollutants*.

Primary Gaseous Pollutants: These pollutants include oxides of sulphur (e.g., sulphur dioxide and sulphur trioxide), oxides of carbon (carbon monoxide, carbon dioxide) oxides of nitrogen (nitric oxide, nitrogen dioxide, ammonia), organic compounds such as hydrocarbons, volatile organic compounds (VOC), polycyclic aromatic hydrocarbons (PAH), halogen derivatives (HF and HCl), hydrogen sulphide, carbon disulphide and mercaptans (odours).

Secondary gaseous pollutants: Secondary gaseous pollutants are the product of thermal, chemical or photochemical reactions of primary gaseous pollutants with other suspended gaseous pollutants in presence of high atmospheric humidity, sunlight and high temperature.

Some examples of formation of secondary gaseous pollutants:
During the day when the temperatures are relatively high, sulphur dioxide is oxidized gradually to sulphur trioxide which, in contact with water vapour, forms sulphuric acid mist. The reaction is catalysed by the presence of manganese and iron oxides in the atmosphere.
Other important products produced as a result of photochemical reactions are ozone (O_3), peroxyacetyl nitrate (PAN), and formaldehyde. These are formed by the reactions between oxides of nitrogen and hydrocarbons in presence of sunlight. The formaldehyde so formed then reacts with HCl to give hazardous substance bis-chloromethyl ether.

Gaseous pollutants their origin and their effects on environment

Oxides of Sulphur (SO_X)

SO_2 is a toxic chemical produced by volcanic eruptions and by various industrial and combustion processes. Combustion of fossil fuels releases large amount of sulphur dioxide in the atmosphere, as

sulphur is present as volatile matter in the composition of fossil fuel. The further oxidation of SO_2, usually in the presence of moisture and NO_2 as a catalyst, results in the formation of H_2SO_4. The acid so formed than precipitates and come down as acid rain on the earth. It has harmful effects on buildings and constructions, it also leads to soil erosion, skin irritation, it also alters the pH of the water bodies thus making it unfit for use.

Oxides of Nitrogen (NO_X)

Nitrogen oxides, particularly nitrogen dioxide (NO_2) are expelled from the fuels when they are burnt at a very high temperature. They are also produced during thunderstorm by electric discharge. Oxides of nitrogen are one of the most prominent air pollutants. They are reddish-brown toxic gases with a pungent acrid odour. They are also responsible for producing acid rain.

Oxides of Carbon

It includes carbon monoxide (CO) and carbon di oxide (CO_2). Oxides of carbon are produced by combustion of fuels in air, respiration and other metabolic processes like decomposition and from exhaust gases of automobiles.

Carbon monoxide (CO): It is a colourless, odourless, toxic yet non-irritating gas. It is produced due to incomplete combustion of fuel such as natural gas, coal, wood and mineral oil. Vehicular exhaust is also a major source of carbon monoxide.

Carbon di oxide (CO_2): The complete combustion of fuel produces CO_2 and water. CO_2 is released in the atmosphere when fossil fuels are burnt completely. It is also a product of respiration. It plays an important role in greenhouse effect and global warming as it as a major greenhouse gases other than ozone and CFCs.

Harmful effects of Carbon monoxide: It suffocates to death if inhaled. Carbon monoxide lowers down oxygen carrying capacity of haemoglobin which ultimately results into death.

Harmful effects of Carbon dioxide: It is a measure greenhouse gas and is responsible for global warming and glasshouse effect. Its concentration in the atmosphere can be controlled and lowered by

afforestation and planting more trees in the cities, using clean and smoke free fuels, reducing the number of livestock, using non-conventional sources of energy.

Volatile organic compounds (VOC)

They are important air pollutants. They are classified as methane (MVOCs) or non-methane (NMVOCs) volatile organic compounds.
Harmful effects of VOC on atmosphere and humans: Volatile pollutants are responsible for global warming as they are not only greenhouse gases themselves but also help, in prolonging the life of methane in the atmosphere which is the most efficient greenhouse gas. The other harmful effects of VOC that affects human life adversely are:

- It causes irritation in Eyes, nose and throat.
- It causes headache, loss of coordination and nausea.
- It causes damage to liver, kidney and central nervous system.
- It is carcinogenic and causes cancer.

Water vapour

Water vapour is one of the earth's most important greenhouse gases, accounting for about 90% of the Earth's natural greenhouse effect; it helps in keeping the Earth warm enough to support life. When liquid water is evaporated to form water vapour, heat is absorbed. This helps to cool the surface of the earth. The presence of water vapour in the atmosphere plays a significant role in determining the weather. Clouds and precipitation occur as a result of the phase change that occurs when water vapour condenses into liquid water. The amount of water vapour in the air is also a measure of atmospheric humidity.

Mist: It is small droplets of water suspended in air. Mist is formed when warmer air over water suddenly encounters the cooler surface of land. However, mist can also be formed when warm air from land suddenly encounters cooler air. Mist can occur as part of natural weather or volcanic activity, and is common in cold air above warmer water, in exhaled air in the cold, and in a steam room of a sauna. The only difference between mist and fog is its visibility.

Frost: It forms when the atmospheric temperature is below freezing. The moisture goes straight from gaseous state to solid state resulting into mist formation.

Dew: If the moisture goes from gaseous to a liquid and then to solid state, then the result will be frozen dew.

Precipitation: The condensation of atmospheric water vapour that falls under gravity is called precipitation. The main forms of precipitation include drizzle, rain, sleet, hail and snow.

Rain: It is the most common kind of precipitation. Drops of water are called rain if they are at least *0.5 millimetres* in diameter. Precipitation made up of smaller drops of water is called mist or drizzle.

Chlorofluorocarbons (CFCs)

Chlorofluorocarbons are compound that contain only carbon, chlorine, and fluorine atoms. They are produced as a volatile derivative of methane, ethane and propane. The Chlorofluorocarbons are more commonly referred to as **CFCs.** They have wide industrial applications such as, propellants in aerosol, propellants in jet fuels, in cooling or refrigeration etc. **CFCs** are commonly known as Freon. They are responsible for depletion of ozone layer in the stratosphere and formation of smog with ground level ozone.

Hydro carbons

These are organic compounds with hydrogen and carbon as major constituents. They could be aliphatic (methane, ethane, ethylene, acetylene) or aromatic (benzene, naphthalene). They could be saturated (methane, ethane) or unsaturated (ethylene, acetylene) as well as straight chain (ethane, ethylene), ring (benzene, naphthalene) or cyclic (cyclohexane) hydrocarbons.

Sources of Hydro carbons: All living beings including plants and animals are made up of hydrocarbons. On burning in air the carbon in the organic matter is released as carbon dioxide and hydrogen forms water vapour. Fossil fuels are the best sources of hydrocarbons.

Fossil fuels: The conventional sources of energy such as coal and petroleum are called fossil fuels. Their products of combustion are largely responsible for air pollution. They produce enormous energy at the cost of environmental pollution. The harmful gases such as CO_2, CO, SO_2, SO_3, NO_X, soot and ash are produced in large amount on combustion of these fuels.
Composition of fossil fuels: Fossil fuels are made up of hydrocarbons with little percentage of volatile matter (nitrogen and sulphur) and oxygen.

Classification of fossil fuels:
Fossil fuels are classified on the basis of their occurrence in nature into *primary* and *secondary* fuels.
They can be further classified into solid, liquid and gaseous fuels based on their aggregation.
The classification is shown schematically in the figure (1) for better understanding.
Primary fuels are those which occur in nature and can be used directly as energy sources.
Examples: wood, peat, lignite, coal, crude oil and natural gas.
Secondary fuels are those which are derived from primary fuels and have better calorific values than primary fuels.
Examples: coke, gasoline, diesel, kerosene, coke oven gas, oil gas, water and producer gas.

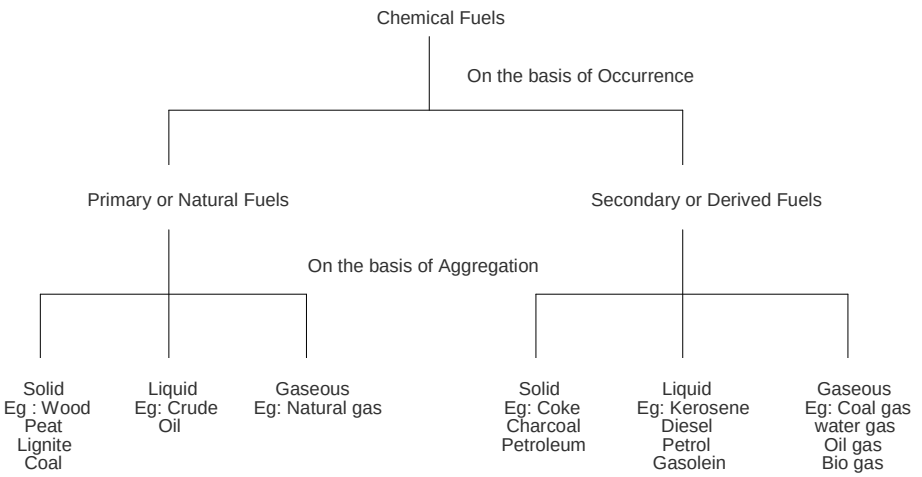

Figure 1: Schematic representation of classification of Fossil fuels

Products of combustion of fossil fuels: They are generally mixture of various harmful oxides of carbon, nitrogen and sulphur, ash and water vapour. Sometimes the water vapour and gases carry along with them particulate matter consisting of unburned carbon and soot along with fine ash. They have the following major environmental drawbacks that lead to severe pollution:

The oxides of carbon are most disastrous greenhouse gases and lead to global warming.

Ash, dust and unburned carbon particles get way in the atmosphere and form suspended matter which gives nuclei for the water-vapour to produce smog, photochemical smog that reduces visibility.

Oxides of sulphur and nitrogen released as a result of burning are responsible for acid rain and harm the constructions, infrastructures, buildings, flora and fauna by altering the pH, soil erosion, skin diseases and many more.

Some major pollutants associated with different sectors are presented in table (2) below:

Table 2. Major Air Pollutants emitted from Various Sectors.

Industry	**Source**	**Emitted Pollutants**
Agriculture	Open burning	SPM, CO, VOC
Mining and quarrying	Coal mining	SPM, SO_2, NO_X, VOC
	Crude petroleum and natural gas production	SO_2
	Non-ferrous ore mining	SPM, Pb
	Stone quarrying	SPM
Manufacturing	Food, beverages and tobacco	SPM, CO, VOC, H_2S
	Textiles and leather industries	SPM, VOC
	Wood products	SPM, VOC
	Paper products, printing	SPM, SO_2, CO, VOC, H_2S, R-SH
Manufacture of chemicals	Phthalic anhydride	SPM, SO_2, CO, VOC
	Chlor-alkali	Cl_2
	Hydrochloric acid	HCl
	Hydrofluoric acid	HF, SiF_4

Industry	Source	Emitted Pollutants
	Sulphuric acid	SO_2, SO_3
	Nitric acid	NO_X
	Phosphoric acid	SPM, F_2
	Lead oxide and pigments	SPM, Pb
Petroleum refineries	Miscellaneous products of petroleum and coal	SPM, SO_2, NO_X, CO, VOC
Non-metallic mineral products manufacture	Glass products	SPM, SO_2, NO_X, CO, VOC, F
	Structural clay products	SPM, SO_2, NO_X, CO, VOC, F_2
	Cement, lime and plaster	SPM, SO_2, NO_X, CO
Basic metal industries	Iron and steel	SPM, SO_2, NO_X, CO, VOC, Pb
	Non-ferrous industries	SPM, SO_2, F, Pb
Power generation	Electricity, gas and steam	SPM, SO_2, NO_X, CO, VOC, SO_3, Pb
Transport		SPM, SO_2, NO_X, CO, VOC, Pb
Community services	Municipal incinerators	SPM, SO_2, NO_X, CO, VOC, Pb

International Agencies who Monitor Air Pollution across the globe

World Health Organization (**WHO**), World Meteorological Organization (**WMO**) and the United Nations Environment Programme (UNEP) are the international bodies that have instituted to monitor research projects in order to address the issues involved in air pollution and to promote measures to prevent further deterioration of public health and environmental and climatic conditions.

GEMS/Air is a Global Environment Monitoring System organised and sponsored by WHO and UNEP, and has developed programme for rational air pollution management.To monitor air pollution besides developing a databasr of urban air pollutant concentrations, it

also provides guides for emission inventories and cost –benefit analysis. It also provides methodology, review handbooks, conducts global assessments of air quality,facilitates review of and validation of assessments, facilitates or identifies regionalcollaboration centres or experts according to the needs of the region.

GAW is Global Atmospheric Watch programme. It provides data and information on the composition and physical characteristics of the atmosphere to understand the relationship between changing atmospheric composition and changes of global and regional climate. This helps in studying long range atmospheric transport and deposition of harmful substances over ecosystem (terrestrial, fresh-water and marine). It also monitors natural cycling of chemical elements in the global system (ocean, atmosphere and biosphere). One of the most important aspects of the GAW is the establishment of Quality Assurance Science Activity Centres to oversee the quality of the data produced under GAW.

The GAW programme has four activity areas namely:

Global Ozone Observing System (GO3OS)
Global Monitoring of background atmospheric composition
Global Zone Observing system (GO3OS)
Global Monitoring of Background Air Pollution Monitoring Network (BAPMoN)

Greenhouse effect

Greenhouse gases: The gases in the atmosphere such as water vapour, carbon dioxide, methane, nitrous oxide, ozone and some artificial chemicals such as chlorofluorocarbons (CFCs) are together referred as greenhouse gases.

Greenhouse effect: It is a natural process that warms the Earth's surface and keeps its temperature optimum for the life to exist on earth. When the Sun rays reach the Earth's atmosphere, some of it is reflected back to the space and the rest is absorbed and re-radiated by greenhouse gases. The absorbed energy warms the atmosphere and the surface of the Earth. This process maintains the Earth's temperature at around 33 degree Celsius thus making the life to exist on the earth. The problem that now we are facing is rising

temperatures every year leading to melting of glaciers and rise in sea-level and it is now going beyond our control. The reason for global warming is attributed to human activities – particularly, burning of fossil fuels (coal, oil and natural gas), increasing use of automobiles, jet planes, modern and artificial mode of living excessive use of air conditioning, cooling, refrigerators, microwaves etc. Agriculture and land clearing (deforestation) are also adding up to the increase in the concentrations of greenhouse gases. All this is the enhanced greenhouse effect, which contributes to the warming of the Earth.

Explanation

Earth constantly gets enormous amount of radiations, from the sun. This solar radiation strikes the earth's atmosphere in the form of visible light, along with the visible light, ultraviolet (UV), infrared (IR) and other types of radiation that are invisible to the human eye also reach the earth's atmosphere.

UV radiations have shorter wavelength and a higher energy level than visible light, while IR radiation have longer wavelength and a weaker energy level. About 30% of the radiation striking the earth's atmosphere is immediately reflected back out to space by clouds, ice, snow, sand and other reflective surfaces, the remaining 70% of incoming solar radiations are absorbed by the oceans, land and the atmosphere. As they heat up, the oceans, land and atmosphere release heat in the form of IR thermal radiations, which passes out of the atmosphere and into space. It's this equilibrium of incoming and outgoing radiations that makes the Earth habitable.

The exchange of incoming and outgoing radiation that warms the Earth is often referred to as the greenhouse effect because a greenhouse (glasshouse) works in the same way. Incoming UV radiation easily passes through the glass walls of a greenhouse and is absorbed by the plants and hard surfaces inside the glass house. Weaker IR radiation, with higher wavelength however, has difficulty passing through the glass walls and thus they are trapped inside, thus warming the glasshouse. This effect lets tropical plants thrive inside a glasshouse, even during a cold winter.

A similar phenomenon can be observed in a car parked outside on a cold, sunny day. The incoming solar radiation warms the car's interior, but outgoing thermal radiation is trapped inside the car's closed windows and the car gets heated up uncomfortable to sit.

Greenhouse effect can thus be summarised in six simple steps as under:

- Solar radiation reaches the Earth's atmosphere - some of this is reflected back into space.
- The un-reflected sun's radiations are absorbed by the land and the oceans, heating the Earth.
- Some of the absorbed heat radiates from Earth towards the space.
- Some of this radiated heat is trapped by greenhouse gases in the atmosphere, keeping the Earth warm to sustain life.
- Human activities such as burning fossil fuels, agriculture and land clearing are increasing the amount of greenhouse gases released into the atmosphere.
- This is trapping extra heat, and causing the Earth's temperature to rise.

A detailed discussion on greenhouse related climate change and its impact on human life are discussed separately in Chapter … under Climate Change.

Fog: It consists of visible cloud water droplets or ice crystals suspended in the air at or near the Earth's surface.

Smog: Smoke in combination with fog is termed as 'smog' but recently in modern times smog is referred to a combination of fine particulate matter and ground level ozone also.

Constituents of Smog: The harmful components of smog other than smoke and water vapour are nitrogen oxides, volatile organic compounds, sulphur dioxide and carbon monoxide. The colour of smog is determined by these suspended particles and is often brown or deep grey but can also be white.

Harmful Effects of smog

- Dense smog leads to low visibility and is very hazardous for fast moving vehicles.

- Smog causes serious health hazards, such as it aggravates asthma, its effects are not limited to the lungs alone, it can cause tightness in chest, irritation in eyes, nose and throat, coughing and wheezing are also common if exposed to smog.

Photochemical smog: The mixture of primary and secondary pollutants along with fog forms photochemical smog.

Constituents of photochemical smog: Primary and secondary pollutants and water vapour are the major constituents of photochemical smog.

Formation of photochemical smog: Photochemical smog is formed as a result of photochemical reactions with the primary pollutants present in the atmosphere. The primary pollutants containing nitrogen are released through many sources in the air, these in presence of solar radiations form smog. The main sources of primary pollutants are automobile emissions and flue gases from various industrial processes. These are rich in nitrogen and VOC. Ultraviolet radiations in the sunlight split nitrogen dioxide into nitric oxide and nascent oxygen. This monatomic oxygen then reacts with oxygen in the air to form ozone. The Pollutants produced as a result of such reactions are ozone, aldehydes and peroxyacetyl nitrates (PAN) and are called secondary pollutants. The mixture of these primary and secondary pollutants together forms photochemical smog with fog (water vapour).

Harmful Effects of Photochemical Smog:

- It lowers the visibility to a minimum. It takes very long to clear. Transport and life comes to a standstill.

- It is very toxic and lead to serious illnesses like asthma and other respiratory tract diseases as it adversely affects the lungs.

Ozone (O_3), Ozone Layer and Ozone Depletion

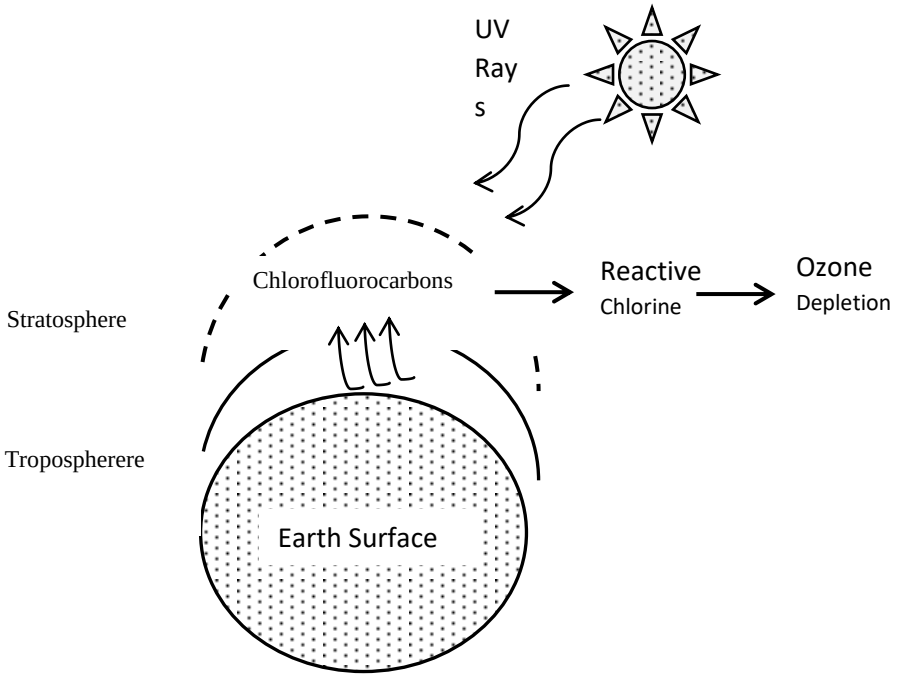

Figure 2. Ozone Layer Depletion by CFCs

Ozone (O_3)

It is a colourless and highly irritating gas that forms naturally when the precursors, present in the air as pollutants such as nitrogen oxide and volatile organic compounds (VOC), react with each other in the presence of sunlight to produce ground-level ozone. This happens most often in urban areas during summer. Periods of high concentration of ground level-ozone can last there for several days and this may occur frequently if a stagnating air mass entraps pollutants over that region. The major source of nitrogen oxide in the air is from the combustion of fossils fuels used in power plants, industries, homes and automobiles.

Harmful effects of ozone

- It poses high health risks. Breathing Ozone can trigger a variety of health problems including chest pain, coughing, throat irritation, and congestion. Ground-level ozone is very hazardous if inhaled it leads to reduced lung function and

inflammation in the linings of the lungs. Repeated exposure may permanently scar lung tissue.

- It is also responsible to damage the vegetation in the region where the concentration of ground level ozone is high.
- It leads to the deterioration of some natural and synthetic materials, including paints and dyes.
- Ozone is also a powerful greenhouse gas, which contributes to climate change.

Ozone Layer and its depletion

Ozone (O_3) layer: The ozone layer is a belt of the naturally occurring gas "ozone." It occurs 15 to 30 kilometres above Earth, and serves as a shield from the harmful ultraviolet B (UVB) radiations emitted by the sun. Ozone is a highly reactive molecule that contains three oxygen atoms. It is constantly being formed and broken down in the high atmosphere, 10 to 50 kilometres above Earth, in the stratosphere region.

Role of ozone layer: It shields the harmful UV radiations to reach the earth.

Harmful effects of UV radiations: They cause skin cancer and cataracts in humans and harm animals as well.

Ultraviolet B radiations on reaching the earth also inhibits the reproductive cycle of phytoplankton. The decrease in phytoplankton populations will in turn lower the populations of other animals. Changes in the reproductive rates of young fish, crabs, frogs and salamanders exposed to excess ultraviolet B, have also been noticed. All these are detrimental effects of UV rays.

Ozone Depletion

The deterioration or wearing out of the amount of ozone in the stratosphere is referred as ozone depletion. Today, there is widespread concern that the ozone layer is deteriorating due to the release of chemicals containing chlorine and bromine called Chlorofluorocarbons (CFCs).

The Chlorofluorocarbons (CFCs): They are mainly found as propellants in aerosol sprays, solvent-soaps, polyurethane insulating foams, as coolants in air conditioners and refrigerators and as jet propellants. They are the actual cause of ozone layer breakdown. Although CFCs are inactive compounds so they do not cause any harm in the troposphere region being unreactive or inert. They are also heavier than air, but in due course of time they reach into the upper atmosphere or stratosphere by action of wind and there they breakdown by the action of UV radiations into chlorine atoms. The chlorine atoms so formed react with ozone molecules and rips them apart, thus initiating ozone layer depletion. One chlorine atom can break more than 100,000 ozone molecules, making the ozone layer thin in that region.

The ozone layer above the Antarctic has suffered the most by CFCs since the mid-1980s. This region's low temperature promotes and accelerates the rate of conversion of CFCs to chlorine. In the southern hemisphere the sun shines for long periods of the day during spring and summer, thus giving an ideal condition to the CFCs to reacts with ultraviolet rays to produce chlorine. The chlorine so produced has led to the destruction of ozone on a massive scale, of up to 65%. This thinning of ozone layer is sometimes referred to as the "ozone hole." In other regions also, the ozone layer has deteriorated by about 20%.

About 90% of CFCs were emitted in the atmosphere currently by industrialized countries in the Northern Hemisphere, including the United States and Europe. Later these countries banned the use of CFCs in 1996, and the amount of chlorine in the atmosphere is falling now. But it is believed that it will take another 50 years for chlorine levels to return to their natural levels and nothing much can be done for its reversal as it will happen naturally.

Acid Rain

Acid rain is caused by a chemical reaction that begins when compounds like sulphur dioxide and nitrogen oxides are released into the air. These substances are released by burning of fossil fuels, industries, automobile exhausts etc. These gases rise very high into the atmosphere, where they mix and react with water, oxygen, and

other chemicals to form acids, which come down on earth as rain known as acid rain.

Harmful effects of acid rain

- It has extremely harmful effects on the environment. It changes the pH of water in the water bodies, and also of soil. This change in the pH leads to increased solubility of many minerals in water, erosion of soil, harmful effects on plants and aquatic animals.
- It has extremely corrosive effect on infrastructure, constructions and buildings.
- In humans it leads to itching and skin allergies.

A great way to **reduce acid rain** is to minimise the use of fossil fuels. Instead, of using conventional energy sources renewable energy sources such as solar and wind power should be advised to be used.

3. Water Pollution

Water is elixir of life. For life to exist in any form anywhere availability of water is first requirement. Thus, life cannot be imagined without water. Mother Earth supports a large variety of life and nurses it with water. Although about 70% of the Earth is covered with water bodies only a small proportion of this (0.3%) is fresh and usable water for human beings and other fresh water creatures. However, because of industrialization and urbanization, during the last century there has been a rapid deterioration in water quality. This is mainly due to release of pollutants to the water bodies and soil. Even underground water is getting contaminated due to percolation of pollutants to the sub-soil water tables. These pollutants gets dissolved in water and impart their characteristic properties like colour, taste, odour, conductance, alkalinity and hardness to water and makes it impure. Mixing of heavy metals and pathogens with water sources makes it a major health hazard. In the modern living water-borne diseases are becoming a serious health issue. Water is also an important raw material for almost all industrial processes. Impure water if used in the industries can lead to severe damage to the finished goods hence use of treated water is recommended in the industries. The reasons for the water pollution are excessive & unsafe industrialization, urbanization, deforestation, improper underground sewage system, landfills and unsafe agricultural practices. Out of this small fraction of available water, bulk of this is contaminated and unfit for human.

Characteristics of Drinking or potable water

The water that can be used for drinking and cooking purposes is termed drinking or potable water. The standards laid down for drinking water by national and international bodies should be strictly followed. The various minerals and their tolerance limits through standard agencies are listed in the table (1).

General characteristics of the drinking water

Colour: It should be colourless.

Odour: It should be odourless.
Taste: It should be tasteless.
Microorganisms: It should be free from germs.
Hardness: It should be free from both types of hardness permanent and temporary.
pH: The water should not be alkaline or acidic. It should be slightly higher than 7.
COD, BOD and DO: It should be very less as high percentage of these indicate impurities in the water.
Fluorides, Chlorides, Nitrates and Sulphates: Presence of these ions should be within the permissible limits as there high concentration in water could be hazardous. A low concentration of fluoride is also not good as it leads to dental caries.

Table 1. Parameters and their tolerance limits through standard agencies

S.No	Parameters	WHO Standards	ISI Standards
1.	Colour Hazen unit, MAX		5
2.	Temp. (^{0}C)		
3.	pH	7.0 – 8.0	6.5 – 8.5
4.	Electrical Conductivity (µs/cm)	1400	-------
5	Turbidity (NTU, MAX)		1
6.	Total Dissolved Solid (mg/l)	1000	500
7.	Total Hardness (mg/l)	100	300
8.	Calcium (mg/l)	75	75
9.	Magnesium (mg/l)	150	30
10.	Total Alkalinity (mg/l)	120	200

Sources of water

Water is a gift of nature and occurs either on the surface of the earth as surface water or under the earth as ground water. Examples of surface water are lakes, rivers, ponds, rain and oceans. The examples for underground water are springs and deep bores. Since water occurs naturally and is also a very good solvent dissolves the minerals

present in the soil. This leads to form the basis of classification of water as *Hard* and *Soft* water.

Classification of Water

Hard water: The water which does not produce lather readily with the soap solution is called hard water. It is due to the presence of bicarbonates, chlorides and sulphates of calcium, magnesium, iron and other heavy metals.

Soft water: The water which produces lather readily with the soap solution is called soft water. The impurities mentioned in hard water are absent from this water.

Hardness: The property of water which prevents lathering of water with the soap solution is called hardness. There are two types of hardness, temporary and permanent hardness. The two together forms total hardness. In good quality water total hardness should not exceed 100 mg/l.

***Temporary hardness*:** The hardness that can be removed by boiling the water is called temporary hardness. It is caused by bicarbonates of calcium and magnesium. Bicarbonates decompose on boiling into carbonates which gets precipitated along with the release of carbon dioxide in the atmosphere leaving behind soft water.

Permanent hardness: The hardness which cannot be removed simply by boiling is termed as permanent hardness. It is due to the presence of chlorides and sulphates of calcium and magnesium. Special methods such as lime-Soda process, Ion-Exchange and Zeolite process are used for its removal.

Water Quality Index (WQI)

Water Quality Index is a modern way to express the water quality of the water bodies according to the degree of purity. These days it is widely used in scientific studies to describe the quality of river waters. It is calculated mathematically using various physico-chemical parameters to express the quality of water of the water bodies. The table (2) below suggests the quality of water based on WQI.

Table 2. Quality of water based on WQI

S.No	Water Quality Index	Water Quality Status
1.	0 – 25	Excellent
2.	26 – 50	Good
3.	51 – 75	Poor
4.	76 – 100	Very Poor
5.	>100	Unsuitable for Drinking

Water pollution

The addition of substances to the water that can alter its characteristics properties are called water pollutants and the pollution is termed as water pollution. It can alternatively be defined as the **contamination** of **water** bodies (e.g. lakes, rivers, oceans, ponds and groundwater). This form of environmental degradation is due to the release of **pollutants** directly or indirectly into the **water** bodies without adequate treatment of the effluents and sewage to remove harmful compounds and microorganisms. Use of chemicals as fertilizers, weedicide, herbicide, insecticides also lead to water pollution as these chemicals are released in the backflow waters of irrigation canals from where they reach the main streams thus polluting them. Water is an important constituent of all form of life on earth and any change in its properties from the normal may lead to serious health hazards.

Water Pollutants

The substances whose presence alters the characteristics of water are called water pollutants. There were various types of water pollutants such as inorganic, organic, gaseous, metals and non-metals, microorganisms, chemicals etc. They are described below:

Inorganic pollutants

- Dissolved salts such as chlorides, sulphates, bicarbonates, fluorides, nitrates etc.
- Colloidal impurities such as soaps and detergents, mineral oil, greases etc.
- Particles such as dust, clay, mud, cement and asbestos, remain suspended in air.

Organic pollutants

- Food and vegetable matter on decomposition produces complex organic compounds in situ. Bio-wastes from the hospitals mixed with drugs and toxic materials.
- Effluents through sugar industries, leather industries, slaughter houses, colouring and dyeing industries etc.

Gaseous pollutants

- Dissolved gases such as O_2, CO_2, H_2S.etc

Metallic and Non- metallic pollutants

- As, Sb, Hg, Pb, Mo, As etc.

Microorganisms:

- Virus, Bacteria, Protozoa and Alga

Water Pollution can be classified on the basis of sources of pollutants released

On this basis it is classified into two type point source water pollution and non-point source water pollution.

Point source water pollution: When water is polluted from industrial effluents, sewer pipes or runoff water from a single farm, it is called **point source water pollution**; hence in short this is pollution from a discrete location. The BP (Bharat Petroleum) oil spill in 2010 is an example of point source pollution, because of the massive amount of oil leaked from a single point of origin.

Non-point source water pollution: When the pollution of water is from several points and sources over a large area and contributes to the pollution of a water body it is called **non-point source water pollution**. A water body may be contaminated by multiple sources like agricultural runoff, city roads runoff, construction sites and residential wastes. Then such an example illustrates non-point source water pollution. Rivers around the world such as Mississippi River, Yamuna River, and Ganges etc. are at greater risk due to non-point source pollution. This type of pollution is difficult to control and monitor.

Water pollution can be classified on the basis of occurrence of water in nature

Water can be classified as surface and underground water depending upon its occurrence in nature. This basis also can be used for the classification of pollution in water as surface water pollution and ground water pollution.

Surface Water Pollution

Surface water includes lakes, rivers, ponds etc. The pollution of these due to rainwater runoff water, roads runoff water, garage washings, garden runoff water etc. it is called surface water pollution. All these run off water carry with it chemicals, salts oils, greases nutrients and fertilizers etc. that can exceed the prescribed standard tolerance limit of the constituents for potable water thus making it contaminated.

If nutrients and fertilizers are the causes of water pollution then such type of pollution is termed as **nutrient pollution**. It leads to an overproduction of colonies of algae and other aquatic plants thus covering the entire water bodies. These results into depletion of oxygen and sunlight in the water bodies, which may cause harm to aquatic animals and may even lead to their extinction.

Sewage disposal is another cause of surface water pollution. With the faecal matter and rotten food and vegetables various pathogenic bacteria, viruses and protozoans also reach the water bodies. Consumption of such water leads to epidemics and water borne diseases such as giardia, typhoid and hepatitis, cholera etc.

Toxic chemicals can also enter water bodies through chemicals used as pesticides, petroleum products from automobiles, rodenticides, herbicides, deodorants etc. This also led to surface water pollution. These chemicals contain toxic and heavy metals such as mercury, lead and arsenic. These chemicals are extremely dangerous for the environment as well as for the organisms.

Groundwater Pollution

The pollution of underground water is called **ground water pollution**; this is due to the percolation of surface water containing chemicals into the layers of soil reaching the sub soil water table. Polluted soil is another important reason of groundwater pollution. The causes of, groundwater pollution are similar to surface water

pollution, but since it is below the ground, it is very difficult to monitor and control this pollution.

Causes of Water Pollution

Most causes of water pollution are because of the additives added to the water through various sources. In the oceans, lakes and rivers around 80% of the pollutants enters the water from the land. The main reason of pollution in the water is through human activities. Use of excessive chemicals such as: fertilizers, insecticides, herbicides etc. by the farmers are gradually washed by rain into the groundwater or nearby surface waters. There are various reasons for pollution of water but it is the most severe pollution among all types of pollution.
Some of the important causes of water pollution are listed below:

- Air deposition that is air saturated with huge amount of suspended matter.
- Sewage disposal in open landfills in low line areas leads to severe air and water pollution.
- Nutrients when discharged in the water bodies are extremely harmful.
- Chemical wastes is harmful as it alters the pH of the water if get mixed with it.
- Radioactive waste remains for thousands of years in water, soil and atmosphere
- Oils and Greases form emulsions and pollute the water.
- Plastics are non-biodegradable and remain suspended and can be swallowed by animals.
- Thermal effect raises the temperature above the normal which is harmful for flora and fauna.

Air deposition: The pollution of water caused by the chemicals released through the chimneys as smoke and flue gases that enter the atmosphere and then fall back to earth as rain flows into the water bodies as run-away water laden with chemicals and microorganisms causing water pollution. This is called **air** or **atmospheric deposition**.

Sewage: Disposal of sewage waste is a major problem and results into most severe water pollution as it leads to deadly and chronic diseases that could be fatal. Sewage is composed of domestic and industrial wastes. If domestic wastes is present in large excess leads to eruption of epidemics and chronic and fatal diseases. According to the World

Health Organization, some 780 million people (11percent of the world's population) don't have access to safe drinking water, while 2.5 billion (40percent of the world's population) don't have proper sanitation. Sewage disposal affects people's immediate environments and leads to illnesses such as diarrhoea, jaundice, cholera and amoebiasis, kill thousands of children every year. In developed countries, most people use flush toilets that take sewage waste quickly away from their homes, but the problem of sewage disposal does not end there. With flushing, the waste goes through the drainage system to the treatment plants or sometimes dumped directly into the water bodies. The sewage treatment works, though remove most of the pollutants but, there is still waste that is not removed completely. If the sewage is completely natural that is not mixed with industrial waste than it could be broken down harmlessly in the environment but this is not so as it contains chemicals such as soaps and detergents, paper, plastics, pharmaceutical drugs etc. The people infected with viruses produce contaminated sewage that go into the environment and contaminate it. This mixing of untreated sewage with water bodies may lead to illnesses such as hepatitis, typhoid, and cholera from river and sea water consumed by the inhabitants.

Nutrients

Fertilizers, herbicides, pesticides, germicides etc. used by the farmer's forms the nutrients as it returns NPK to the soil but if it gets mixed with the runoff water during irrigation or rains it reaches the water bodies leading to a massive increase in the growth of algae or plankton that overwhelms huge areas of oceans, lakes, or rivers. This is known as a **harmful algal bloom.** Thus excessive use of these chemicals should be restricted and farmers should be educated to use moderate quantities of these chemicals that could be absorbed rapidly by the soil. Industries, Slaughter houses, hospitals, are other sources of release of nutrients and causing water pollution.

Chemical wastes

The chemicals that are described as nutrients are though toxic but are very mild. There are other chemicals which are highly toxic and cause severe damage to the characteristics of water. Heavy metals such as lead, cadmium, and mercury are extremely toxic and fatal as they

are carcinogenic. Toxic chemicals such as **polychlorinated biphenyls (PCBs)**, were once widely used to manufacture electronic circuit boards, but with the recognition of their harmful effects many countries have restricted there use. But as it has already entered the environment their effects will be felt for many decades because they last a long time in the environment without breaking down.
Use of Lead in gasoline (petrol) is also now restricted in many countries, but Mercury and Cadmium are still not discontinued in batteries. Another highly toxic chemical called tributyltin (TBT) used in paints to protect boats from the ravaging effects of the oceans has also caused sufficient damage to the water bodies. The Mina Mata disease contaminating the fish can best illustrate water pollution due to mercury when hundreds of people died or became disabled by eating mercury infected fish.

Radioactive waste

Radioactive wastes are very harmful. At high concentrations it kills and at lower concentrations it causes chronic diseases such as cancers and other illnesses. The biggest sources of radioactive pollution are nuclear power plants, nuclear reactors. The nuclear materials are disposed in ocean or in the depths of the earth in lead capsules, but if the nuclear waste during disposal leaks into the atmosphere, then it leads to radioactive pollution. The major drawback of radioactive waste disposal in the atmosphere is its existence in the atmosphere for hundred thousands of years.

Oil pollution

Oil spills in oceans are a few reasons for oil pollution in water. The other reasons for oil pollution in water are through routine shipping, garage washings and from the oil people pour down in drains and reaches water bodies and soil.

Plastics

Plastic is a very dangerous contaminant and should be discontinued immediately. It is light and floats on water hence can travel long distances across the water bodies. Plastics are generally non-biodegradable and can survive up to approximately 450 years in sea water. Although plastics are non- toxic, hence they do not pose major

threat to seabirds, fish, and other marine creatures. But, plastic fishing lines and other debris can strangle or choke fish. (This is sometimes called as **ghost fishing)**

Invasive species

Alien species also known as **invasive species** are animals or plants from one region that have been introduced into a different ecosystem where they do not belong. Outside their normal environment, they have no natural predators, so they rapidly run wild, crowding out the usual animals or plants that thrive there. Common examples of alien species include zebra mussels in the Great Lakes of the USA, which were carried there from Europe by ballast water. The Mediterranean Sea has been invaded by a kind of alien algae called *Caulerpa taxifolia*. In the Black Sea, an alien jellyfish called *Mnemiopsis leidyi* reduced fish stocks by 90 percent after arriving in ballast water. In San Francisco Bay, Asian clams called *Potamocorbula amurensis,* also introduced by ballast water, have dramatically altered the ecosystem.

Thermal Pollution

Heat or **thermal pollution** from factories and power plants also causes problems in rivers and water bodies. The rise in temperature reduces the amount of dissolved oxygen (DO) in the water, thus also reducing the level of aquatic life that the river or any water body can support. As a result of decrease in DO if there is a subsequent increase in the values of COD (Chemical Oxygen Demand) and BOD (Bio-Chemical Oxygen Demand) in the water, then it infers the presence of high amount of inorganic and organic impurities dissolved in the water. The COD and BOD are explained as under:

Chemical Oxygen Demand (COD): It is the amount of oxygen required for the complete oxidation of organic and inorganic waste matter present in one litre of waste water sample in presence of a strong oxidising agent.

Bio-Chemical Oxygen Demand (BOD): It is the amount of oxygen required for the complete oxidation of the organic matter present in one litre of waste water sample over a period of 5 days maintained at 20^0C.

Sediment pollution

This type of pollution involves the disruption of **sediments** (fine-grained powders) that flow from rivers into the sea. Dams built for hydroelectric power or water reservoirs may reduce the sediment flow. But with reduction of sediment flow the formation of beaches is affected, it also leads to increase in coastal erosion. However, increased sediments can also present a problem. During construction work, soil, rock, and other fine powders enter nearby rivers in large quantities that lead to turbidity. The sediments if reach the gills of fish blocks them, thus causing their death through suffocation.

Effects of water pollution

There are many views and arguments in the intellectual community on the causes and effects of pollution:

Some groups of people believe that pollution is an inescapable result of human activity: Their argument is that with the advancement of the society in terms of modern living technology, some degree of pollution is indispensable. Modernization, urbanisation, industrialization is responsible for irreparable damage to the environment and people have to cope with it. In other words, pollution is a necessary evil that people have to learn live with it.

Fortunately, not everyone agrees with this view. The other group of people who disagrees with this idea have woken up to the problem of pollution. They say that it brings costs of its own that undermine any economic benefits that come about by polluting. The argument can be illustrated taking the example of Oil spills, if tankers are too poorly built to survive accidents at sea. But the economic benefit of compromising on tanker quality brings an economic cost when an oil spill occurs. The oil can wash up on nearby beaches, devastate the ecosystem, and severely affect tourism. The main problem is that the people who bear the cost of the spill (typically a small coastal community) are not the people who caused the problem in the first place (the people who operate the tanker). Yet, arguably, everyone who puts gasoline (petrol) into their car or uses almost any kind of petroleum-fuelled transport contributes to the problem in some way. So oil spills are a problem for everyone, not just people who live by the coast and tanker operators.

Sewage is another good example of how pollution can affect us all. Sewage discharged into coastal waters can wash up on beaches and cause a health hazard. People who bathe or surf in the water can fall ill if they swallow polluted water, yet sewage can have other harmful effects too. It can poison shellfish (such as cockles and mussels) that grow near the shore. People who eat poisoned shellfish risk suffering from an acute and sometimes fatal illness called paralytic shellfish poisoning. Shellfish is no longer caught along many shores because it is too polluted with sewage or toxic chemical wastes that have discharged from the nearby land.

Water pollution matters because it harms the potable water on which people depend. The water is everything that surrounds us that gives us life and health. Destroying the quality of water ultimately reduces the quality of our own lives and that, most selfishly, is why water pollution should matter to all of us.

Prevention of water pollution

It's a long road to solve water pollution as it is not an easy way to solve it. There are different things that can be done to tackle the problem of water pollution

1. Treatment of Sewage
2. Education through public awareness
3. Control laws
4. Economics
5. Work together as a team.

Treatment of Sewage

Industrial wastes together with domestic wastes form Sewage. Treatment of sewage is important because if untreated sewage is released into water bodies it may lead to serious water pollution. The sewage treatment takes place in three steps namely: Primary treatment, Secondary Treatment and Tertiary treatment. The treatments and the impurities removed at different stages are given in the table ( )

Primary treatment of Sewage: It involves removal of coarser, colloidal and suspended impurities from the sewage. This is achieved

by allowing sewage through large ducts provided with natural filters (large stones and steps in the ducts prevents the floating impurities) to the sedimentation tanks for treatment. The water in the sedimentation tanks is mixed with coagulating agents (alum, sodium aluminate) and the solution is agitated to bring about mixing of the colloidal and suspended impurities with the coagulating agents. The mixture is then left undisturbed for hours to bring about settling of the precipitated matter. The top layer is then decanted and subjected to secondary treatment.

Secondary treatment of Sewage: The sewage loaded with organic matter is subjected to activated sludge treatment method for the removal of organic matter.
The activated sludge method is a two-step process. In the first step, the sewage loaded with organic impurities is brought to an aeration tank containing activated sludge from previous processes and in the second step it is passed through clarifier to separate sludge from the water.
First step: Sewage from primary treatment is mixed with activated sludge. The mixture is then aerated by mechanical aerators or through compressed air bubbling method in presence of sunlight. After aeration for sufficient time the sewage is led to the clarifier or settling tank.
*S**econd step***: The sewage is brought into the clarifier, where supernatant is separated from the sludge. Small portion of the sludge is recycled to the tank for treatment of fresh instalment of the sewage and remaining is used as manure.
The decanted water is then sent for tertiary treatment if it contained heavy and toxic metals from industries, otherwise it is used in irrigation after killing the germs through chlorination, but it is not mixed with the river or lake water.

Activated sludge: The precipitate or sludge which is formed as a result of activated sludge treatment method contains microorganisms thus the name activated sludge. This sludge when added to the fresh instalment of sewage water laden with organic matter supplies food to the microorganisms, thus they grow and multiply rapidly in presence of air and sunlight by thriving on the organic matter present in the sewage. The organic matter is used as food by the microorganisms. After sufficient time this water is led to the clarifiers for separation of sludge from the supernatant.

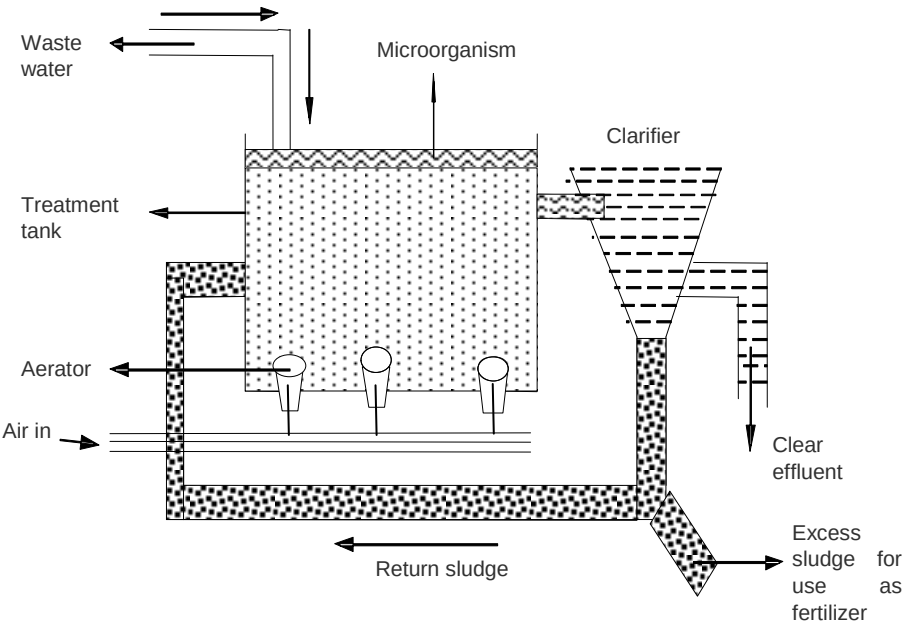

Figure 1. Activated Sludge treatment method

Tertiary treatment of sewage: In the third and final step of sewage treatment the heavy metals, phosphates, organic compounds, colloidal impurities, colour etc. are removed. This is necessary if the sewage is mixed with industrial effluents that contain high concentration of the above substances.

- Heavy metals like Fe, Pb, and Hg etc. are removed by treating the sewage water with sulphide. On Sulphide treatment heavy metals reacts and precipitates and removed as metal sulphides (FeS, PbS, HgS).
- Phosphates are removed by treating the sewage with lime ($Ca(OH)_2$), thereby removing the phosphates as calcium phosphates ($Ca_3(PO_4)_2$).
- Colloidal impurities that are either present or produced during the sewage treatment process are removed by treating with alum.
- Organic compounds and colour etc. are removed by their adsorption on activated charcoal.

Table 3. Steps involved in treatment of water

Primary treatment	Secondary treatment	Tertiary treatment
Suspended matter and colloidal matter are removed.	Organic matter is removed.	Heavy metals, colloidal matter and colours are removed.
Sedimentation, decantation tanks are constructed.	Activated sludge tanks with aerators are constructed.	Chemicals and activated Carbon is required.
Filters are required to remove suspended impurities. Coagulating agents are required to remove the colloidal impurities.	Activated sludge from the previous process is required. Sunlight and oxygen is required. Sterilization is required to kill the microorganisms.	Lime is required to remove phosphates. Sulphides are required to remove heavy metals. Activated charcoal is required to remove organic compounds and colour. Coagulants are required to remove colloidal impurities.

Education Through Public Awareness

Making people aware of the problem is the first step to solving it. In the early 1990s, when surfers in Britain grew tired of catching illnesses from water polluted with sewage, they formed a group called *surfers* against sewage to force governments and water companies to clean up the water. People who've grown tired of walking the world's polluted beaches have formed communities together to organize beach-cleaning sessions. Anglers who no longer catch so many fish have campaigned for tougher penalties against factories that pour pollution into our rivers. Greater public awareness can make a positive difference. Narmada Bachao Andolan (NBA) is one such

example where local tribes and farmers are working in this direction of saving Narmada River from getting polluted.

Control Laws

Water pollution is trans-boundary in nature. Many rivers cross countries, while seas span whole continents. Pollution discharged by factories in one country with poor environmental standards can cause problems in neighbouring nations, even if they have tough laws and high Environmental standards. Environmental laws are made to prevent the people to pollute it, but to have really effective laws they have to operate across national and international borders. This is the reason we have international laws governing the oceans, in 1982 UN convention law of sea was signed by more than 120 nations, In1972 London (Dumping) convention, in1978 MARPOL International Convention for the prevention of pollution from ships and in1998 OSPAR Convention for the protection of the Marine Environment of the North East Atlantic was signed. Similarly the European Union has water-protection laws (known as directives) that apply to all of its member states. They include the 1976 Bathing Water Directive (updated in 2006) which seeks to ensure the quality of the waters that people use for recreation. Most countries also have their own water pollution laws. In United States, for example, there is the 1972 Clean Water Act and the 1974 Safe Drinking Water Act. India also is working on cleaning of its major rivers under National River Conservation Plan (NRCP), cleaning of river Ganga under Ganga action plan (GAP).

Economics

Most environmental experts agree that the best way to tackle pollution is through something called the **polluter pays principle**. This means that whoever causes pollution should have to pay to clean it up. Polluter pays can operate in all kinds of ways. It could mean that tanker owners should have to take out insurance that covers the cost of oil spill clean ups, for example. It could also mean that shoppers should have to pay for their plastic grocery bags, to encourage recycling and minimizing waste. It also means that factories that use rivers must have their water inlet pipes downstream of their effluent outflow pipes, so if they cause pollution they themselves are the first people to suffer. Ultimately, the polluter pays

principle is designed to deter people from polluting by making it less expensive for them to behave in an environmentally responsible way.

Work together as a team

We can work together to keep the environment clean so that the plants, animals, and people who depend on it remain healthy. We can take individual action to help reduce water pollution, by keeping our surroundings clean, recycling most of the goods instead of dumping them in the landfills. Promotion of consumption of organic food and vegetables, fruits and consumables for our day to day use, using environmentally friendly soaps and detergents, not pouring oil down the drains, reducing the use of pesticide and insecticide etc. Working together we can definitely reduce all forms of pollution including water pollution and can make this world a better place.

4. SOIL POLLUTION

The soil pollution is defined as the addition of chemicals beyond its buffering capacity which are detrimental to its economic and ecological function. Soil pollution may result from contamination from industrial and domestic wastes or by natural functions such as erosion, floods, deforestation or fire. Industrial revolution and rapid urbanization has accelerated the pace of deterioration of soil health. Intensive agriculture with indiscriminate use of chemicals has seriously altered its natural characteristics to support a health life. Soil pollution is discussed in this chapter in detail to understand the causes and possible remedies to minimize soil pollution in future.

What Is Soil: soil is defined as a mixture of mineral and organic material that settles just below the Earth's surface. It can be further explained as a dynamic natural body with properties derived from the combined effects of climate and biotic activities**.** It is composed of five major components namely matrix of minerals, organic matter, air, and water. Each component is important for supporting plant growth, microbial communities, and chemical decomposition. The largest component of soil is the mineral portion, which makes up approximately 45% to 49%.

Significance of Soil: Soil is an important constituent of environment as it provide food through crops, shelter through trees and abode to all living and non-living materials, such as rocks, minerals, nutrients, bacteria and, animals including humans. Soil can be classified looking at its physical characteristics, such as pH, colour, particle size, permeability and water-holding capacity. There are over 20,000 different kinds of soil.

Formation of Soil

Soil formation is a continuous process and it takes thousands of years in getting converted from rocks to soil. The rocks break down due to climatic factors such as floods, heat, earthquakes, high winds and storms etc. These in turn are further broken into much smaller particles. As a result of breaking down the minerals with which the

rocks are made up of get mixed up with humus (the dead and decaying organic material from plants and animals). This mixture of minerals and humus together is called soil.
The main factors that create soil are: parent material (rocks or stones and organic matter), climate, biology, topography and time.

Parent material in the formation of soil: The material with which the new soil forms includes both mineral and organic material. The ***organic material*** is dark and spongy, and comes from dead and decaying organic material from plants and animals and is referred as **humus**. The ***mineral material*** comes from weathered rocks, and it is the type of mineral material present in the soil that helps in determining and classifying the type of soil.

Climate: It is an important factor that is responsible in the formation of soil. The climate includes temperature, moisture, wind and rainfall. These influence to the weathering of the rocks and conversion of rocks into minerals. They are also responsible for the production of organic matter. For example in warm and humid climate plants grow rapidly throughout the year resulting into rain forests. This also produces large quantities of humus thus a soil with more organic matter is formed in such a climate compared to dry and cool climate. At high humidity and temperature, the decomposition of organic matter takes place rapidly, thus there is a little or no accumulation of these materials in the soil.

Biotic influences: The organic matter present in the soil enters from plants, animals, bacteria and fungi. Plants and animals help in recycling the nutrients by decaying, consuming and by absorbing them. The plants have roots to absorb minerals and water from the soil. It also helps in anchoring the soil in place and prevents soil erosion. The microorganisms that dwell in the soil also help mix the soil and minerals and promote recycling of nutrients.

Topography: The shape of the land that includes the steepness, depressions and floodplains is called topography. The soil formation is affected by water, sediments and rocks etc. If the land is very steep, it will lead to more runoff water during rainfall, leading to landslides which will transport more rocks and minerals. This will result into increased level of erosion. Such soil will likely to have more minerals and less organic material in it which will further affect the soil quality.

Time: It plays a critical role in soil formation because the interaction of all the above factors is an extremely slow and a continuous process. The entire process of soil formation starting from weathering of rocks to erosion and transportation of sediments and deposition takes very long. Its mixing with the decomposed organic matter takes very long. Thus the formation of soil takes place very slowly in the due course of time. Hence, soil is very precious and should be conserved.

The Horizons of Soil: The soil formation is a gradual process and takes place very slowly with the formation of layer after layer. This stack of many layers is termed as a horizon. Thus the horizons that develop during soil formation have layers of soils with different characteristics that are parallel to the surface. To characterise the soil scientists use a vertical section of soil from the surface which is called a soil profile. There could be many horizons in a soil profile as the number of soil horizons is unlimited, but a typical soil can be described using six major horizons in a soil profile.

O Top organic layer of soil made up of leaf litter and humus

A Dark coloured made of humus with mineral particles

B Light coloured leaching layer made of sand and silt, having lost most minerals and clay, as water drips through soil.

C Also called subsoil, contain clay and mineral deposits

D Also called regolith, contains fragmented rocks with very little soil. Roots do not penetrate in this layer

E Unweatherd rock layer

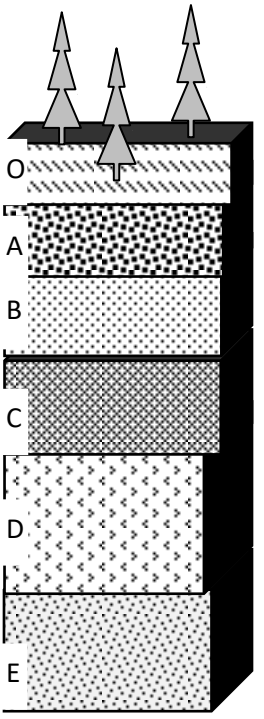

Figure 1. Different Soil Profiles

Constituents of soil: Soil is formed by five basic constituents such as minerals, water, organic matter, gases and microorganisms. All these constituents are necessary for the soil for healthy life and vegetation. They are listed in the table (1).

Table 1. Constituents of soil and their functions

S.No	Name of the constituent	Functions	Examples
1.	Minerals	Gives texture to the soil	Silicates, iron, magnesium, potassium, calcium etc.
2.	Water	Effects water holding capacity of the soil	Available water, not available water
3.	Organic matter	Responsible for cation exchange capacity	Plant dead matter, animal dead and shed off matter
4.	Gases	Aids in respiration and nitrogen fixation in leguminous plants	Oxygen, carbon di oxide, nitrogen
5.	Microorganisms	Decomposes organic matter and recycle it to produce humus	Bacteria, fungus, algae etc.

Minerals

The largest component of soil is the mineral portion, which makes up to approximately 45% to 49% of the volume. There are two principal types of minerals *Primary* and *Secondary*.

Primary minerals are those which are found in sand and silt, and are similar to the parent material from which they formed. They are often round or irregular in shape.

Secondary minerals are formed from the weathering of the primary minerals, as a result of breaking down they release important ions and itself gets converted into silicate clay a stable mineral form. Clays have a large surface area, which enhances water-holding capacity of the soil. The negative and neutral charges found around soil minerals is capable of retaining important nutrients, such as cations, contributing to soils cation exchange capacity (CEC).

Texture: The texture of a soil can be determined from its sand, silt, and clay content present in it. The identification of sand, silt, and clay are made based on size. The following standards are used in the United States:
Sand 0.05 - 2.00 mm in diameter
Silt 0.002 - 0.05 mm in diameter
Clay < 0.002 mm in diameter

For example, if a soil contains 20% clay, 40% sand, and 40% silt (total = 100%), then it is a **loam**.

Water

Water is an important basic component of soil. Water makes up to approximately 2% to 50% of the soil volume. Water is important for transportation of nutrients to growing plants and soil organisms. It also facilitates biological and chemical decomposition.
Soil water availability : It is the capacity of a soil to hold water that is available for plant use. The capacity of a soil to hold water is largely depends on soil texture. The smaller the particles of soils, the more water it can retain. Thus, it can be concluded that the clayey soils having the greatest water-holding capacity and sandy the least. Organic matter in the soil also influences the water-holding capacity of soils. Organic matter has high affinity for water, thus higher the percentage of organic material in soil, the higher the soil's water-holding capacity. When water is bound very tightly to soil particles, it is not available for most plants to extract, which limits the amount of water available for plant use. Although clay can hold the most water of all soil textures, the fine micro pores on clay surfaces hold water so tightly that plants have great difficulty extracting all of it. Thus, loams and silt loams are considered some of the most productive soil textures because they hold large quantities of water that is available for plants to use.

Wilting coefficient: The point where the water is held microscopically with too much energy for a plant to extract is called wilting coefficient or permanent wilting point.

Organic Matter

Organic matter is another important component of soils and ranges from 1% to 5%. It is derived from dead plants and animals and has a high capacity to hold and provide essential elements and water to the plants for their growth as they have very high "plant available" water-holding capacity, which can enhance the growth potential of soils with poor water-holding capacity such as sand. Soils with high in organic matter have a high cation exchange capacity (CEC) and are, therefore, very productive for plant growth. The percent of decomposed organic matter in or on soils is often used as an indicator of a productive and fertile soil. However, prolonged decomposition of organic materials can lead it to become unavailable for plant use, creating what are known as recalcitrant carbon stores in soils.

Gases

Gases or air is the next basic component of soil. Oxygen is essential for root and microbe respiration, which helps and support plant growth. Air can occupy the same spaces as water, and can make up approximately 2% to 50% of the soil volume. Carbon dioxide and nitrogen are also important for underground plant functions such as for nitrogen-fixing bacteria. In a waterlogged soil gas exchange is prevented leading to plant death, which is a common concern after floods.

Microorganisms

Microorganisms are basic element of soils, and are found in the soil in very high numbers but make up much less than 1% of the soil volume. A common estimate is that one thimble full of topsoil may hold more than 20,000 microbial organisms. Microorganisms are the primary decomposers of raw organic matter. Decomposers consume organic matter, water, and air to recycle raw organic matter into humus, which is rich in readily available plant nutrients. Other microorganisms such as nitrogen-fixing bacteria have symbiotic relationships with plants that allow plants to extract this essential

nutrient. Such "nitrogen-fixing" plants are a major source of soil nitrogen and are essential for soil development over time. Mycorrhizae are fungal complexes that form mutual relationships with plant roots. The fungus grows into a plant's root, where the plant provides the fungus with sugar and, in return, the fungus provides the plant root with water and access to nutrients in the soil through its intricate web of hyphae spread throughout the soil matrix. Without microbes, a soil is essentially dead and can be limited in supporting plant growth.

Thus the largest organisms found in the soil are earthworms and nematodes and the smallest are bacteria, actinomycetes, algae, and fungi. Microorganisms are the primary decomposers of raw organic matter. Decomposers consume organic matter, water, and air to recycle raw organic matter into humus, which is rich in readily available plant nutrients.

Soil Classification

There are large variety of soil types based on their geology, topography, fertility status, mineral composition, texture and structure. The predominant soil types from agricultural suitability are: Alluvial soils, Black soils, Red soils, Laterite and Lateritic soils, Forest and Mountain soils, Arid and Desert soils, Saline and Alkaline soils and Peaty and Marshy soils. The various types of soils, their origin, occurrence and the types of crops cultivated are listed in the table (2).

Alluvial Soils

Alluvial soils are formed mainly due to silt deposited by rivers. In coastal regions some alluvial deposits are formed due to wave action, Rocks of the mountains form the parent material. Thus the parent material of these soils is of transported origin. More than 40% of the India’s population is supported by alluvial soils as they are the most productive agricultural lands.

Characteristics of Alluvial Soils: Alluvial soil is Sandy and clayey in nature and because of loamy texture these soils are porous and have good drainage. Because of good fertility status these soils are suitable for agriculture with high levels of productivity.

Occurrence of Alluvial Soils: These types of soils are common in Indo-Gangetic plains, deltas of the Mahanadi, Godavari, the Krishna and the Cauvery. Alluvial soils are also found in the Narmada valley of central India and Northern parts of Gujarat.

Crops Grown in Alluvial Soils: Major Crops in these soils are rice, wheat, sugarcane, tobacco, cotton, jute, maize, oilseeds and vegetables.

Black Soils

Black soil formation is a result of disintegration of volcanic rocks.

Characteristics of Black Soils: These soils are formed by the solidification of lava that spread over large areas during volcanic activity in the Deccan Plateau, thousands of years ago. The presence of titaniferous magnetite or iron minerals in it gives black colour to the soil hence the name black soil. Black Soils have in general the following composition: 10 per cent of alumina, 9-10 per cent of iron oxide, 6-8 per cent of carbonates of calcium and magnesium, less than 0.5percent of Potash and phosphates, percentage of nitrogen and humus are also very low.

Occurrence of Black Soils: Distribution of Black Soils Spread over 46 lakh sq km (16.6 per cent of the total area) across Maharashtra, Madhya Pradesh, parts of Karnataka, Telangana, Andhra Pradesh, Gujarat and Tamil Nadu.

Crops Grown in Black Soils: Black soil is most suitable for cotton crop. Other major crops grown on the black soil are wheat, jowar, linseed, virginia tobacco, castor, sunflower and millets. Rice and sugarcane can also be cultivated where good irrigation facilities are available. It is also ideal for growing large varieties of vegetables and fruits. This soil requires little or no addition of fertilizers and manures without getting exhausted.

Red Soils

Red soils are formed from crystalline and metamorphic rocks such as acid granites, gneisses and quartz. The red colour of the soil is due to the presence and diffusion of rust or iron oxide in it under oxidizing conditions.

Characteristics of Red Soils: The textures of red soil vary from sand to clay, but the majority are being loams. They could be gravelly and porous in the uplands, but in the lower areas they are rich, deep dark and fertile, and rich in the lower areas. The Red Soils are generally acidic depending upon the nature of the parent rocks, though they have little alkali content also. They are poor in lime, magnesia, phosphates, nitrogen and humus content. They are fairly rich in potash and potassium.

Occurrence of Red Soil: Red soils mostly occur in the regions of low rainfall. These soils are spread on almost the whole of Tamil Nadu, parts of Karnataka, parts of south east Maharashtra, Telangana, Andhra Pradesh, Madhya Pradesh, Chhattisgarh, Orisa, Chota Nagpur plateau, parts of south Bihar, West Bengal, Uttar Pradesh, eastern half of Rajasthan and some parts of North-Eastern states.

Crops grown in Red Soils: Red soils are mostly loamy and hence cannot retain water like the black soils. Using good agricultural techniques including optimum use of fertilizers and good irrigation cotton, wheat, rice, pulses, millets, tobacco, oil seeds, potatoes and fruits can be cultivated profitably.

Laterite and Lateritic Soils

Laterite soil is originated from a Latin word that means "brick". They are formed as a final product of weathering of rocks, and cannot be weathered further thus it is durable. The Lateritic Soils are formed under extreme atmospheric conditions such as high temperature and heavy rainfall with alternate spells of wet and dry periods.

Characteristics of Laterite and Lateritic Soils: Heavy rainfall accelerates leaching (nutrients gets washed away by water) of soil, thus lime and silica are leached away from the soil and a soil rich in oxides of iron and aluminium compounds is left behind. The soil then gets hardened on loosing moisture. It is red in colour due to little clay and more gravel of red sand-stones. Laterite soils are rich in bauxite and ferric oxides but very poor in lime, magnesia, potash and nitrogen. In wet and places with high rainfall the humus content could be high in the soil.

Occurrence of Laterite – Lateritic Soils: Laterite soils are found on the summits of Western Ghats, Eastern Ghats, the Vindhyas, Satpuras and Malwa Plateau. They are well developed in south Maharashtra, parts of Karnataka etc.

Crops in Laterite – Lateritic Soils: Laterite soils are suitable for growing plantation crops like tea, coffee, rubber, cinchona, coconut, arecanut, etc.

Forest – Mountain Soils

These soils are mainly heterogeneous soils found on the hill slopes covered by forests.

Characteristics of Forest – Mountain Soils: The mountain soil formation is mainly governed by the deposition of organic matter from forests along with the changes in their characteristics with parent rocks, topography and climate. Thus they differ greatly even if they occur in close proximity to one another. The forest soils are very rich in humus, but are deficient in potash, phosphorus and lime.

Occurrence of Forest – Mountain Soils: Such soils are mainly found in valleys, less steep and north facing slopes of the Himalayan region. The south facing slopes are very steep and exposed to denudation and hence do not support soil formation. It is also found in Western and Eastern Ghats.

Crops in Forest – Mountain Soils: This type of soil is suitable for plantations of tea, coffee, spices and tropical fruits in peninsular region of India. In Himalayan region it is ideal for growing Wheat, maize, barley and temperate fruits.

Arid – Desert Soils

These soils are formed from weathering of igneous rocks with some amount of volcanic ash in it. The desert soils consist of Aeolian sand about 90 to 95 per cent and remaining clay (5 to 10percent). The presence of sand inhibits soil growth. The neighbouring soils is also affected and converted to desert due to intrusion of desert sand under the influence of wind [Aeolian sand].

Characteristics of Arid – Desert Soils: Arid – Desert Soils are usually poor in organic matter. With varying degree of alkalinity due to the presence of soluble salts like calcium carbonate. The phosphate content of these soils is almost same as in alluvial soils. Percentage of nitrogen is low but some of it is available in the form of nitrates.

Occurrence of Arid – Desert Soils: This type of soil is found in arid and semi-arid regions of Rajasthan, Punjab and Haryana. Sandy soils without clay factor are also found in coastal regions of Odisha, Tamil Nadu and Kerala.

Crops of Arid – Desert Soils: The drought resistant and salt tolerant crops such as barley, cotton, millets, maize and pulses are grown in this type of soil.

Saline – Alkaline Soils

Un-decomposed rock fragments on weathering give rise to sodium, magnesium and calcium salts along with sulphurous acid. Thus, the Saline and Alkaline Soils are the top soil that is impregnated with saline and alkaline salt particles.

Characteristics of Saline – Alkaline Soils: The regions with low water table, salts percolate into sub soil but, regions with good drainage, the salts are washed away by flowing water. Places where the drainage system is poor, the water with high salt concentration become stagnant and deposit all the salts in the top soil. Regions where sub-soil water table is high, salts move to the top soil by the capillary action as a result of evaporation of water and get deposited on the top soil in the dry season.

Occurrence of Saline – Alkaline Soils: Saline and alkaline soils occur in the drier parts of Rajasthan Uttar Pradesh, Bihar, Haryana, Punjab and Maharashtra.

Crops of Saline – Alkaline Soils: Salt resistant crops like berseem, rice and sugarcane can be grown by adding gypsum or lime. Other crops like wheat, cotton and tobacco etc. can also be cultivated.

Peaty – Marshy Soils

These are soils which are black, heavy and highly acidic due to large amount of organic matter and considerable amount of soluble salts present in it. The most humid regions have this type of soil.

Characteristics of Peaty – Marshy Soils: They are deficient in potash and phosphate. Most soils are old and mature especially of the peninsular plateau of India compared to soil of the great northern plain of India. These soils are deficient in nitrogen, mineral salts, humus and other organic materials.

Occurrence of Peaty – Marshy Soils: It is found in Kottayam and Alappuzha districts of Kerala, coastal areas of Odisha and Tamil Nadu, Sunderbans of West Bengal, in Bihar and Almora district of Uttarakhand.

Crops of Peaty – Marshy Soils: Most of the peaty soils are under water during the rainy season but as soon the rains cease, they are put under paddy cultivation.

Table 2. Types of soils, their origin, occurrence and crops cultivated

S.No	Type of Soil	Origin	Occurrence	Crops Cultivated
1.	Alluvial soils	silt deposited by rivers	Indo - Gangetic plains, deltas of the Mahanadi, Godavari, the Krishna and the Cauvery	Rice, Wheat, Sugarcane, Tobacco, Cotton, Jute, Maize, Oilseeds and Vegetables.

S.No	Type of Soil	Origin	Occurrence	Crops Cultivated
2.	Black Soils	Solidification of lava after volcanic eruptions	Maharashtra, Madhya Pradesh, parts of Karnataka, Telangana, Andhra Pradesh, Gujarat and Tamil Nadu.	Cotton, Wheat, Jowar, linseed, Virginia Tobacco, Castor, Sunflower, Millets, Rice and sugarcane
3.	Red Soils	Generated from crystalline and metamorphic rocks	Tamil Nadu, parts of Karnataka, parts of south east Maharashtra, Telangana, Andhra Pradesh, Madhya Pradesh, Chhattisgarh, Orisa, Chota Nagpur plateau, parts of south Bihar, West Bengal, Uttar Pradesh, eastern half of Rajasthan	Cotton, Wheat, Rice, Pulses, Millets, Tobacco, Oil seeds, Potatoes and Fruits

S.No	Type of Soil	Origin	Occurrence	Crops Cultivated
4.	Laterite and Lateritic Soils	Weathering of rocks under extreme weather conditions	Western Ghats, Eastern Ghats, the Vindhyas, Satpuras and Malwa Plateau	Tea, Coffee, Rubber, Cinchona, Coconut, Arecanut
5.	Forest – Mountain Soils	Formed with deposition of humus with rocks on the hill slopes	slopes of the Himalayan region, Western and Eastern Ghats	Wheat, Maize, Barley and Temperate fruits
6.	Arid – Desert Soils	Igneous rocks with volcanic ash containing Aeolian sand and little clay	Rajasthan, Punjab and Haryana, Coastal regions of Odisha, Tamil Nadu and Kerala.	Barley, Cotton, Millets, Maize and Pulses
7.	Saline – Alkaline Soils	Weathering of undecomposed rock fragments	Rajasthan Uttar Pradesh, Bihar, Haryana, Punjab and Maharashtra	Berseem, Rice Sugarcane, Wheat, Cotton, and Tobacco

S.No	Type of Soil	Origin	Occurrence	Crops Cultivated
8.	Peaty – Marshy Soils	Soil with very high humidity	Kerala, coastal areas of Odisha and Tamil Nadu, Sunderbans of West Bengal, in Bihar and Almora district of Uttarakhand.	Paddy

Uses of Soil

- Soil is important for plants growth,
- Allows gaseous exchange to happen between the land and air,
- Provides habitat for most of the organisms on Earth,
- Holds and cleans water,
- Recycles nutrients,
- Used for constructing structures like buildings and roadbeds.
- Soil erosion

Healthy Soil

Soil erosion is a naturally occurring process that affects all landforms. It is the process by which the surface of the earth gets worn down caused by natural elements such as high speed winds and glacial ice or floods. In agriculture, soil erosion refers to the weathering of topsoil by the natural physical forces of water, wind or through tillage.

The soil erosion by water is a result of the high speed rivers which remove the top layer of the soil, mainly during the floods near the hills. The soil erosion is mainly due to the decrease in forest cover area.

The soil erosion due to the high speed winds brings the particles of sand from dry areas. Most of the land becoming desert can be explained by this phenomenon. Thar Desert in Rajasthan was once a

fertile land around few thousand years back. The sand of Gujarat coast turned the Thar of Rajasthan into a desert.
Soil erosion should be checked as it may result into decrease in fertility of the soil thereby leading to deforestation. It is a result of soil pollution.

Soil Pollution

Contamination of soil is termed as soil pollution. There could be various reasons for soil pollution they are: toxic compounds, radioactive materials, salts, chemicals etc. The soil pollution is generally caused when the presence of materials in the soil which are harmful to the living beings cross their threshold concentration levels. The factors or substances which affect the soil are not static. Soil pollution can be both positive and negative.
Negative soil pollution is due to the overuse of soil and subsequently leading to soil erosion.
Overgrazing and excessive cultivation are the main causes of overuse of the soil that leads to demineralization of the soil and can be referred as contaminated or poor soil. The overgrazing and felling of timber converts the land into a desert at the rate of 9 kilo meter per year

Causes of Soil Pollution

The main causes of soil pollution are natural or man-made. Natural or negative soil pollution is due to wind, floods, melting of glaciers etc.
Man-made soil pollution is also referred as positive soil pollution. It includes:
Excessive use of fertilizers: to increase land fertility.
Excessive use of pesticides, fungicides, herbicides and insecticides etc: All these substances are not bio-degradable thus leading to their accumulation in the soil, thus entering the food chain. Through soil they enter into the plants and then into the animals who consume them. They even percolate down in the earth down to the water table thus contaminating the ground water.
Dumping of solid wastes in the soil: This includes dumping of batteries, oils, domestic wastes, solid industrial wastes and heavy metals, soaps and detergents, polymers, paper, food, dumping of garbage, empty bottles, furniture and ash etc. in open area outside the town that not only affect the land on which they are dumped but also the nearby

land. This type of pollution is referred as the landscape pollution which is extremely harmful etc. The best way to deal with landscape problem is to bury the waste in low lying areas and to burn the garbage so that it can be turned into the compost, while the rubbish should be sorted out and subjected to recycling.
Deforestation: excessive industrialization and urbanization are major cause of deforestation. Construction works, roads, houses, unplanned townships, underground and leaky sewage systems are all results of urbanization. With the growth of cities and townships grows the industries which discharge their toxic and untreated effluents in the soil and water bodies thus causing pollution.

Sources of Soil pollution: Soil pollution has become a serious threat in the modern period with growing industrialization and urbanization. An agricultural practice in modern intensive agriculture which heavily relies on use of chemicals has been another major source of soil pollution. High level of harmful chemicals deposition takes place beyond their buffering capacity making soils unsuitable to support *flora* and *fauna.* Polluted soils are a major health hazards also as polluted soils add toxicity to water and vegetation grown on these soils. Major causes of soil pollution are Industrial wastes, urban wastes, agricultural practices, radioactive pollutants and biological agents. Different types of soil pollutants with examples and their harmful effects are listed in table no (3).

Table 3. Pollution Sources, Soil Pollutants and their Harmful Effects.

S.No	Type of wastes	Pollutants	Harmful Effects
1.	Industrial waste	Chemicals, heavy and toxic metals, rubber, polymers	Contaminate soil and water
2.	Urban waste	Road run away water containing oil, slaughter house waste, hospitals and institutional wastes, construction materials	Result into landfills with toxic and non-biodegradable material causing air, water and soil pollution

S.No	Type of wastes	Pollutants	Harmful Effects
3.	Agricultural waste	Fertilizers, herbicides, fungicides, germicides,	Accumulation of these non-biodegradable chemicals in the soil leading to soil erosion
4.	Radioactive waste	Radioactive isotopes with long half-life period	Emission of Gama radiations
5.	Biological waste	Excreta, rotten food, fruits and vegetables	Spreads diarrhoea, cholera, and other water borne diseases

Industrial wastes

Improper disposal of Industrial wastes is one of the major sources for soil pollution

Sources: Industrial pollutants are mainly discharged as effluents from various industries such as pulp and paper mills, chemical fertilizers, oil refineries, sugar factories, tanneries, textiles, steel, distilleries, fertilizers, pesticides, coal and mineral mining, drugs, glass, cement, petroleum and engineering industries etc.

Effects: These pollutants when discharged untreated in the soil alters its physic-chemical and biological properties. As a result, hazardous chemicals find a path into human food chain from the soil or water, thus disturbing the biochemical process leading to serious and chronic diseases.

Urban wastes

It comprises of both commercial and domestic wastes. It generally consists of rubbish that is solid waste and sewage. The urban solid wastes are referred as refuse.

Constituents of Refuse: Refuse consists of garbage and rubbish materials like plastics, glasses metallic cans, fibers, paper, rubbers, street sweepings, fuel residues, leaves, food, containers, abandoned

vehicles and other discarded manufactured products. Urban domestic wastes though is disposed of separately from effluents, is still very harmful. This is because of its non - degradable nature.

Agricultural practices

Modern agricultural practices contribute the most for soil pollution. With the advancement in agro-technology, it has grown as an industry leading to the use of huge quantities of fertilizers, pesticides, herbicides and weedicides etc. to increase the crop yield. Most of these are inorganic chemicals and non-degradable thus causing soil pollution. Other practices such as excessive and faulty farming, excessive grazing, converting forest lands into cultivating lands etc. also lead to soil erosion which is also a type of soil pollution.

Radioactive pollutants

Radioactive substances released as a result of explosions from nuclear testing laboratories and industries give rise to radioactive wastes, which penetrate the soil and accumulate there giving rise to soil pollution. Below are some examples of radioactive pollutants: Radio nuclides of Radium, Thorium, Uranium, isotopes of Potassium (K-40) and Carbon (C-14) are commonly found in soil, rock, water and air.

Explosion of hydrogen weapons and cosmic radiations include neutron, proton reactions by which Nitrogen (N-15) produces C-14. The C-14 participates in Carbon metabolism of plants and then enters into animals and human beings through food chain.

Radioactive waste contains radio nuclides such as Strontium90, Iodine-129, Cesium-137 and isotopes of Iron. Strontium is very hazardous as it get deposited in bones and tissues instead of calcium.

Nuclear reactors produce waste containing Ru-106, I-131, Ba-140, Cs-144 and La-140 along with primary nuclides such as Sr-90 with a half-life 28 years and Cs-137 with a half-life 30 years. Rain water carries Sr-90 and Cs-137 to be deposited on the soil where they are held firmly with the soil particles by electrostatic forces. All these radio nuclides emit gamma radiations which can cause serious effects on the animals such as gene mutation.

Biological agents: Human, animal and bird excreta is a major source of land pollution for example excess of manures and digested sludge can cause serious damage to plants within a few years.

Control Measures of Soil Pollution

Control of soil pollution has become a serious challenge to the man-kind. With prolonged use and dumping of wastes in the soil it is already at the verge of exhaustion. Human activities have done big damage to the earth by altering its physico-chemical characteristics to a great extent. If the corrective measures are not taken seriously it could lead to the extinction of many species from the earth. Some important parameters to control soil pollution are discussed as under:

Control of Soil Erosion can be done by using good forestry and farm practices. Some of the control techniques are given below:

- Stop cutting the trees for cultivation.
- Plantation on barren slopes
- Contour cultivation and strip cropping may be practiced instead of shifting cultivation
- Terracing and building diversion channels should be undertaken.
- Substituting chemical manures by manures.
- Avoid the use of chemicals such as herbicide, germicide, pesticide etc.

Appropriate Dumping of Waste Materials: Excess wastes by man and animals pose a disposal problem. Open dumping is the most commonly practiced technique. Nowadays, controlled tipping is followed for solid waste disposal. The surface so obtained is used for housing or sports field

.

Use of manure and bio-materials as pesticides, herbicides: Manure should be used in place of chemical fertilizers and bio-pesticides should replace the use of toxic pesticides. Organic wastes in animal dung can be used to prepare compost instead of throwing it away in the soil and polluting it.

Proper sanitation habits: People should be trained regarding proper sanitary habits and
Lavatories should be equipped with quick and effective disposal methods.

Public awareness: Informal and formal public awareness programs should be imparted to educate people on health hazards by environmental education.

Recycling and Reuse of wastes: To minimize soil pollution, the wastes such as paper, plastics, metals, glasses, organics, petroleum products and industrial effluents etc. should be recycled and put to use again. Effluents should be properly treated at source by adopting integrated waste treatment methods.

Prohibition on the use of Toxic chemicals: Ban should be imposed on non-biodegradable chemicals and pesticides like DDT, BHC, etc. which are fatal to plants and animals. Nuclear explosions and improper disposal of radioactive wastes should be banned.

5. Noise Pollution

Sound is an oscillating wave with a broad range of frequencies. Humans hearing frequency ranges from 20 Hz to 20,000Hz (20 KHz). Hence sound waves falling in this frequency range are called audible sound. To measure the loudness of sound decibel is used. Decibel (DB) is a unit of sound that indicates the loudness of the sound. Humans can hear sounds between 0 and 140 decibels. A sound higher than 140 decibels is too painful for human ears and can permanently damage ones hearing. According to laws a person working in an environment of 80 decibels or higher should use hearing protection on daily basis in U.K. Some examples of sound at various decibels are listed below in the table (1).

Table 1. Sound and its audacity at different decibels

S.No	Decibel	Sound	Example
1.	10	Almost audible	Falling of a leaf
2.	20	Audible	Rustles of leaves during autumn
3.	30	Very quiet	Whispering voice
4.	40	Quiet	Quiet classroom
5.	50	Limited sound	Sound of refrigerator, car during driving
6.	60	Audible	Talking gently during normal conversation
7.	70	Irritating	Vacuum cleaner, kitchen mixer-grinder
8.	80	Unpleasant	Doorbell, Alarm clock, Horns in traffic
9.	85	Loud	Mixer, Sawing
10.	90	Noisy	Screaming, yelling,
11.	95	Very Noisy	Drill,
12.	100	Extremely unpleasant	Machines in factories, compressor

S.No	Decibel	Sound	Example
13.	105	Louder than above	Helicopters overhead
14.	110	Extremely loud	Rock concert
15.	120	Unbearable	Loudest police siren
16.	130	Frightening and unbearable	Thunder
17.	140	Pain thresh hold	
18.	150	Permanent hearing loss	
19.	160		Shooting with pistol
20.	180		Rocket Launch platform

Thus it can be concluded that sound is one which is good to hear and the listener enjoys it. If the sound becomes irritating and uncomfortable it becomes a noise. However the same sound could be music to someone and noise for the other, but generally speaking music is a periodical and regular phenomenon which is pleasing to ears while noise is an unpleasant and irregular sound irritating and annoying to the listener.

Noise

Unpleasant, unwanted loud sounds are referred as noise. They make the listener uncomfortable, irritating and annoying.

Noise Pollution

Noise pollution is a type of audio frequency that leads to harm the environment. It is neither healthy for the human ears nor to the other creatures on the planet and causes them great harm.

Causes of Noise Pollution

- It includes horns of vehicles.
- All modes of transport whether it is trains, buses, planes all create noise. Traffic as a whole is noisy and annoying.

- Working and running machines also produce large noise; these include drilling, welding, lathe, cutting, harvesting and sewing machines etc.
- Loud music, loud speakers, large public gatherings using PA system generates unbearable noise.
- Festivals when crackers are burnt especially the noise producing ones are very hazardous.

Effects of Noise Pollution

- Over long periods of exposure to noise the loss of hearing could result due to damage in the ear drums, which may lead to permanent hearing impairment.
- High noises can cause diseases related to heart called cardiovascular diseases which can raise or lower the blood pressure levels.
- Loud noise can affect sleeping patterns leading to irritation and sleeplessness, thus affecting the performance of the individuals. This may result into stress and anxiety.
- Stress and anxiety affects the psychological health of the people. In modern days it has become very common.
- Noise causes headache and difficulty in communication while talking.
- Marine animals like whales find their food through sound finds it difficult to identify its prey due to excessive noise produced by oil drilling machines, submarines and other vessels.

Animals and wildlife also depends upon sound. Noise interferes with their hearing mechanism thus making them very aggressive.

Solutions to Noise Pollution

- People awareness is the most important thing that can eradicate noise pollution.
- Use of loudspeakers and mikes should be banned.
- Burning of crackers should be banned as they not only cause noise pollution but also is responsible for air pollution.
- Use of horns in the vehicles should not be too penetrating and they should not be blown too frequently.

Prevention of Noise Pollution

- Government should make strict laws and should be enacted and enforced.
- Plantation of trees acts as natural buffers to absorb sound and in turn reduces noise pollution.
- Airport terminals, Railway terminals and industries should be far from the cities and living habitats.
- Construction and manufacture of soundproof machines and their installation should be encouraged.

6. Thermal Pollution

Thermal pollution is defined as the addition of excess or undesirable heat to air and water thereby making it harmful to flora and fauna both in air as well as in water.

Thermal pollution in air: It is due to the hot flue gases and automobile exhausts released in the atmosphere. These contain greenhouse gases which are responsible in trapping the heat energy without letting it dissipate in the outer space. This makes the most of the global warming and melting of glaciers and polar caps as well as rise in the sea level.

Remedies to Thermal Air Pollution

- Flue gases coming out of the chimneys should be cooled down and passed through precipitators before their release in the atmosphere. Their heat can be recycled and used in reheating the furnaces.
- A regular check of the automobiles should be made mandatory before bringing it on the road.

Thermal pollution in water bodies: It is due to sudden change in temperature of water bodies by human activities and influences. It can be explained further as the degradation of water quality by any process that changes ambient water temperature. The main reason attributed to the rise in temperature of water is the use of water as coolants by power plants and other industrial sectors.

Sources of Thermal Pollution:

The following are the sources responsible for thermal pollution

1. Nuclear power plants
2. Coal fired plants
3. Industrial effluents
4. Domestic sewage

5. Hydro-electric power

Nuclear Power Plants

Nuclear power plants coolant water, hospital wastes, and chemical wastes from research institutions, nuclear experiments and explosions, discharge a lot of heat along with this traces of toxic radio nuclides are also discharged into nearby water streams. All these are responsible for increasing the temperatures of water bodies. The power reactors and nuclear fuel processing are the major contributors of heat in the aquatic environment. Heated effluents from power plants are discharged at approximately10^{o}C higher temperature than the receiving waters that affects the aquatic flora and fauna.

Coal Fired Plants

Coal fired power plants constitute a major source of thermal pollution. The hot condenser coils in such plants are cooled with water from nearby lakes or rivers. The resulting heated water is then discharged into streams thereby raising the temperature of the water body by 15^{o}C. The heated effluent also decreases the dissolved oxygen in the water resulting in death of fish and other aquatic organisms. The sudden fluctuation of temperature also leads to "*thermal shock*" killing of aquatic life.

Industrial Effluents

Industries like textile, paper, pulp and sugar and distilleries release huge amounts of cooling water along with the effluents into nearby natural water bodies. The waters thus get polluted by sudden and heavy organic loads. The result is severe drop in the levels of dissolved oxygen and increase in BOD values, leading to the massive growth of algae and death of several aquatic organisms.

Domestic Sewage

Domestic sewage is discharged into rivers, lakes, canals or streams with minimal treatment or without any treatment. Microorganisms present in the sewage make the temperature very high due to their metabolic activities and also increases the organic load of the sewage. This leads to decrease in dissolved oxygen content in the receiving

waters. It also sets-up of anaerobic conditions causing release of foul and offensive gases in water. Eventually, this leads to development of anoxic conditions resulting in rapid death of aquatic organisms.

Hydro-electric Power

Generation of hydroelectric power leads to negative thermal loading in water systems. Apart from electric power industries, many factories with cooling requirement contribute to thermal loading.

Causes of Thermal Pollution

The main causes of thermal pollution are

- Rapid industrialization and urbanization has led to improper planning of dumping of wastes.
- Deforestation: To acquire land for industries and townships.
- Removal of stream side plantation for construction of recreation centers.
- Improper practices of agriculture that leads to soil erosion and increase in livestock.

Effects of Thermal Pollution

Reduction in dissolved oxygen: Concentration of Dissolved Oxygen (DO) decreases in water with rise in temperature.

Increase in solubility: The rise in temperature increases the solubility of minerals in water. With increasing temperature solubility also increases thus with a $10^{o}C$ increase in temperature of water solubility of the salt doubles and thus the toxicity effect doubles. Massive mortality of fish is an example of increased solubility of potassium cyanide at high temperatures.

Interference in biological activity: Temperature is of vital significance to physiology, metabolism and biochemical processes that control respiratory rates, digestion, excretion, and overall development of aquatic organisms. Change in temperature leads to total disruption to the entire ecosystem.

Interference in reproduction of aquatic species: In fishes and frogs several activities like nest building, spawning, hatching, migration and reproduction depend on optimum temperature. All these are affected by sudden change in temperature to which these organisms are not acclimatized.

Increase in mortality rate of aquatic animals: Thermal pollution is directly responsible for mortality of aquatic organisms. Increase in temperature of water leads to exhaustion of microorganisms thereby shortening their life span. Above a certain temperature, fish die due to failure of respiratory system and nervous system failure.

Food stock for fish: Sudden change in temperature alters the seasonal variation in the type and abundance of lower organisms leading to shortage of food for fish.

Control of Thermal Pollution

The thermal pollution can be controlled if the following measures are adapted:
Cooling of water: before returning it to the water bodies. The industries using water as coolant should first cool the water by passing it through cooling towers provided with condensers which help in transferring the heat of the water to the atmosphere through evaporation and then return it to the water bodies. There are two types of cooling towers.

Wet cooling tower: They provide direct contact between the cooling water and air passing through the tower. Hot water from the industries is allowed to spray over baffles in the cooling tower. High velocity cool air is blown from sides, which takes away the heat from the water. The major drawback with this type of cooling is carried over of particulate matter as drift droplets.

Dry cooling tower: Here, hot water is allowed to flow in long spiral pipes. Cool air with the help of a fan is passed over these hot pipes, which cools down hot water. This cool water can be recycled.

Cooling water in cooling ponds: Cooling ponds is the best method to cool thermal discharges. In ponds hot effluents loses maximum heat by dissipation of heat to the atmosphere.

Spray ponds: The water coming out from condensers is allowed to pass into the ponds through sprayers. Here water is sprayed through nozzles as fine droplets. Heat from the fine droplets gets dissipated to the atmosphere.

Artificial lakes: Artificial or man-made lakes are a good choice for cooling hot effluents. The heated effluents can be discharged into the lake at one end and the water for cooling purposes in the industry may be withdrawn from the other end. The heat is eventually dissipated through evaporation.

7. Radioactive Pollution

Nuclear Energy

It is the energy in the core of an atom called nucleus. Atoms are tiny indivisible particles, which are the building block of all objects in the universe. The atoms unite with bonds to give molecules. These bonds which hold the atoms together are very strong and require enormous energy for making and breaking of bonds. This is termed as nuclear energy. The nuclear energy can be used to generate electricity, by two types of reactions namely nuclear fusion and nuclear fission.

Nuclear fusion: When atoms are combined or fuse together to form large atom, the energy released is called nuclear fusion. Sun also produces energy through nuclear fusion reactions.

Nuclear fission: When the atoms are ripped apart to form small atoms, the reactions are called nuclear fission reactions. Nuclear power plants use nuclear fission reactions to produce electricity.

Nuclear Reactions: Nuclear reactions involve transmutation of one element into a different isotope or an entirely different element. There are two types of nuclear reactions:

***Radioactive Decay*:** In this the decay of bonds within the nucleus takes place that emits radiations as it decays and transforms to a more stable state.

***Billiard Ball type reaction*:** Here the nucleus or nuclear particle (proton) is slammed into another nuclear particle or nucleus.

Radioactivity: Radiations is a natural phenomenon. Radiations are energy in the form of waves or stream of particles. There are various types of radiations such as sound radiations, visible light radiations, UV radiations, IR radiations. The radioactivity is a kind of energy in the atoms or nucleus that can cause changes in atoms, creating electrically charged atoms called ions. The radiations that produce ions are called ionizing radiations. All forms of life on earth are evolved by these ionizing radiations. Unlike other radiations these

radiations are invisible and cannot be sensed, but they can be detected and measured even in traces with simple radiation measuring instruments.

Ionizing Radiations: The radiations produced as a result of radioactive decay is called radioactive or ionizing radiations. The major ionizing radiations are alpha (α) and beta (β) particles, gamma (γ) rays, X-rays and neutrons. All these types of radiations cause serious injuries to exposed parts. They cause cancer and genetic damage and genetic mutations which pass on to future generations.

Alpha (α) particles: It consists of two protons and two neutrons and is positively charged. They are non-penetrating and can be stopped by paper.

Beta (β) particles: They are fast moving electrons and are negatively charged. They are more penetrating than alpha particles, but can be stopped by book or human tissue.

Gamma (γ) rays: It is radiation emitted as result of ejection of α and β particles. The gamma radiations are highly penetrating and can pass through human body, but it gets absorbed in lead.

X-rays: They are very penetrating and are produced artificially.

Neutrons: They are produced from nucleus by nuclear fission reactions.

Sources of radioactive radiations

Radioactive radiations can be obtained from:

1. Natural sources
2. Artificial sources of radioactive radiations.

Natural sources of radioactive radiations: Uranium and other radioactive materials occur naturally and they are present everywhere in nature in rocks and soil. These naturally radioactive materials decay and change and produce a gas called radon which is also present in air that we breathe.

Artificial sources of radioactive radiation: The artificial sources of radioactive radiations include:
Medical sources using ionization radiations, Nuclear power plants where nuclear explosions take place, Consumer products containing radioactive material.

Capabilities of Nuclear Power:

A sustainable source of energy: Uranium Reserves 'Red Book' published by the U.N. IAEA suggests that there are over 200 years of Uranium reserves at current demand. There is also a very large supply of uranium dissolved in seawater at very low concentration.

Ecologically clean: It does not add to any pollutants to the atmosphere. Actually it emits nothing in the atmosphere except clean hot water. Very little CO_2 or other climate-changing gases come out of nuclear power generation, the amount of CO_2 produced is about 50 times less than the combustion of coal and 25 times less than natural gas plants.

Gives energy independence: It gives energy independence to countries which lack fossil fuel: Many nuclear reactor designs can provide high-quality process heat in addition to electricity, which can in turn be used to desalinate water, prepare hydrogen for fuel cells, or to heat neighbourhoods, among many other industrial processes.

Hazards of Nuclear energy: Below are explained the hazardous effects of nuclear materials and the radiations emitted by it.

Generation and Disposal of nuclear waste: During nuclear fission, atoms split to release energy, these smaller atoms that are left behind are often left in excited states, along with the emission of energetic particles that can cause biological damage. Some atoms do not decay quickly and have a very long half-life. Thus they remain present in the atmosphere for hundreds and thousands of years.
The presence of the nuclear material and their radiations are harmful even after decades.

Storage of Nuclear Material: Care should be taken in storing the radioactive material as any leakage of the radiations from the storage

box could lead to severe damage to the lives and environment which would be irreparable.

Working with the radioactive material: Scientists and technologists should follow the security instructions very strictly while working with these materials in laboratories or Nuclear plants to avoid any exposure to the radiations.

Biological Hazardous effects of Nuclear radiations: An ionising radiation when penetrates living tissues the chemical nature and structure of living cells can change. If exposure is long and to moderate or high level of radiations, sufficient radiation are absorbed, by the cells and it may result in permanent alteration or destruction of the cell. Though Living tissue has a great ability to repair itself, but in some cases these cellular changes can undergo mutation and develop cancer. They could also cause genetic damage or birth defects. These effects are most likely when a person is exposed to high or moderate levels of radiation.

Nuclear accidents and tragedies: The three major and most dreaded accidents that have occurred in commercial plants can never be forgotten namely: Chernobyl, Three Mile Island and Fukushima.

Chernobyl: It is known for its uncontrolled explosion which released large amount of radiations in the environment, killing over 50 people and mass evacuation of thousands of people, causing cancer to up to 4000 people.

Three Mile Island: It was a partial-core meltdown, where coolant levels dropped below the fuel and allowed some of it to melt. No one was hurt and very little radiation was released, but the plant had to shut down, causing the operating company and its investors to lose a lot of money.

Fukushima: It was a station black-out caused by a huge Tsunami. Four neighbouring plants lost coolant and the decay heat melted the cores. Radiations were released and the public was evacuated.

Applications of Nuclear material and radiations

Nuclear or radioactive material should be used properly, and with care. Radiation offer many benefits in medical field. For example, using X-rays for medical diagnoses has more potential benefits than potential risks. Radioisotopes are used for many medical diagnostic procedures and for the treatment of cancer. Radiation is also used to sterilize objects.

Radioisotopes are used in a number of consumer products such as smoke detectors, emergency exit signs. X-rays are used at airports, Malls, Movie theatres to inspect baggage. Industries also use radiation to inspect structural welds in pipelines and in shipbuilding.

Radiations are used in scientific research. Naturally-found radioisotopes play an important role in dating archaeological artefacts. In agriculture, radioisotopes help scientists develop new strains of plants and track the habits of insects and pests.

Reactors and particle accelerators in physics and technology are used to create new radioisotopes to be used in medicine and industry.

Nuclear reactors are used to generate clean electrical power.

Nuclear Pollution

Any undesirable effect caused to the environment due to radioactive substance or radiations is referred as nuclear pollution. It comes from a variety of sources such as nuclear fission and radioactive mining. It can also be released into the water, air or soil as a result of human activity, either by accident or by design during the production of nuclear fuel reactor materials, or when radioactive materials are used in medicine and other industries.

Harmful Effects of Radiations From Nuclear Materials

The radioactive minerals contain different forms of uranium, thorium and plutonium which emit energetic radiation causing pollution.

The radio nuclides that are present in the atmosphere break down further into smaller parts, emitting radiation and enter in the organisms during breathing.

Similarly, cosmic rays contain high energy particles and cause pollution as they reach on Earth.

Nuclear radiation has catastrophic effects on the health of humans such as damage to the embryo, leukemia, permanent physical deformation, skin burns and even death if the person is exposed to severe radiations. .

Radiations lead to mutations which bring unwelcoming changes in DNA molecules hence causing severe deformations in the generations coming ahead.
Release radiations in the environment by the man-made sources that include nuclear plants, radioactive wastes produced during Atom Bomb testing, nuclear explosion and radio isotopes. The nuclear plants produce a lot of waste causing pollution and lately its disposal has posed serious global problem as it remain in the environment for indefinite length of time causing pollution.

Damage Control from Radiations

In order to control the nuclear damages, it is very important to follow the instructions strictly. They are as under:

Disposal of the nuclear wastes: It should be done in safe and scientific manner. The radioactive wastes should be closed in tight containers underground or remote areas and be allowed to decay.

Exposure time: People who work in radiation areas must reduce their time of stay near radioactive sources. The shorter the period of exposure to radiation, the less radiation will be absorbed by them.

Distance from radioactive material: The intensity of ionizing radiation decreases rapidly with distance, thus by increasing the distance from a radioactive source, the amount of exposure is reduced.

Use of Protective clothing: It should be provided to the people working with radioactive materials which can give them protection against radiations.

Shielding materials: People working with or near radiation sources should protect themselves by barriers which include shielding of lead, concrete, and other heavy materials.

Use of Dosimeters: People working near radioactive materials should wear devices called dosimeters. These devices monitor and record ionizing radiation doses to guard them against the possibility of over exposures.

Rules and Laws: The rules and regulations laid down for working in radiation areas should not be overlooked. Strict preventive measures should be in taken to avoid accidents and safety measures should be adopted against the accidental release of any radioactive elements. This must be obligatorily implemented at all the plants.

8. Agricultural Pollution

Civilization and Agriculture are contemporary, with the beginning of cultivation began the human civilization. Early man was food gatherer but hunger and safety taught him to grow the grains and store them for future use with this need started the learning processes and development of innovative techniques in agriculture. For thousands of years, agriculture was a natural and environmental friendly process. However, with modern agricultural practices the agriculture came booming up as an industry. The world demand was also at a high for crops and consumables especially fruits and vegetables. This growing need brought revolution in agriculture converting it into a full fletched industry. Agricultural industry is the largest among all other industrial sectors in the world. With the growth of agriculture on such a large scale required many inputs for getting high yield, multiple crops in a season, temperature resistant and many more. This gave rise to addition of chemicals to the crops as fertilizers, hormones, pesticides, insecticides, fungicides and germicides. Production of these chemicals required the use of large amount of conventional sources of energy from the fossil fuels. Irrigation of huge farmlands in the dry and poor rainfall areas required more energy to run the water pumps. Veterinary also gained momentum with agriculture not only for milk and milk products and meat but also for other valuable articles obtained from animals such as wool, leather, gelatin etc. This has led to the excessive growth of livestock. All these practices which though look green are actually most harmful as they cause maximum damage to the earth.

Agricultural pollution in India: In India agriculture is one of the most important economic sectors engaging more than 60% of the population directly or indirectly. It is a nation's life line that ensures food security to the world second largest population. The most coveted goal of food security was achieved with the grand success of green revolution with intensification of farming. The green revolution though heavily depended on heavy reliance on energy intensive

inputs and scarce resources like water. During the latter half of the twentieth century, desperate attempts to produce more and more food grains has ignored the indiscriminate and excessive use of water and chemicals which has caused enormous damage to environment. During the last fifty years, agricultural practices have caused serious environmental damage like soil health, water and air which lead to serious health problems. Punjab which was the cradle of green revolution has unprecedented high number of cases which are largely attributed to high levels of pollutants and pesticides soil and water entering to the food system. Very high levels of fertilizer use particularly N fertilizers have caused pollution on water bodies and impacted soil health. Excessive exploitation of water resources has depleted water tables. Soil has lost fertility with growing salinity and desertification. Indiscriminate and excessive use of pesticides has been another landmark of modern agriculture resulting to high levels of pesticide residues in the soil. The latest addition to this, already serious, problem, is menace of residue burning particularly in north western part of the country. Millions of tonnes of rice and wheat straw left in the field after combine harvesting is burnt which has seriously affected air quality there and in the neighbouring states.

Important Agricultural Pollutants

Pesticides and Fertilizers: There has been tremendous growth in technical grade pesticides to control insect pest and fertilizer use to supply essential nutrients. Addition of N fertilizers in large quantities has been particularly damaging to the environment because N is water soluble and moves with water to water bodies. The results of addition of these chemicals in the beginning were very encouraging so the farmers started adding them in excess to the amounts advised by the experts. This led to the accumulation of the chemicals in the soil layers as most of it was not absorbed by the plants. This accumulation led to severe contamination of the soil.

Fumigants: The chemicals that are added for pest control during storage of the produce are called pesticides. Fumigants are commonly used pesticides. These fumigants slowly vaporize to release volatile organic compounds (VOCs) that kill the pest and keep the produce secured. These VOCs are highly poisonous and if consumed or inhaled could be fatal. The fumigants are volatile gets leaked from the silos and reach the atmosphere thereby polluting the air.

Sediments: Deposition of minerals in the layers of the soil is called sedimentation. Sedimentation in the soil can change the pH of the soil, increase salinity or alkalinity in the soil. All this leads to crop damage and is also destructive for the soil.

Causes of Agricultural Pollution

Soil Erosion: There are several other reasons for contamination of soil besides the use of chemicals, they are over grazing and over use of forest land for cultivation, cutting down of trees in the forest for land and timber lead to deforestation. All these selfish human activities are responsible for the environmental degradation due to soil erosion, a type of soil pollution, where the fertile soil layer is washed away from the earth surface thus converting it into a barren land.

Contamination of water: The irrigation back flow water is allowed to mix with water bodies. This water is saturated with dissolved chemicals and when it mixes with the water in the rivers or lakes make them polluted. This is referred as Agricultural nonpoint source (NPS) pollution.

The ground water also gets polluted due to the leaching of impurities in the layers of soil which reaches ground water table leading to ground water pollution. These VOCs are highly poisonous and if consumed or inhaled could be fatal. The fumigants are volatile gets leaked from the silos and reach the atmosphere thereby polluting the air.

Emission of greenhouse gases: Gases such as CO_2 and methane are largely released as a result of agriculture. These are greenhouse gases and are responsible for global warming and other environmental risks such as increase in the sea level, melting of glaciers, climate change etc. The main sources of gas emissions are:

Residue burning: The burning of farming residues is causing serious drawbacks. The farm residue burning generates smoke leading to air pollution that makes the agriculture sector accounts for almost for 35% of greenhouse gas emissions.

Deforestation: Forest belts have been greatly reduced to acquire forest land for cultivation and grazing grounds for the cattle. This has led to

major environmental issues such as soil erosion, increase in the concentration of greenhouse gases, increase in concentration of ground level ozone etc.

Livestock and organic matter: A high increase in the number of cattle and other farm animals is not only requires fodder for their survival but also the disposal of their waste organic matter results into the emission of greenhouse gases in the atmosphere. Both developed and developing countries, ammonia emissions from agriculture and livestock is on a continue rise.

Contamination of air: The emission of greenhouse gases, VOCs, deforestation, burning of farm residues, large herds of farm animals, sewage dumping all results into pollution of air their by contaminating it.

Health issues in human: Major health problems are caused due to the consumption of contaminated agricultural produce whether it is grains, fruits, vegetables, milk and meat. Use of polluted water for drinking and cooking purposes also leads to serious health issues. The deposition of heavy metals and toxic minerals in the tissues of plants and animals is unhealthy for them and kills them. The consumption of contaminated vegetables and food by the humans cause serious health problems.

Effect on life cycle of aquatic and marine animals: The animals that are water dwellers get infected with the dissolved impurities that are responsible for the change in their metabolism, reproduction and breeding and even death.

Radioactive pollution: The extensive use of radioactive isotopes in agriculture can lead to the radioactive pollution as these materials have a very long half-life period and can remain in the atmosphere for thousands of years.

Long and frequent dry and wet spells: This is due to the change in climate and lead to unpredictability of the weather which can affect the cultivation and farming thereby causing famine.

Agricultural waste: The waste that is produced as a result of various agricultural operations such as manure, wastes from poultry, slaughter of cattle, harvest waste, irrigation run-off containing

fertilizers, pesticides and insecticides are referred as agricultural waste. This waste when reach in the different eco-systems affects them adversely.

Agro-waste: The rejected stuff of agricultural produce such as plant stalks, hulls, leaves, disposable vegetable matter, dung etc. are defined as agro-waste. It is produced as a result of farming activities.

Agricultural Waste Management

Soil in agriculture plays an important role in disposal and waste management of agricultural and agro-waste. It is generally the soil which is used as disposal sites for the waste. Proper selection of soil can minimize environmental damage. The treatment of the waste before its disposal in the soil can further reduce it. Physical Sorting and Separation of waste: The wastes produced from various sources should be kept separately.

Manure and food processing waste: This should be subjected to decomposition in large tanks under aerated condition to convert it into manure which if supplied to the soil increases crop production. They are rich in nitrogen content which is highly required for plants. They could be in the form of solid, slurry or liquid.

Sewage sludge: The sludge formed as a result of secondary treatment of sewage employing activated sludge process for treatment of sewage is called sewage sludge. It is rich in nutrients, cell mass mainly bacteria, sand, silt and other solid debris. The hazardous and toxic metals if incorporated from various processing units should be removed by tertiary treatment methods prior to its use as manure to the plants to prevent it from entering into the food chain through plants.

Sewage water: The percentage of water in the sewage varies from 40-98%. If the %age of water is more than 90% the sludge produced is called liquid. If the water content is between 50-90% it is called slurry and below 50% is termed as solid. The disposal of treated sewage water in irrigation not only improves crop production but also prevents rivers, lakes and other water bodies from getting contaminated.

Paradoxes of Agriculture

Trees, plants, and microorganism clean the atmosphere and act as natural sinks or buffer. Polluting gases, complex organic compounds, minerals etc. are consumed, decomposed and broken down during their metabolic processes thus converting these pollutants into useful and simple compounds. These are recycled in the environment as humus, nutrients, minerals and food (crops, grains, vegetables, fruits) for humans and other animals and plants. This natural recycling of the waste is a gift of agriculture to the environment. On the other hand livestock and agriculture are the major sectors that contribute to maximum air pollution by themselves. The chemicals used in agriculture to increase crop production in modern agricultural practices are industrially manufactured synthetic products. The flue gases released from the chimneys are hot and sometimes carry particulate matter with them. This suspended matter in air provides nuclei for the formation of rain, fog and snow which damage the plants and harvests. The flue gases also contain high concentration of CO_2 and CO which are toxic and greenhouse gases. However the main source of greenhouse gases emission is manure and livestock. Thus agriculture is the main source of production of greenhouse gases, which has the largest share in the climate change.

If used intelligently the same can bring about a reverse to climate change. The main source in greenhouse gases is carbon, which is the basis of all living things on earth. Carbon also follows a carbon cycle similar to water cycle. Carbon is stored in living things and in fossil fuels which are produced from living things by their burial into the ground for centuries together such as-oil, coal and natural gas. When these are burnt the carbon stored in them is released as CO2. The released CO_2 gas is recycled into new life forms keeping the carbon levels and atmosphere in a dynamic natural balance. With industrial revolution this carbon cycle got disrupted resulting in a highly destabilized climate. Modern agriculture techniques are contributing further in its disruption. Using regenerative carbon farming practices the climate change can be reversed by adding more carbon into the ground than is released into the atmosphere. This method will not only make the soil more productive and resilient to climate change but will also improve the infiltration and water holding capacities of the soil. Such farming practices could mitigate 4-6 billion tons of CO_2

eq/year or 10-12 % of global human caused greenhouse gas emissions and protect the environment.

Other methods to reduce pollution are elimination or reduction of tilling of soil. Use of diverse cropping systems over mono-cropping should be preferred. All this could help in reversing the climate change.

9. Climate Change

The protective gaseous cover of atmosphere provides benign conditions for all forms of life on Earth to propagate and perpetuate. Various forms of life evolved on Earth over millions of years are adapted to the existing climatic conditions and survive by making use of available natural resources. Any major perturbations in the atmospheric conditions over a short period of time will lead to serious ecological consequences and threat to this living planet The Earth. The atmosphere has mixture of gases like Nitrogen, Oxygen, Carbon dioxide, other inert gases and water vapor. This gaseous mixture, besides its life supporting role, together with water vapor imparts certain physical characteristics to atmosphere which regulates the solar energy flow in and out of atmosphere thus controls energy balance, air temperature and general air circulation systems around the Earth surface and in the outer atmosphere. Day to day natural variation in atmospheric conditions at a place in terms of energy (solar radiation), air temperature, wind circulation (speed & direction), water vapor content (humidity) caused due to Earth rotation and local factors is called weather. Whereas, such variation in atmospheric conditions at a given location or geography over a long period of time is called Climate. At a given locality, there is a daily and seasonal natural variability in weather and climate of a place depending on its geo-positional and local factors like water bodies, vegetation and topography.

However, in a polluted environment, caused by various human activities as discussed in preceding chapters, natural atmospheric processes get disturbed and lead to unnatural variations. Such long term unnatural variability in global atmospheric conditions is referred to as Climate Change. As per United Nations Framework Convention on Climate Change (UNFCC), Climate change is defined as '*change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'*. Such changes in climatic conditions are causing major ecological disturbances and disruption to economic activities. The adverse effects of climate change means *changes in the physical environment or biota resulting from*

climate change which have significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare'.

The climate change is man-made problem with disastrous consequences. It is the result of excessive exploitation of natural resources for human greed. A perpetual polluting life style and increasingly indiscriminate use of conventional energy sources has resulted into excessive pumping of certain gases, called Greenhouse gases (GHG) in to the atmosphere which resulted to climate change. Greenhouse gases, as defined by Intergovernmental Panel on Climate Change (IPCC) are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorbs and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect causing global warming. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine- and bromine containing substances. Presence of GHGs essentially alters the energy balance in the atmosphere causing a net rise in energy budget thus resulting to increase in temperature.

Major greenhouse gases are naturally present in the atmosphere however; anthropogenic addition of these gases increases their concentration beyond threshold level which causes warming due to greenhouse effect. Warming effect of these GHGs depends on their global warming potential (GWP) or radioactive forcing. Global Warming Potential is defined as an index, based on radioactive properties of greenhouse gases, measuring the radioactive forcing following a pulse emission of a unit mass of a given greenhouse gas in the present day atmosphere integrated over a chosen time horizon, relative to that of carbon dioxide. The GWP of CO_2 is taken as 1. Radioactive forcing is the change in the net, downward minus upward, radioactive flux (expressed in W m–2) at the tropopause or top of atmosphere due to a change in an external driver of climate change, such as, for example, a change in the concentration of carbon dioxide or the output of the Sun.

The change in concentration of different GHG over pre-1750 period and their global warming potential is given in table 1. It is noteworthy here that although the concentration of some of the gases in the atmosphere is very low (in parts per billion or parts in trillion) but

their warming potential is much higher than CO_2. Methane, for example has 28 times more warming potential than CO_2. Also note the life time of the GHGs which can last for centuries and therefore any mitigation efforts will have its impact only in the long term. Since CO_2 is the major GHG (*ca.* 80%) in the atmosphere GWP of a GHG is expressed in relation to GWP of CO_2 as CO_2-equivalent. Although water vapor is an important GHG but its exact concentration cannot be given because of its spatial and temporal variations in the atmosphere. Average water vapor content is about 5000 ppm but in the warmer climate it is likely to be higher as warmer temperature can hold more water vapor.

Table 1. Concentration, GWP Radiative Forcing of Different GHGs (IPCC 2013).

GHG	**Pre-1750 Trpospheric Concentration**	**Recent Tropospheric Concentration**	**GWP (100 Year Time Horizon)**	**Atmospheric Life Time**	**Increased Radiative Forcing (W/m^2)**
Carbon Dioxide (CO_2)	280 M	> 400 ppm	1	100 - 300	1.94
Methane (CH_4)	722 ppb	1834 ppb	28	12.4	0.50
Nitrous Oxide (N_2O)	270 ppb	328 ppb	265	121	0.20
Ozone (O_3)	237	337	NA	Hours/ Days	0.40
CFC-11 (CCl_3F)	0	232	4660	45	0.06
CFC-12 (CCl_2F_2)	0	516	10,200	100	0.166
Carbon Tetrachloride (CCl_4)	0	82	1730	26	0.014
Sulphur Hexafluoride (SF_6)	0	8.6	23,500	3200	0.0049

A Brief History of Evolution of Science of Climate Change and International Cooperation

History of climate change, supported by credible scientific evidences is relatively new. Reports on increasing GHG, particularly CO_2 concentration in the atmosphere and rise in temperature with possible consequences to crop productivity started appearing in later half of the twentieth century. Kimball (1983) reviewed impact of CO_2 x temperature on number of crop species suggesting possibility of a positive impact of CO_2 on crop productivity. However, a large number of scientific reports on climate change appeared during eighties and nineties clearly suggesting a major net negative impact of climate change on world food supplies with major disruptive impact in developing world (see review Rosenzweig and Parry, 1994). Taking cognizance of growing scientific evidence for climate change and its serious consequences, **The Intergovernmental Panel on Climate Change (IPCC)** was set up in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) to collect and collate available scientific information and present an assessments on all aspects of climate change and its possible impacts on all aspects of human life and formulate realistic response strategies. IPCC has a global community with current membership of 195 countries. Thousands of scientists from all over the world contribute to the IPCC reports. The initial task for the IPCC as outlined in UN General Assembly Resolution 43/53 of 6 December 1988 was to prepare a comprehensive review and recommendations with respect to the state of knowledge of the science of climate change; the social and economic impact of climate change, and possible response strategies and elements for inclusion in a possible future international convention on climate. Today the IPCC's role is as defined in Principles Governing IPCC Work, "*...to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. IPCC reports should be neutral with respect to policy, although they may need to deal objectively with scientific, technical and socio-economic factors relevant to the application of particular policies*" (www.ipcc.ch).

Since its inception in 1988 IPCC has presented a large body of most comprehensive scientific literature and irrefutable evidence with

increasing confidence levels on climate change impacts, regional vulnerabilities, adaptation & mitigation strategies and policy framework to address this serious threat to entire humanity and our only home - The Earth. Other than assessment reports, IPCC also periodically publishes various technical papers and Special reports prepared by different working groups and task force (IPCC, 2010). First IPCC Assessment Report was released in 1990 presenting comprehensive scientific evidence for climate change, emphasizing the importance of climate change as a global challenge and need for international cooperation to combat and prepare to deal with its impact. By sensitizing the global community about the serious implications of the climate change, first IPCC report played a pivotal role in the creation of the United Nations Framework Convention on Climate Change (UNFCCC) which came into force in March 1994.

The IPCC Second Assessment Report was published in1995. This report presented the framework for adoption of the Kyoto Protocol in 1997. The Third Assessment Report came out in 2001 and the Fourth in 2007. The Fourth Assessment Report emphasized on sustainable development with major focus on mitigation and adaptation strategies. The Fifth Assessment Report (AR5) was released in four parts between September 2013 and November 2014. It consists of three Working Group (WG) reports and a Synthesis Report (SYR) which integrates and synthesizes material in the WG reports for policymakers. Compilation work on The Sixth Assessment Report is in progress and it is likely to be released in 2022.

United Nations Framework Convention on Climate Change (UNFCCC): Post Brundtland Commission report titled "Our Common Future" by United Nations World Commission on Environment and Development published in 1987, there was growing realization about the anthropogenic environmental degradation and it's far reaching ecological & economic consequences. The report, also referred to as 'Sustainability Report', made a huge impact and created global consensus about protection of environment and preservation of our dwindling finite natural resources for the sake of our safe future. With this in background and supported by scientific evidences on human interferences with our climate system presented in first IPCC report on Climate Change in 1990, global community was quick to adopt United Nations Framework Convention on Climate Change presented in the Earth Summit (Rio Summit) in 1992. After ratification by

member countries, the treaty came in force in 1994 with current membership of 197 called 'parties'. The UNFCC secretariat is at the UN Campus in Bonn, Germany. The ultimate objective of this International treaty, as outlined in Article 2 of the treaty, is to *"……stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."*

As per the guiding principles of the convention, 'the Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities'. Parties should take mitigation measures to minimize the adverse effects and develop policies to taking in account the impact of climate change in various sectors. Conventions calls for international cooperation in sustainable development through international economic cooperation including technological transfer and exchange of relevant scientific, technological, technical, socio-economic and legal information related to the climate system and climate change. Creating awareness and dissemination of information is important part of this convention for larger participation by all sections of the society to limit further anthropogenic emissions.

As per article 7 of the convention a conference of the parties (COP) was established as supreme decision making body of this convention to monitor and review the progress in effective implementation of the convention. All states which are party to the convention are represented at the COP. List of all the COPs along with major outcome from each COP is listed in table.. . Some of these COPS have been major events in the progress towards climate change mitigation and are important milestones in global efforts to limit the extent of emissions and the extent of global warming.

Year	COP	Place	Major Outcome
28 March – 7 April, 1995	COP 1	Berlin Germany	Agreed on activities implemented Jointly in international climate action
18 July 1996	COP 2	Geneva, Switzerland	Discussions and acceptance of IPCC second assessment report (1995).

Year	COP	Place	Major Outcome
December, 1997	COP 3	Kyoto, Japan	Adoption of Kyoto Protocol for certified emission reductions (CERs) and Kyoto mechanism on emission trading and clean development mechanism (CDM).
November, 1998	COP 4	Buenos Aires, Argentina	Plan of action for implementing Kyoto protocol.
October - November, 1999	COP 5	Bonn, Germany	Technical Meeting and General Discussions.
November, 2000	COP 6	The Hague, Netherland.	No agreements. Negotiations rescheduled for 2001 in Bonn, Germany
July, 2001	COP 6	Bonn, Germany	USA rejected Kyoto protocol and did not participate. Agreements on carbon credits and finance mechanism for climate change adaptation programs.
October - November, 2001	COP 7	Marrakech, Morocco	The Marrakech Accord. Rules for emission trading and Implementation of CDM.
October - November, 2002	COP 8	New Delhi, India	New Delhi Ministerial Declaration. Call for transfer of technology to developing countries and minimize the impact of climate change.
December, 2003	COP 9	Milan, Italy	Utilization of funds and technological support to developing countries for capacity building.
December, 2004	COP 10	Buenos Aires, Argentina	Emphasis on climate change mitigation and adaptation.
November-December, 2005	COP 11	Montreal, Quebec, Canada	Kyoto Protocol came into force.

Year	COP	Place	Major Outcome
November, 2006	COP 12	Nairobi, Kenya	Discussions on Mitigation and Adaptation strategies and Implementation of CDM
December, 2007	COP 13	Nusa Dua, Bali, Indonesia	Adoption of Bali Action Plan. Timeline on post-2012 Kyoto Protocol.
December, 2008	COP 14	Poznan, Poland	Funding to the poorest nations to cope with climate change.
December, 2009	COP 15	Copenhagen, Denmark	Discussions on Post-Kyoto Agreements.
November-December, 2010	COP 16	Cancum, Mexico	Discussions on setting up of Green Climate Fund. Agreement to a warming limit of 2 ^{o}C.
November-December, 2011	COP 17	Durban, South Africa	Discussions on setting up of Green Climate Fund.
November-December, 2012	COP 18	Doha, Qatar	Doha Amendment to the Kyoto Protocol.
November, 2013	COP 19	Warsaw, Poland	Major Outcome
December, 2014	COP 20	Lima, Peru	Post Kyoto Protocol Discussions.
November-December, 2015	COP 21	Paris	Paris Agreement
November, 2016	COP 22	Marrakech, Morocco	Water scarcity and water Security

For example, Kyoto Protocol was an important milestone in proposing an innovative cooperative mechanism for emission reductions. The protocol included mutually beneficial, market-based mechanism for emission reduction. The mechanism of certified emission reduction credits allowed industrialized nations (referred as Annex I countries) to fund emission reduction projects in developing countries and claim that emission reduction to their credit. Thus, promoting a sustainable development in developing countries and

also achieving emission reduction targets. As stated in Kyoto Protocol Article 12.2 "The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3." Some of the energy intensive specific areas were identified for joint implementation like energy efficiency, renewable energy projects, agriculture, industrial processes and afforestation & reforestation projects. A joint monitoring and validation mechanism was also proposed for assessing and granting the CERs.

Recently, Paris agreement 2015 was another major step forward where International community committed to keep warming well below $2^{o}C$ above pre-industrial levels. Parties also committed to 'nationally determined contributions' to achieve this ambitious target. Out of total 197 parties, 155 have already ratified the treaty and it came into force in November, 2016. India also ratified the treaty and committed its Intended Nationally Determined Contribution (INDC) for the period 2021-2030 by setting an ambitious target of reducing the emission intensity of GDP by 33-35% by 2030 from 2005 levels by adopting a climate friendly and cleaner path of development.

These commitments are guided by philosophy of "*Development without Destruction*". Number of initiatives has been taken by Government of India in following priority areas to achieve the INDC targets:

1. Introducing new, more efficient and cleaner technologies in thermal power generation.
2. Promoting renewable energy generation and increasing the share of alternative fuels in overall fuel mix.
3. Reducing emissions from transportation sector.
4. Promoting energy efficiency in the economy, notably in industry, transportation, buildings and appliances.
5. Reducing emissions from waste.
6. Developing climate resilient infrastructure.
7. Full implementation of Green India Mission and other programmes of afforestation.
8. Planning and implementation of actions to enhance climate resilience and reduce vulnerability to climate change.

Impact of Climate Change

There are some key indicator parameters to assess the extent of climate change over a period of time. Some of the important indicator parameters are increase in greenhouse gas concentration, surface temperature, atmospheric water vapor, change in precipitation, occurrence of extreme weather conditions, rise in sea level and changes in snow cover & glaciers. As per the latest scientific evidences, collated and reported in IPCC Fifth Assessment Report (AR5), there is clear evidence of human influence on climate system. There is increase in the concentration of greenhouse gases and climate warming is unequivocal. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished and sea level has risen. There is need for substantial global emission reduction to arrest the pace of climate change and prevent major changes in global climate system.

Changes in the climatic system have serious consequences on all aspects of human life. Some of the most sensitive system with high level of vulnerability is food system, health, natural ecosystems, agriculture and water systems. With the dwindling natural resources, food production system is already constrained and climate change related biotic and abiotic stresses will further impact the global food production systems. Similarly, impact of climate change on health is a major challenge before humanity. Due to direct and indirect effect of changing climatic condition will pose new risk to human health. Incidence of new diseases is already in the horizon with new biotypes of virus. Menace of Vector-borne diseases already affecting large population in countries like India like malaria, encephalitis is likely to further aggravate. In India, health problems related to heat waves, flooding, air pollutants, ultraviolet radiation, vector borne and infectious diseases and climate sensitive diseases like Chikungunya, Dengue, Malaria, West Nile Virus, Tick-borne Encephalitis, and Lyme disease are going to be major health challenges. Looking to seriousness of the problem Indian government proposed a new mission on 'National Health Mission with a goal to reduce morbidity, mortality, injuries and health vulnerability to climate variability and extreme weathers in the National Action Plan on Climate Change. Ministry of Health and Family Welfare prepared a National Action Plan on Climate Change and Health (NAPCCH). The NAPCCH aims to provide policy frame work to protect health of citizens of India

against climate sensitive illness, especially among the vulnerable like children, women and marginalized population.

Agriculture sector is particularly vulnerable to climate change. Enhanced climatic variability will further exacerbate the biotic and abiotic stresses reducing crop yields. Occurrence of new plant diseases and insect pest's infestation is real threat to crop production in the climatic change scenario. Rise in temperature and occurrence of extreme weather conditions like flooding and drought are going to have major impact on crop production. Large body of scientific literature assessing the impact of climate change on crop yield in India suggest major negative impact of higher temperature and monsoon variability on major crops like Wheat, Rice and pulses. The rainfed production system, which constitutes for major part of the Indian agriculture, is particularly going to be adversely impacted thus further aggravating agrarian crisis. Rainfed production system is not only important for food security but also critical to nutritional security of the country and any major perturbations in the rainfed production system are going to affect large population. These systems also have limited adaptation capacity thus making it particularly vulnerable. Rise in sea levels is another major threat to agricultural production systems in the coastal regions. Water systems are intricately linked to human health and agriculture. Water scarcity is already a serious issue in many parts of the country and in climate change projections, despite increased precipitation in some parts of the country; water availability is going to be seriously impacted thus seriously impacting agricultural production and health.

Action Plan and New Initiatives in India to Tackle Climate Change:

In concurrence to its stated policy to adopt a climate friendly and a cleaner path of economic development, there are number of measures adopted by Government of India to alleviate the impacts of climate change by developing mitigation and adaptation strategies. Ministry of Environment, Forest & Climate Change (MOEF&CC) is the nodal ministry for matters related to Climate Change. Formulation of National Environmental Policy 2006 emphasizes the commitment to environmental protection and a high level Prime Minister's Council on Climate Change has been formulated to advice proactive measures facilitate inter-ministerial coordination and guide policy in relevant areas.

A National Action Plan on Climate Change (NAPCC) was finalized in June 2008 to addresses the urgent and critical concerns of the country through enhancement of the current and planned programmes. It outlines a number of steps to simultaneously advance India's development and climate change related objectives of adaptation and mitigation. The plan identified eight national missions: 1. National Mission on Sustainable habitat 2. National Mission for Sustaining the Himalayan Ecosystem 3. National Mission for Sustainable Agriculture 4. National Solar Mission 5. National Mission for Enhanced Energy Efficiency 6. National Water Mission 7. National Mission on Strategic Knowledge for Climate Change 8. National Mission for "Green India". This action plan was further revised in 2014 by Executive Committee on Climate Change by formulating four new missions - 1. National Mission on Health 2. National Mission on "Waste to Energy Generation" 3. National Mission on India's Coastal areas 4. National Wind Mission. In addition to the NAPCC, almost all Indian states have also prepared their State Action Plan on Climate Change (SAPCC) based on their vulnerability and priorities. SAPCC are aimed at implementation of climate change programmes particularly, in priority areas like agriculture, water and energy. SAPCC are fully aligned with the eight national missions. Key sectors covered by SAPCCs include agriculture, water, habitat, forestry, health and disaster management among others. Most SAPCC emphasize on adaptation strategies to climate change however, these action plans have the potential to contribute towards climate change mitigation programmes also.

The most remarkable development in Indian climate change policy is the integration of climate change action plan components in the development planning framework and their effective implementation at both centre and state levels. As such there has been a remarkable progress in NAPCC missions particularly in solar, water, sustainable agriculture and green India missions. For example, production of clean energy got major thrust with the solar mission. In the beginning of 2010, the total installed capacity of solar power in the country was a mere 17.8 MW which grew to 506.9 MW by March 2012 and to 2.75 GW by July 2014. National Mission for a Green India has the objective for enhancing ecosystem services and carbon sinks through afforestation on degraded forestland and expansion of forest and tree cover. Through this mission, India aims to create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030.

National mission on Sustainable Agriculture aims to ensure food security and protecting land, water, biodiversity, and genetic resources for sustainable production of food. The mission, with major focus on adapting to climate change has four thrust areas of dry land agriculture, risk management, access to information and use of biotechnology. The mission has revised mandate of four interventions namely Rain fed Area Development (RAD), On Farm Water Management (OFWM), Soil Health Management (SHM) and lastly Climate Change and Sustainable Agriculture. Some of the major initiatives in agriculture which is one of the most important sectors in India include National Initiative on Climate Resilient Agriculture (NICRA), Soil Health Card Scheme to issue soil health cards to every farmer to achieve nutrient use efficiency and enhance farm income and National Agroforestry Policy (NAP) of India to increase the green cover in non-forest area. NICRA has four main components of Natural Resource Management, improving crop production, livestock and fisheries and institutional interventions. In the background of particular vulnerability of agriculture to climate change, NICRA has the specific objectives of (i) Enhancing resilience of Indian agriculture covering crops, livestock and fisheries to climatic variability and climate change through development and application of improved production and risk management technologies (ii). To demonstrate site specific technology packages on farmers' fields for adapting to current climate risks and (iii). to enhance the capacity of scientists and other stakeholders in climate resilient agricultural research and its application.

Climate change is a formidable challenge for a country like India with its large population, climatic & cultural diversities, its dependence on agriculture sector which is mostly rainfed & vulnerable to climatic variability and economy which is one of the fastest growing economy in the world. It also has World's second largest aspiring population with rising income to lead a western life style. Therefore, in India the energy paradox of economic growth, consumption and environmental protection is particularly challenging. Wheels of economic growth run on energy which is polluting and is a major source of GHGs. Its large agriculture sector is energy inefficient and a significant contributor to climate change. World's largest cattle population is unproductive and a major source of methane emission. Increasing pressure on land is causing deforestation. Given all these challenges it is a daunting task

to achieve higher economic growth and simultaneously address the challenge of climate change. However, India has the resolve and resource to achieve these two seemingly opposing objectives. Indeed, the emission intensity of India's GDP has been decreasing and with the steady growth of non-conventional sources energy sector it is likely to reduce further. The ambitious NAPCC has outlined key areas to address climate change and economic development. Guided by the fundamental philosophy of economic prosperity 'Development without Destruction' it would be possible to tackle the climate change related challenges with larger participation of all the stakeholders.

10.Waste Disposal And Its Management

With the rapid industrialization and urbanization humongous quantity of industrial and domestic waste is generated every day. Given the large size of population and limited land resources, waste disposal is daunting task. Environmental concerns require proper disposal with least adverse effects to the surrounding environment. There are laws governing the waste disposal however, enforcement of these regulatory provisions are overlooked. It's imperative to strictly enforce the proper waste disposal to protect the environment and its consequences on human health.

Landfill

Disposing the waste in the soil by digging large pits in the earth and burying waste is called landfill. This is a common practice in almost all countries in the world. Landfills are established in abandoned quarries or voids created through mining. Landfill method of disposal of waste is less expensive and if managed properly than it is hygienic too. However, Older and poorly-designed and poorly-managed landfills can create environmental pollution. The wind -blown litter, vermin and formation of liquid leachate are common from such landfills which are not well maintained. Other problems are the escape of gases mainly methane and carbon di oxide from these disposal site, which is a result of anaerobic decomposition of the organic matter present in the sewage. These are greenhouse gases that lead to air pollution, and also kill nearby vegetation. They are also mixed with foul smelly gases such as NH_3 and H_2S produced by anaerobic respiration. The other drawback of dumping waste in landfills is its collection cost and its transportation cost to the disposal sites. A modern landfill is constructed keeping in mind about these difficulties by making thin and compact layers of refuse and levelling it by bulldozers and then covering it with a layer of clean earth before spreading other layer on it. The care is taken that these landfills are made in the ground where flooding should not occur, ground water is low and plantation can be done to reduce the effect of greenhouse gases.

Incineration

It is defined as the combustion of the waste matter and is a thermal treatment method of the waste. In incinerators waste is burnt and converted into gas, steam and ash along with the evolution of heat energy. The incineration can be done both on small as well as large scale. All kind of waste (solid, liquid and gaseous) can be disposed of using this technique. Incineration method is considered as a wonder method to get rid of some hazardous waste materials too. However there are some arguments and unacceptability due to the gas emission issues of this method of disposal of wastes. Japan, however uses incineration method of disposal where land scarcity is an issue. In modern era the terms W to E (waste to energy) and E from W (energy from waste) has given importance to incineration method of disposal of wastes. When waste is burnt in a furnace or boiler it generates heat, steam and electricity out of it. The major drawback of incinerators is that sometimes the combustion is incomplete which lead to the production of micro pollutants in gaseous emissions. Particularly the dioxins that are created in the incinerators are highly toxic and have serious environmental consequences. But, the advantage is recycling of waste to useful energy which cannot be overlooked.

Recycling methods

The process of extracting useful resources from waste is referred as recycling. Many methods are suggested and practiced to recycle the waste and obtain materials that can be extracted, reprocessed or converted to heat and electricity. It is an area of continuous research and innovation to develop such methods of recycling the waste without causing much environmental changes or disturbance. Some methods are described below.

Physical processing: it is the collection of refuse every day in separate containers for rubbish (paper, clothes, plastics, leather, cans), glass (bottles, glass wares, crockery), electronic wastes (discarded mobile

phones, batteries). All these wastes are then sorted and common types are heaped together. The most common consumer products from which useful material can be recycled with relative ease are aluminium beverage cans, steel food and aerosol cans, glass bottles and jars, plastic bottles, shoe soles made of PVC, paper and batteries. The electronic gadgets such as computer, cell phones, radios, watches are complicated and need dismantling before recycling of the useful out of it.

Biological Processing: The organic matter such as peels of fruits and vegetables, rotten and stale food, tetra packs and paper and cardboard boxes are sorted out and subjected to composting and digestion processes. This is brought about by decomposition of organic matter in the waste and the compost produced is recycled in the soil for replenishing it with humus and minerals. The method is useful in agriculture and farming. The waste gas produced is used to generate electricity. Many methods for composting and digestion are practiced from simple home composting to industrial scale enclosed-vessel digestion.

Energy Recovery

This type of management is referred as harnessing the energy by directly subjecting to combustion or indirectly by processing them and using it as fuel. Various methods are employed for this process of energy harnessing such as: thermal treatment method where the waste is used for cooking and or heating. Pyrolysis and gasification are the commonly used thermal treatment methods. In these methods the process is carried out in sealed vessels under high pressure. During pyrolysis, the solid waste converts into liquid and gaseous products. These products are burnt as fuels in cooking, boilers to generate steam and electricity in turbines. The residue (char) left is refined to obtain useful products such activated carbon and the discarded substance can be used as manure.

The gasification or advanced Plasma arc are used to convert complex organic compounds directly into synthetic gas consisting of carbon and hydrogen and is burnt to produce electricity.

Composting

The method involves pre-sorting of the materials that cannot be composted. The waste is then led to cutters to break it into small pieces to improve the efficiency of decomposition process. It is then layered or piled in mechanical system or ground, where it is degraded under aerobic activity to humus. The humus generated has 1-3% of NPK content depending upon the composted matter. The compost is ready for curing and blending with additives, packaging and marketing after about three weeks.

Control and Prevention of Pollution

The Environment control approach: The environment can be protected if we concentrate in reducing the amount of pollutants to enter into the air, water and soil. This can be achieved in two steps summarized below:

Capacity concept, confirms the existence of a specified level of emissions into the environment that does not lead to any damage to the environmental or human health.

Control concepts, accepts that environmental damage can be prevented by controlling the rate, time and manner at which pollutants enter the environment.

Prevention of Pollution

Pollution can be prevented by adopting the following methods:

Reduction and removal of waste at the source.

Using Conservation techniques.

Using nontoxic substances.

Recycling of waste.

Using biodegradable materials.

Modifications in production processes.

Afforestation.

Using non-conventional sources of energy.

Management of Environment

It is important to attain environmental protection from toxic elements, but most important is to retain this. Various methods adapted to manage the control of environmental pollution are suggested here:

Environmental Management Systems (EMS) is a tool for managing the impacts of an organisation's activities on the environment. It gives a structured approach to planning and strict implementation of environment protection measures by the society.

Public awareness programmes is another effective way of environment management.

Complete ban on the use of non-biodegradable materials.

Cleaning programmes for the rivers and sea shores.

ABOUT THE BOOK

This book was conceived with an overall objective of compiling the relevant scientific information on the topics in a lucid and simple manner. This book can be useful for students at school and graduation levels and also for any other general reference on the topic. The book is limited in scope and yet covers this entire important area in generality.

Authors have long experience of teaching and research in this specialized area and benefitted from their International exposure. Authors have published large number of research papers in national and International journals.