Module 1
AIR POLLUTION

ENVIRONMENT

The word Environment is derived from the French word "Environ" which means "surrounding". Our surrounding includes biotic factors like human beings, Plants, animals, microbes, etc and abiotic factors such as light, air, water, soil, etc. Environment is a complex of many variables, which surrounds man as well as the living organisms. Environment includes water, air and land and the interrelation ships which exist among and between water, air and land and human beings and other living creatures such as plants, animals and micro organisms.

PARTS OF ENVIRONMENT

Components of Environment Our environment has been classified into four major components:

1. Hydrosphere,
2. Lithosphere,
3. Atmosphere,
4. Biosphere.

1. Hydrosphere

Hydrosphere includes all water bodies such as lakes, ponds, rivers, streams and ocean etc. Hydrosphere functions in a cyclic nature, which is termed as hydrological cycle or water cycle.

2. Lithosphere

Lithosphere means the mantle of rocks constituting the earth's crust. The earth is a cold spherical solid planet of the solar system, which spins in its axis and revolves around the sun at a certain constant distance .Lithosphere mainly, contains soil, earth rocks, mountain etc. Lithosphere is divided into three layers- crusts, mantle and core (outer and inner).

3. Atmosphere

The cover of the air, that envelopes the earth is known as the atmosphere. Atmosphere is a thin layer which contains gases like oxygen, carbon dioxide etc. and which protects the solid earth and human beings from the harmful radiations of the sun. There are five concentric layers within the atmosphere, which can be differentiated on the basis of temperature and each layer has its own characteristics. These include:

1. Troposphere,
2. Stratosphere,
3. Mesosphere,
4. Thermosphere and
5. Exosphere

4. Biosphere

It is otherwise known as the life layer, it refers to all organisms on the earth's surface and their interaction with water and air. It consists of plants, animals and micro-organisms, ranging from the tiniest microscopic organism to the largest whales in the sea. Biology is concerned with how millions of species of animals, plants and other organisms grow, feed, move, reproduce and evolve over long periods of time in different environments.

ENVIRONMENTAL POLLUTION

Pollution is the effect of undesirable changes in our surroundings that have harmful effects on plants, animals and human beings. Pollutants include solid, liquid or gaseous substances present in greater than natural abundance produced due to human activity, which have a detrimental effect on our environment. The nature and concentration of a pollutant determines the severity of detrimental effects on human health. An average human requires about 12 kg of air each day, which is nearly 12 to15 times greater than the amount of food we eat. Thus even a small concentration of pollutants in the air becomes more significant in comparison to the similar levels present in food.

CLASSIFICATION OF POLLUTION

Depending upon the area or the part of environment affected, pollution may be of the following types:

1. Air pollution
2. Water pollution
3. Land pollution
4. Noise pollution

POLLUTANTS

Any substance present in the environment in harmful concentration, which ad-versely alters the environment by damaging the growth rate of a species and by interfering with the food chains, is toxic and affects the health, comfort and property etc. is considered as a pollutant.

AIR POLLUTION

The atmospheric air contains about 79% nitrogen and 21% of oxygen and the negligible traces of other sixteen elements such as carbon dioxide, methane, carbon monoxide, ammonia, sulphur dioxide etc. are found, which have practically no adverse effect. This air is considered as pure or healthy and is always desirable for human life, animal life and plant life. Bit due to various factors the balance of nitrogen and oxygen is getting disturbed gradually and is causing adverse effects on human health, animal life, plant life and other materials of the universe.

So, the accumulation of destructive elements in the air from the natural or unnatural sources is termed as air pollution.

CLASSIFICATION OF POLLUTANTS

The classification of pollutants is done from different points of view:

(i) Depending upon their existence in nature pollutants are of two types.

(a) Quantitative Pollutants:

These are those substances normally occurring in the environment, who acquire the status of a pollutant when their con-centration gets increased due to the unmindful activities of man. For exam-ple, carbon dioxide, if present in the atmosphere in concentration greater than normal due to automobiles and industries, causes measurable effects on humans, animals, plants or property, then it is classified as a quantita-tive pollutant.

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(b) Qualitative Pollutant:

These are those substances which do not normally occur in nature but are added by man, for example, insecticides.

(ii) Depending upon the form in which they persist after being released into the environment, the pollutants are categorized into two types.

(a) Primary Pollutants:

These are those which are emitted directly from the source and persist in the form in which they were added to the environ-ment. Typical examples of pollutants included under this category are ash, smoke, fumes, dust, nitric oxide, sulphur dioxide, hydrocarbons, radioactive compounds etc.

(b) Secondary Pollutants:

These are those which are formed from the pri-mary pollutants by chemical interaction with some constituent present in the atmosphere. Examples are: Sulphur trioxide, nitrogen dioxide, alde-hydes, ketones, ozone etc.

Nitrogen oxides and hydrocarbons are two primary pollutants released from automobiles but in the presence of sunlight, they react to form peroxyacyl ni-trate (PAN) and ozone, two secondary pollutants which are far more toxic than the primary pollutants from which they are derived. This phenomenon of in-creased toxicity by chemical interaction among the pollutants is known as Synergism.

(iii) From the ecosystem point of view, i.e., according to their natural disposal, pollutants are of two types:

(a) Bio-degradable Pollutants:

These are the pollutants that are quickly degraded by natural means. Heat or thermal pollution, and domestic sewage are considered in this category as these can be rapidly decomposed by natural processes or by engineered systems such as municipal treatment, plants etc.

(b) Non-degradable Pollutants:

These are the substances that either do not degrade or degrade very slowly in the natural environment. These include mercury salts, long chain phenolic chemicals, DDT and Aluminum cans etc.

Such non-degradable pollutants accumulate and are biologically magnified as they move in the biogeochemical cycle and along food chains in the ecosystem. For example, DDT, when washed from the ground goes to the streams where it is absorbed by the phytoplankton's which are eaten by the fishes.

So, the initial dose of DDT which was harmless in the phytoplankton becomes very harmful as it accumulates in the fish day by day, with the result that large populations offish die or become sterile and same is the case with the birds feeding on such fishes. This phenomenon is known as bio-magnification or biological magnification.

(iv) Classification of pollutants on the basis their physical state:

(a) Gaseous pollutants

CO, CO_2, SO_2, SO_3, H_2S, oxides of nitrogen etc.

(b) Liquid pollutants

Domestic sewage, industrial effluents, acid rains, run-off from the lands, oil pollutants from cargos etc.

(c) Solid pollutants

Smoke, dust, smog, fog, aerosols, particulates, pollen grains

MAJOR AIR POLLUTANTS

Some major air pollutants are discussed here.

1. Carbon dioxide

Carbon dioxide is one of the major gases which contribute towards air pollution. It is mainly produced during the combustion of fuel in factories, power stations, household etc. The increasing CO2 in the atmosphere is likely to have the following effects:

(i) A rise in atmospheric temperature or global warming due to greenhouse effect. Also causes climate change.

(ii) Reduced productivity of the marine ecosystem. This is due to the fact that water in the oceans would be more acidic due to increased concentration of CO2 in the air, which dissolves in the water.

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(iii) Due to Global warming, the increased surface temperature would cause melting of continental and mountain glaciers and thus would cause flooding of coastal areas of some countries.

2. Sulphur dioxide

It is produced by the burning of coal in power houses and automobiles (car, trucks etc.). It causes chlorosis and necrosis of plants, irritation in eyes and injury to the respiratory tract (asthma, bronchitis) in humans responsible for discoloration and deterioration of buildings. High concentration of sulphur dioxide in the atmosphere dissolves in rain drops to form sulphuric acid which causes acid rain.

3. Carbon monoxide

Carbon monoxide is produced as a result of incomplete combustion of fossil fuels like coal, petroleum and wood charcoal. Automobiles using diesel and petroleum are the major sources of carbon monoxide which gets added to the atmosphere. Carbon monoxide is more dangerous than carbon dioxide. It is a poisonous gas which causes respiratory problems. When it reaches the blood stream, it replaces oxygen due to its high affinity for haemoglobin. It also causes hiddiness, headache and interferes with normal function of the heart.

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4. Fluorides

Upon heating„ rocks, soils and minerals that contain fluorides, give out hydrogen fluoride gas. This is an extremely toxic gas, which causes serious injury to livestock and cattle.

5. Oxides of nitrogen

A few oxides of nitrogen, such as nitric oxide (NO), nitrous oxide (N2O) and nitrogen dioxide (NO2) are produced by natural processes as well as from thermal power stations, factories, automobiles and aircrafts (due to burning of coal and petroleum). They reduce the oxygen carrying capacity of blood, may cause eye irritation and skin cancer in human beings.

6. Smog

Smog is a mixture of smoke, dust particles and small drops of fog. Smog may cause necrosis and develop a white coating on the leaves (silvering) of plants. In human beings and animals, it may cause asthma and allergies.

7. Aerosol spray propellants

Suspended fine particles in the air are known as aerosols. Aerosols contain chlorofluoro carbons (CFCs) and fluorocarbons used in refrigerants. They cause depletion of the ozone layer.

8. Domestic air pollutants

Smoke from cigarettes and other such objects using burning tobacco, burning of coal, firewood, cow dung cakes, kerosene oil and liquefied gases are major domestic pollutants. The common pollutant gases emitted during the domestic burning of coal, kerosene oil, firewood, cow dung cakes, etc. are carbon monoxide (CO), carbon dioxide (CO2), sulphur dioxide (SO2), etc. The pollution due to these pollutants causes suffocation, eye and lung diseases and low visibility.

EFFECTS OF AIR POLLUTION

In general effects of the polluted atmosphere can be classified under the following four heads:

i. **Effect on certain materials**
ii. **Effect on plants**
iii. **Effect on animals**
iv. **Effect on human health**
v. **Effect on physical features on the atmosphere**

i. Effect on certain materials

Air pollutants affect certain materials by the following five ways:

1. Abrasion
2. Deposition
3. Direct chemical attack
4. Indirect chemical attack
5. Corrosion

1. It causes deterioration of building material.
2. It causes corrosion and incrustation of metals
3. It causes discolouration of paints, cement colour etc.
4. It causes reduction of strength of materials

Some of the harmful effects of air pollution have on various materials are given in the table given below:

Materials	*Air pollutants*	*Other factors*	*Effects*
Building materials	SO_2, acid, gases and adhering substances	Moisture	Discolouration
Metals	SO_2, acid, gases	Moisture, temperature	Tranishing of surface; loss of metal
Textiles	SO_2, acid, gases	Moisture, Sunlight	Reduction in tensile strength
Rubber	Oxidants	Sunlight	Cracking
Paints	SO_2,H_2S and particulates	Moisture, fungus	Discolouration
Paper	SO2, acid, gases	Sunlight	Embrittlement

ii. Effect of air pollutants on plants

Air pollution has long been known to have adverse effect on plants. Air pollutants affecting plants are:

1. Sulphur dioxide
2. Hydrogen fluoride
3. Hydrogen chloride
4. Chlorine
5. Ozone
6. Oxides of nitrogen
7. Ammonia
8. Mercury
9. Ethylene
10. Hydrogen sulphide

The most obvious damage caused by air pollutants to plants and vegetation occur is the leaf structure. The stomata (tiny opening or void) of leaf gets clogged thereby reducing intake of CO_2 and thus affecting photosynthesis. The adverse effect is range from reduction in growth rate to death of the plant. The concentration of nitrogen dioxide, sulphur dioxide and ozone may damage plants, vegetables, fruit trees, and forest areas.

Some of the typical effect on vegetation is as follows.

1. Plants may be dried up, the yield of crop may decrease, the quality of crops may decline or may be affected by diseases.
2. The growth of vegetables may stop, the quality may be inferior or may be affected by diseases.
3. The quality of fruits may become inferior or the quantity may also decrease.
4. The forest area may get destroy gradually. The growth of tree may become stunted or they may dry up completely.

iii. Effect on animals

The effect of pollutants on farm animals takes place in two steps (i) accumulation of air pollutants in the vegitation, plants and forage, and (ii) subsequent poisoning of the animals when they eat the contaminated vegitation. Important contaminants that affect the live stock are (a) fluorine, (b) arsenic and (c) lead. These pollutants originate either from the industries situated nearby, or from dusting and spraying.

Out of these contaminants, fluorine contamination is most prominent since cattle and sheep are found to be more susceptible to it. Symptoms of advanced fluorosis include lac of appetite, general ill health due to malnutrition, lowered fertility, reduced milk production and growth retardation. Arsenic in dusts or sprays on plants can cause to poisoning of cattle leading to salivation, thirst, vomiting, uneasiness, feeble and irregular pulse and respiration.

iv. Effect on Human beings

The inhalation of undesirable gases from the atmosphere has marked adverse effects on human health. This adverse effect can be divided into two classes: accute effects and chronic effects. Acute effects manifest themselves immediately upon short term exposure to air pollutants of high concentrations while chronic effects become evident only after continuous exposure to low levels of air pollution.

Following is a list of health effects of air pollutants:

1. Ear, nose and throat irritation.
2. Irritation of respiratory tract
3. Odour nuisance due to hydrogen sulphide, ammonia merceptants, even at low concentrations.
4. Chronic pulmonary diseases (such as bronchitis, asthma) etc. are aggravated by high concentrations of SO2, No2, particulate matter and photochemical smog.
5. Pollens etc. initiate asthmatic attacks.

6. Carcinogenic agents cause cancer.
7. Respiratory disease is caused by dust particles. Silicosis is caused by silica dust of cement factories and asbestosis is caused by asbestos plants.
8. Lead poisoning is caused due to entry of lead through the lungs.
9. Bone fluorosis and mottling of teath is caused by hydrogen fluoride.
10. Carbon monoxide may cause death by asphyxiation. It also increases stress on personssuffering from cardiovascular and pulmonary diseases

11. Air pollution in general is cause increase in mortality rate and morbidity rate.
12. Radio-active fallout may cause cancer, shortening of life span and genetic disorder.

v. Effect air pollutants on physical features on the atmosphere

The physical effects of pollutants on the atmosphere can be classified under three heads:

1. Effects on visibility.
2. Effects on urban atmosphere and weather conditions.
3. Effects on atmosphere constituents.

1. Effects on visibility: The visibility is reduced due to the concentration and physical properties of particulate pollutants present in the atmosphere. The measurement of prevailing visibility is a standard meteorological practice. The stormy wind raises dust particles resulting in decrease in the visibility. In unsaturated humidity conditions, the hygroscopic particles pick up moisture and as they increase in size, the visibility is affected. Due to the angle of the sun, visibility observation in polluted area is showing strong directional variations. Other meteorological factors such as inversion, height and wind speed, presence of hygroscopic particles and relative humidity also affect the visibility. Fog and photochemical smog reduces the visibility considerably.

2. Effects of urban atmosphere and weather conditions: Urban, air pollution is mainly caused due to smoke, dust, fog and other aerosols, and all of these affect the weather conditions. Polluted area becomes more cloudy, more foggy, resulting in reduction of solar radiation to an extent of about 30%. The area may have 5 to 10% more precipitation, since air pollutants can add to the condensation of nuclei of the cloud system.

3. Effects on atmospheric constituents: Due to air pollution, the balance between various constituents of air is disturbed. Atmospheric carbon dioxide is the main source of organic carbon in the biosphere. It has been noted that there is steady increase in the percentage of CO_2 in the atmosphere due to combustion and other factors causing air pollution. CO2 is interpreted as a factor responsible for rise in ambient temperature. Due to continued air pollution, the lead aerosol concentration is now 30 times more than that in pre-industrial days. Freezing nuclei are formed in large numbers when automobile exhaust gases are exposed to minute quantities of iodine vapors. These nuclei are the main basis of weather modification cloud seeding operations.

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AMBIENT AIR QUALITY STANDARDS

Ambient air quality refers to the condition or quality of air surrounding us in the outdoors. National Ambient Air Quality Standards are the standards for ambient air quality set by the Central Pollution Control (CPCB) that is applicable nationwide. The CPCB has been conferred this power by the Air (Prevention and Control of Pollution) Act, 1981.

AMBIENT AIR QUALITY STANDARDS

Ambient Air Quality Standards in India

The Air (Prevention and Control of Pollution) Act 1981 was enacted by the Central Government with the objective of arresting the deterioration of air quality. The Air (Prevention and Control of Pollution) Act 1981 describes the main functions of the Central Pollution Control Board (CPCB) as follows:

1. To advise the Central Government on any matter concerning the improvement of the quality the air and the prevention, control and abatement of air pollution.
2. To plan and cause to be executed a nation-wide programme for the prevention, control and abatement of air pollution.
3. To provide technical assistance and guidance to the State Pollution Control Board.
4. To carry out and sponsor investigations and research related to prevention, control and abatement of air pollution.
5. To collect, compile and publish technical and statistical data related to air pollution; and
6. To lay down and annul standards for the quality of air.

Ambient Air Quality Standards

Pollutant	Averaging Period	Primary Standards	Secondary Standards	
Carbon Monoxide (CO)	8 hours	9 ppm	None	
	1 hour	35 ppm		
Lead (Pb)	Rolling 3-month average	0.15 $\mu g/m^3$	Same as Primary	
Nitrogen Dioxide (NO_2)	Annual	53 ppb	Same as Primary	
	1 hour	100 ppb	None	
Particulate Matter (PM_{10})	24 hours	150 $\mu g/m^3$	Same as Primary	
Particulate Matter ($PM_{2.5}$)	Annual	12 $\mu g/m^3$	15.0 $\mu g/m^3$	
	24 hours	35 $\mu g/m^3$	Same as Primary	
Ozone (O_3)	8 hours	0.075 ppm	Same as Primary	
Sulfur Dioxide (SO_2)	1 hour	75 ppb	3-hour	0.5 ppm

Module 2
WATER POLLUTION

Water pollution may be defined as “any change in the physical, chemical and biological properties of water as well as contamination with any foreign substance, which would constitute a health hazard or otherwise decrease the utility of water”.

It may also be defined as addition of excess of undesirable substance to water that make it harmful to man, animal, and aquatic life or otherwise causes significant departures from the normal activities of various living communities in or around water.

The indications of water pollution are:

1. Bad taste of drinking water.
2. Offensive odours from lakes, rivers and ocean beaches.
3. Unchecked growth of aquatic weeds in water bodies.
4. Decrease in number of fish in fresh water, river water and seawater.
5. Oil and grease floating on water surfaces.

The above conditions disturb the normal use of water for:

1. Drinking purposes.
2. Recreation.
3. Fish, other aquatic life and wildlife.
4. Agriculture.
5. Industry.

Causes of water pollution

The main source of water pollution is the discharge of solid or liquid waste products containing pollutants on to the land surface, or into surface or coastal waters. The main causes of water pollution are:

Sewage (Waste Water)

Sewage is another name for waste water from domestic and industrial processes. Despite strict regulatory control, the Environment Agency data shows that the water and sewage industry accounted for almost a quarter of the serious water incidents in the world.

Agricultural Pollution

The agriculture industry covers 76% of the land area. Agricultural processes such as uncontrolled spreading of slurries and manure, disposal of sheep dip, tillage, ploughing of the land, use of pesticides and fertilisers can cause water pollution. Accidental spills from milk dairies can also affect the quality of water.

Oil Pollution

Oil spillages affect water quality in a number of ways. Oil can make drinking water unsafe to drink. A substantial amount of oil released into oceans and seas will destroy wildlife and the ecosystems that sustain them. Oil spills also reduce oxygen supplies within the water environment. The main causes of oil related water pollution are:

· loss from storage facilities

· spillage during delivery and;

· deliberate disposal of waste oil to drainage systems

Radioactive Substances

Radioactive waste is another source of water pollution. Radioactive substances are used in nuclear power plants, industrial, medical and other scientific processes. They can be found in watches, luminous clocks, television sets and x-ray machinery. There are also naturally occurring radioisotopes from organisms and within the environment. If not properly disposed of, radioactive waste can result in serious water pollution incidents.

River dumping

Lots of people dump supermarket trolleys, bicycles, garden cuttings and electronic waste into rivers or river banks. River dumping not only causes water pollution; it also harms wildlife and increases the risk of flooding.

Marine Dumping

The Worldwide Fund for Nature (WWF) estimates that a staggering amount of waste enters into the sea every year. Part of this is due to deliberate dumping of waste into coastal waters. Other sources of waste at sea include plastics and other materials blown or washed from land. Marine dumping is illegal under international legislation.

Sources of water pollution

Surface water and groundwater have often been studied and managed as separate resources even though they are interrelated. Surface water seeps through the soil and becomes groundwater. Conversely, groundwater can also feed surface water sources. Sources of surface water pollution are generally grouped into two categories based on their origin.

1. **Point sources**
2. **Non-point sources**

1. Point sources

Point source water pollution refers to contaminants that enter a waterway from a single, identifiable source, such as a pipe or ditch. Examples of sources in this category include discharges from a sewage treatment plant, a factory, or a city storm drain. This type of discharges can be controlled easily. Water pollution caused by these sources can be minimised if the effluent from these sources are controlled, treated up to acceptable levels and disposed off.

2. Non-point sources

Nonpoint source pollution refers to diffuse contamination that does not originate from a single discrete source. This type of pollution is often the cumulative effect of small amounts of contaminants gathered from a large area. A common example is the leaching out of nitrogen compounds from fertilized agricultural lands. Nutrient runoff in storm water from "sheet flow" over an agricultural field or a forest is also cited as examples of non-point source pollution. Contaminated storm water washed off of parking lots, roads and highways, called urban runoff, is sometimes included under the category of non-point sources. However, because this runoff is typically channeled into storm drain systems and discharged through pipes to local surface waters, it becomes a point source.

SEWAGE CHARACTERISTICS

Characterization of wastes is essential for an effective and economical waste management programme. It helps in the choice of treatment methods deciding the extent of treatment, assessing the beneficial uses of wastes and utilizing the waste purification capacity of natural bodies of water in a planned and controlled manner. While analysis of wastewater in each particular case is advisable, data from the other cities may be utilized during initial stage of planning. Domestic sewage comprises spent water from kitchen, bathroom, lavatory, etc.

The factors which contribute to variations in characteristics of the domestic sewage are daily per capita use of water, quality of water supply and the type, condition and extent of sewerage system, and habits of the people. Municipal sewage, which contains both domestic and industrial wastewater, may differ from place to place depending upon the type of industries and industrial establishment. The important characteristics of sewage are discussed here.

TEMPERATURE

The observations of temperature of sewage are useful in indicating solubility of oxygen, which affects transfer capacity of aeration equipment in aerobic systems, and rate of biological activity. Extremely low temperature affects adversely on the efficiency of biological treatment systems and on efficiency of sedimentation. In general, under Indian conditions the temperature of the raw sewage is observed to be between 15 and 35^{o}C at various places in different seasons.

THE pH

The hydrogen ion concentration expressed as pH, is a valuable parameter in the operation of biological units. The pH of the fresh sewage is slightly more than the water supplied to the community. However, decomposition of organic matter may lower the pH, while the presence of industrial wastewater may produce extreme fluctuations. Generally the pH of raw sewage is in the range 5.5 to 8.0.

COLOUR AND ODOUR

Fresh domestic sewage has a slightly soapy and cloudy appearance depending upon its concentration. As time passes the sewage becomes stale, darkening in colour with a pronounced smell due to microbial activity.

SOLIDS

Though sewage generally contains less than 0.5 percent solids, the rest being water, still the nuisance caused by the solids cannot be overlooked, as these solids are highly degradable and therefore need proper disposal. The sewage solids may be classified into dissolved solids, suspended solids and volatile suspended solids. Knowledge of the volatile or organic fraction of solid, which decomposes, becomes necessary, as this constitutes the load on biological treatment units or oxygen resources of a stream when sewage is disposed off by dilution. The estimation of suspended solids, both organic and inorganic, gives a general picture of the load on sedimentation and grit removal system during sewage treatment. Dissolved inorganic fraction is to be considered when sewage is used for land irrigation or any other reuse is planned.

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NITROGEN AND PHOSPHORUS

The principal nitrogen compounds in domestic sewage are proteins, amines, amino acids, and urea. Ammonia nitrogen in sewage results from the bacterial decomposition of these organic constituents. Nitrogen being an essential component of biological protoplasm, its concentration is important for proper functioning of biological treatment systems and disposal on land. Generally, the domestic sewage contains sufficient nitrogen, to take care of the needs of the biological treatment. For industrial wastewater if sufficient nitrogen is not present, it is required to be added externally. Generally nitrogen content in the untreated sewage is observed to be in the range of 20 to 50 mg/L measured as TKN.

NITROGEN AND PHOSPHORUS

Phosphorus is contributing to domestic sewage from food residues containing phosphorus and their breakdown products. The use of increased quantities of synthetic detergents adds substantially to the phosphorus content of sewage. Phosphorus is also an essential nutrient for the biological processes. The concentration of phosphorus in domestic sewage is generally adequate to support aerobic biological wastewater treatment. However, it will be matter of concerned when the treated effluent is to be reused. The concentration of PO4 in raw sewage is generally observed in the range of 5 to 10 mg/L.

FATS GREASE AND OILS

Fats and oil are mainly contributed from kitchen wastes, because they are major components of food stuffs such as butter, lard, margarine, and vegetable oils and fats are also commonly found in meats, seeds, nuts and some fruits. Grease and oils are also discharged from industries like garages, workshops, factories etc. Fats and oils are compounds of alcohol or glycerol with fatty acids. Such matters float on the top of sedimentation tanks, often choke pipes in the winter, and clog filters. They thus interfere with functioning of normal treatment plants. The particles interfere with biological action and cause maintenance problems. Fats are among the more stable of organic compounds and are not easily decomposed by bacteria.

It is therefore necessary to detect and remove these from wastewater. Fats, grease, mineral oils and lubricating oils are soluble in hexane or ether. Hence it can be treated with ether.

SURFACTANTS

Surfactants come primarily from synthetic detergents. These are discharged from bathrooms, kitchens, washing machines etc. Surfactants are large organic molecules which cause foaming in wastewater treatment. Due to this, aeration of wastewater is hindered. The content of surfactants in wastewater is determined by measuring the colour change in standard solution of methylene blue dye.

TOXIC COMPOUNDS

Copper, lead, silver, chromium, arsenic and boron are some of the cations which are toxic to micro-organisms resulting in the malfunctioning of the biological treatment plants. These are results from industrial wastewaters. Some toxic anions, including cyanides and chromates, present in some industrial waste also hinder the waste water treatment facilities. Hence their presence should be taken into consideration in the design of biological treatment plants.

OTHER GASES

Following are the gases that are commonly found in untreated wastewater:

a) Nitrogen

b) Oxygen

c) Carbon dioxide

d) Amonia

e) Methane

The first three are the gases of atmosphere which are found in all waters exposed to air, the later three are as a result of decomposition of organic matter present in the waste water. Methane gas is the principal by-product of the anaerobic decomposition of the organic matter in wastewater. This gas is colourless and odourless and is highly combustible. Since its explosion hazard is high, manholes, sewer junctions, chambers etc. should be kept well ventilated.

ORGANIC MATERIALS

Organic compounds present in sewage are of particular interest for environmental engineering. A large variety of microorganisms (that may be present in the sewage or in the receiving water body) interact with the organic material by using it as an energy or material source. The utilization of the organic material by microorganisms is called metabolism. The conversion of organic material by microorganism to obtain energy is called catabolism and the incorporation of organic material in the cellular material is called anabolism.

To describe the metabolism of microorganisms and oxidation of organic material, it is necessary to characterize quantitatively concentration of organic matter in different forms. In view of the enormous variety of organic compounds in sewage it is totally unpractical to determine these individually. Thus a parameter must be used that characterizes a property that all these have in common. In practice two properties of almost all organic compounds can be used: (1) organic compound can be oxidized; and (2) organic compounds contain organic carbon.

In environmental engineering there are two standard tests based on the oxidation of organic material: 1) the Biochemical Oxygen Demand (BOD) and 2) the Chemical Oxygen Demand (COD) tests. In both tests, the organic material concentration is measured during the test. The essential differences between the COD and the BOD tests are in the oxidant utilized and the operational conditions imposed during the test such as biochemical oxidation and chemical oxidation. The other method for measuring organic material is the development of the Total Organic Carbon (TOC) test as an alternative to quantify the concentration of the organic material.

Oxygen in a sample of wastewater is reported in the following three ways:

a) Oxygen consumed

Oxygen in a sample of wastewater is reported in the following three ways:

a) Oxygen consumed

b) Dissolved oxygen

c) Oxygen demand

Oxygen consumed: Oxygen consumed is the oxygen required for the oxidation of carbonaceous matter. This quantity of oxygen is determined by adding standard amount of pottassium permanganate with dilute sulphuric acid to a sample of wastewater. This test is made to determine the relative strength of sewage instead of BOD test. But this test does not give the total oxygen needed for the biological oxidation of all or the bulk of the organic matter.

Dissolved oxygen: Dissolved oxygen (DO) is the amount of oxygen in the dissolved state in the wastewater. Though wastewater generally does not have DO, its presence in untreated wastewater indicates that the wastewater is fresh. Similarly, its presence in treated wastewater/effluent indicates that considerable oxidation has been accomplished during the treatment stages. While discharging the treated waste water into receiving waters, it is essential to ensure that at least 4 ppm of DO is present in it. If DO is less, the aquatic animals like fish etc. are likely to be killed near the vicinity of disposal. The presence of DO in waste water is desirable because it prevents the formation of noxious odours.

2.13 BIOCHEMICAL OXYGEN DEMAND (BOD)

The biochemical oxygen demand (BOD) is a measure of the oxygen requred to oxidize the organic matter present in a sample, through the action of micro-organisms contained in a sample of waste water. It is the most widely used parameter of organic pollution applied to both wastewater as well as surface water. The BOD may be defined as the oxygen required for the micro-organisms to carry out biological decomposition of dissolved solids or organic matter in the wastewater under aerobic conditions at standard temperature.

The BOD test results are used for the following purposes:

1. Determination of approximate quantity of oxygen required for the biological stabilization of organic matter present in the wastewater.
2. Determination of size of wastewater treatment facilities
3. Measurement of efficiency of some treatment process.
4. Determination of strength of sewage.
5. Determination of amount of clear water required for the efficient disposal of wastewater by dilution

Organic matter in sewage can be classified in two groups:

Organic matter in sewage can be classified in two groups:

a) Carbonaceous matter

b) Nitrogenous matter

In the first stage, carbonaceous matter is oxidised and in the second stage, nitrogenous matter is oxidised. It is found that for complete stabilisation of organic matter a long period of about 100 days or more will be required. But it is observed that the rate of demand in the first stage is very rapid and it slowly decreasesas stabilisation progresses. Hence in actual practice, the BOD test is made for a period of 5 days or 10 days, the former being very common. It has been proved by various experiments that 5 day BOD is about 68% and 10 day BOD is about 90% of the ultimate BOD.

CHEMICAL OXYGEN DEMAND (COD)

The BOD test takes a minimum of 5 days time, and due to this, it is not useful in the control of treatment processes. An alternative test is the COD test. COD can be determined only in 3 hours in contrast to 5 days BOD test. In COD test, a strong chemical oxidising agent is used in acidic medium to measure the oxygen equivalent of organic matter that can be oxidised. The COD test involves an acidic oxidation with potassium dichromate. A measured amount of potassium dichromate is added to the sample. The acidified sample is then boiled for 2 hours, cooled and the amount of dichromate remaining is measured by titration with ferrous ammonium sulphate. To accelerate the oxidation of certain types of organic compounds a catalyst, usually silver sulphate, is required to aid the oxidation.

BACTERIOLOGICAL TEST

In sewage analysis, bacteriological tests are of not much importance and hence they are rarely made. Presence of bacteria in a sample of sewage has no effect on the choice or selection of the sewage treatment method. Presence of biological life is essential in sewage for the efficient working of the treatment units. Absence of bacteria in a sample of sewage indicates the presence of industrial waste which is harmful to the bacterial life in sewage.

WATER-BORNE DISEASES

Waterborne diseases are caused by pathogenic microorganisms that most commonly are transmitted in contaminated fresh water. Infection commonly results during bathing, washing, drinking, in the preparation of food, or the consumption of food that is infected. Various forms of waterborne diarrheal disease probably are the most prominent examples, and affect mainly children in developing countries; according to the World Health Organization, such diseases account for an estimated 3.6% of the total DALY (*Disability- Adjusted Life Year)* global burden of disease, and cause about 1.5 million human deaths annually. The World Health Organization estimates that 58% of that burden, or 842,000 deaths per year, are attributable to unsafe water supply, sanitation and hygiene.

Among the many types of microorganisms that may cause waterborne diseases are:

- Protozoa
- Bacteria
- Intestinal parasites
- Viruses

When the contaminated water is consumed, the microorganisms are passed onto the individual drinking the water. In some cases, waterborne diseases simply cause unpleasant symptoms and can be easily treated. However, others have been found to be fatal, particularly when insufficient medical treatment is provided.

The some of the important water-borne diseases are given below.

- **Amebiasis:** caused by protozoa. Symptoms include fatigue, diarrhea, flatulence, abdominal discomfort and weight loss.
- **Campylobacteriosis:** caused by bacteria. Symptoms include diarrhea, abdominal pain and fever.
- **Cholera:** caused by bacteria. Symptoms include muscle cramps, vomiting and diarrhea.
- **Cryptosporidiosis:** caused by protozoa. Symptoms include diarrhea and abdominal discomfort.
- **Giardiasis:** caused by protozoa. Symptoms include diarrhea and abdominal discomfort.

- **Hepatitis:** caused by a virus. Symptoms include fever, chills, jaundice, dark urine and abdominal discomfort.
- **Shigellosis**: caused by bacteria. Symptoms include bloody stool, diarrhea and fever.
- **Typhoid fever:** caused by bacteria. Symptoms include fever, headache, constipation, diarrhea, nausea, vomiting, loss of appetite and an abdominal rash.
- **Viral gastroenteritis:** caused by a virus. Symptoms include gastrointestinal discomfort, diarrhea, vomiting, fever and headache.

INDIAN STANDARD SPECIFICATIONS FOR DRINKING WATER
IS: 10500

S.NO.	Parameter	Requirement desirable Limit	Remarks
1.	Colour	5	May be extended up to 50 if toxic substances are suspected
2.	Turbidity	10	May be relaxed up to 25 in the absence of alternate
3.	pH	6.5 to 8.5	May be relaxed up to 9.2 in the absence
4.	Total Hardness	300	May be extended up to 600
5.	Calcium as Ca	75	May be extended up to 200
6.	Magnesium as Mg	30	May be extended up to 100
7.	Copper as Cu	0.05	May be relaxed up to 1.5
8.	Iron	0.3	May be extended up to 1
9.	Manganese	0.1	May be extended up to 0.5
10.	Chlorides	250	May be extended up to 1000
11.	Sulphates	150	May be extended up to 400
12.	Nitrates	45	No relaxation
13.	Fluoride	0.6 to 1.2	If the limit is below 0.6 water should be rejected, Max. Limit is extended to 1.5
14.	Phenols	0.001	May be relaxed up to 0.002
15.	Mercury	0.001	No relaxation
16.	Cadmium	0.01	No relaxation
17.	Selenium	0.01	No relaxation
18.	Arsenic	0.05	No relaxation
19.	Cyanide	0.05	No relaxation
20.	Lead	0.1	No relaxation
21.	Zinc	5.0	May be extended up to 10.0
22.	Anionic detergents (MBAS)	0.2	May be relaxed up to 1
23.	Chromium as Cr^{+6}	0.05	No relaxation
24.	Poly nuclear aromatic Hydrocarbons	--	--
25.	Mineral Oil	0.01	May be relaxed up to 0.03
26.	Residual free Chlorine	0.2	Applicable only when water is chlorinated
27.	Pesticides	Absent	--
28.	Radio active	--	--

Module 3
SOLID WASTE

Solid wastes are the organic and inorganic waste materials such as product packaging, grass clippings, furniture, clothing, bottles, kitchen refuse, paper, appliances, paint cans, batteries, etc., produced in a society, which do not generally carry any value to the first user(s). Solid wastes, thus, encompass both a heterogeneous mass of wastes from the urban community as well as a more homogeneous accumulation of agricultural, industrial and mineral wastes.

While wastes have little or no value in one setting or to the one who wants to dispose them, the discharged wastes may gain significant value in another setting. Knowledge of the sources and types of solid wastes as well as the information on composition and the rate at which wastes are generated/ disposed is, therefore, essential for the design and operation of the functional elements associated with the management of solid wastes.

CLASSIFICATION OF SOLID WASTE

Solid wastes are classified on the basis of **Source of generation** and **Type**.

1 Source-based classification

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

(i) Residential:

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

(ii) Commercial:

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

(iii) Institutional:

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

(iv) Municipal:

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

(v) Industrial:

This mainly consists of process wastes, ashes, demolition and construction wastes, hazardous wastes, etc., due to industrial activities.

(vi) Agricultural:

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

(vii) Open areas:

This includes wastes from areas such as Streets, alleys, parks, vacant lots, playgrounds, beaches, highways, recreational areas, etc. It is important to define the various types of solid wastes that are generated from various sources which we will do, next.

2 Type-based classification

Classification of wastes based on types, i.e., physical, chemical, and biological characteristics of wastes, is as follows:

(i) Garbage:

This refers to animal and vegetable wastes resulting from the handling, sale, storage, preparation, cooking and serving of food. Garbage comprising these wastes contains putrescible (rotting) organic matter, which produces an obnoxious odour and attracts rats and other vermin. It, therefore, requires special attention in storage, handling and disposal.

(ii) Ashes and residues:

These are substances remaining from the burning of wood, coal, charcoal, coke and other combustible materials for cooking and heating in houses, institutions and small industrial establishments. When produced in large quantities, as in power-generation plants and factories, these are classified as industrial wastes. Ashes consist of fine powdery residue, cinders and clinker often mixed with small pieces of metal and glass. Since ashes and residues are almost entirely inorganic, they are valuable in landfills.

(iii) Combustible and non-combustible wastes:

These consist of wastes generated from households, institutions, commercial activities, etc., excluding food wastes and other highly putrescible material. Typically, while combustible material consists of paper, cardboard, textile, rubber, garden trimmings, etc., non-combustible material consists of such items as glass, crockery, tin and aluminium cans, ferrous and non-ferrous material and dirt.

(iv) Bulky wastes:

These include large household appliances such as refrigerators, washing machines, furniture, crates, vehicle parts, tyres, wood, trees and branches. Since these household wastes cannot be accommodated in normal storage containers, they require a special collection mechanism.

(v) Street wastes:

These refer to wastes that are collected from streets, walkways, alleys, parks and vacant plots, and include paper, cardboard, plastics, dirt, leaves and other vegetable matter. Littering in public places is indeed a widespread and acute problem in many countries including India, and a solid waste management system must address this menace appropriately.

(vi) Biodegradable and non-biodegradable wastes:

Biodegradable wastes mainly refer to substances consisting of organic matter such as leftover food, vegetable and fruit peels, paper, textile, wood, etc., generated from various household and industrial activities. Because of the action of micro-organisms, these wastes are degraded from complex to simpler compounds. Nonbiodegradable wastes consist of inorganic and recyclable materials such as plastic, glass, cans, metals, etc. Table 1.1 below shows a comparison of biodegradable and non-biodegradable wastes with their degeneration time, i.e., the time required to break from a complex to a simple biological form.

(vii) Dead animals:

With regard to municipal wastes, dead animals are those that die naturally or are accidentally killed on the road. Note that this category does not include carcasses and animal parts from slaughter-houses, which are regarded as industrial wastes. Dead animals are divided into two groups – large and small. Among the large animals are horses, cows, goats, sheep, pigs, etc., and among the small ones are dogs, cats, rabbits, rats, etc. The reason for this differentiation is that large animals require special equipment for lifting and handling when they are removed. If not collected promptly, dead animals pose a threat to public health since they attract flies and other vermin as they decay. Their presence in public places is particularly offensive from the aesthetic point of view as well.

((viii) Abandoned vehicles:

This category includes automobiles, trucks and trailers that are abandoned on streets and other public places. However, abandoned vehicles have significant scrap value for their metal, and their value to collectors is highly variable.

(ix) Construction and demolition wastes:

These are wastes generated as a result of construction, refurbishment, repair and demolition of houses, commercial buildings and other structures. They consist mainly of earth, stones, concrete, bricks, lumber, roofing and plumbing materials, heating systems and electrical wires and parts of the general municipal waste stream.

(x) Farm wastes:

These wastes result from diverse agricultural activities such as planting, harvesting, production of milk, rearing of animals for slaughter and the operation of feedlots. In many areas, the disposal of animal waste has become a critical problem, especially from feedlots, poultry farms and dairies.

(xi) Hazardous wastes:

Hazardous wastes are those defined as wastes of industrial, institutional or consumer origin that are potentially dangerous either immediately or over a period of time to human beings and the environment. This is due to their physical, chemical and biological or radioactive characteristics like ignitability, corrosivity, reactivity and toxicity. Note that in some cases, the active agents may be liquid or gaseous hazardous wastes. These are, nevertheless, classified as solid wastes as they are confined in solid containers.

Typical examples of hazardous wastes are empty containers of solvents, paints and pesticides, which are frequently mixed with municipal wastes and become part of the urban waste stream. Certain hazardous wastes may cause explosions in incinerators and fires at landfill sites. Others such as pathological wastes from hospitals and radioactive wastes also require special handling. Effective management practices should ensure that hazardous wastes are stored, collected, transported and disposed of separately, preferably after suitable treatment to render them harmless.

(xii) Sewage wastes:

The solid by-products of sewage treatment are classified as sewage wastes. They are mostly organic and derived from the treatment of organic sludge separated from both raw and treated sewages. The inorganic fraction of raw sewage such as grit and eggshells is separated at the preliminary stage of treatment, as it may entrain putrescible organic matter with pathogens and must be buried without delay. The bulk of treated, dewatered sludge is useful as a soil conditioner but is invariably uneconomical. Solid sludge, therefore, enters the stream of municipal wastes, unless special arrangements are made for its disposal.

WASTE COMPOSITION

Some of the general observations associated with the composition of wastes include the following:

1. The major constituents are paper and decomposable organic materials.
2. More often than not, metal, glass, ceramics, textile, dirt and wood form part of the composition, and their relative proportion depends on local factors.
3. Average proportions of the constituents reaching the disposal sites are consistent and urban wastes are fairly constant although subject to long-term changes such as seasonal variations.

Waste composition varies with the socio-economic status within a particular community, since income, for example, determines life style, composition pattern and cultural. The Table given below illustrates this phenomenon in India:

Sr. no.	Component of solid waste	Composition (g/2 kg)	Composition (%)
Organic			
1	Leaves	199	9.9
2	Market waste	210	10.5
3	Wooden matter	190	9.5
4	Paper	122	6.1
5	Kitchen waste	200	10
6	Slaughter house waste	45	2.02
7	Cloths and gunny bags	50	2.5
8	Other	204	10.2
	Total	1,220	61%
Inorganic			
1	Rock, sand, bricks, stones	250	12.5
2	Plastic	120	6
3	Metal	100	5
4	Bones	20	1
5	Rubber and leather	50	2.5
6	Glass	40	2
7	Other	110	5.50
	Total	780	39
Grand total, organic + inorganic		2,000 g	100

SOLID WASTE CHARACTERISTICS

In order to identify the exact characteristics of municipal wastes, it is necessary that we analyse them using physical and chemical parameters.

1. Physical characteristics

Information and data on the physical characteristics of solid wastes are important for the selection and operation of equipment and for the analysis and design of disposal facilities. The required information and data include the following:

(i) Density: Density of waste, i.e., its mass per unit volume (kg/m3), is a critical factor in the design of a SWM system, e.g., the design of sanitary landfills, storage, types of collection and transport vehicles, etc. To explain, an efficient operation of a landfill demands compaction of wastes to optimum density. Any normal compaction equipment can achieve reduction in volume of wastes by 75%, which increases an initial density of 100 kg/m3 to 400 kg/m3 . In other words, a waste collection vehicle can haul four times the weight of waste in its compacted state than when it is uncompacted.

A high initial density of waste precludes the achievement of a high compaction ratio and the compaction ratio achieved is no greater than 1.5:1. Significant changes in density occur spontaneously as the waste moves from source to disposal, due to scavenging, handling, wetting and drying by the weather, vibration in the collection vehicle and decomposition.

(ii) Moisture content: Moisture content is defined as the ratio of the weight of water (wet weight - dry weight) to the total weight of the wet waste. Moisture increases the weight of solid wastes, and thereby, the cost of collection and transport. In addition, moisture content is a critical determinant in the economic feasibility of waste treatment by incineration, because wet waste consumes energy for evaporation of water and in raising the temperature of water vapour. In the main, wastes should be insulated from rainfall or other extraneous water. We can calculate the moisture percentage, using the formula given below:

$$\text{Moisture content (\%)} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Wet weight}} \text{ X } 100$$

A typical range of moisture content is 20 to 40%, representing the extremes of wastes in an arid climate and in the wet season of a region of high precipitation. However, values greater than 40% are not uncommon.

(iii) Particle Size: Measurement of size distribution of particles in waste stream is important because of its significance in the design of mechanical separators and shredders. Generally, the results of size distribution analysis are expressed in the manner used for soil particle analysis. That is to say, they are expressed as a plot of particle size (mm) against percentage, less than a given value.

2. Chemical characteristics

Knowledge of the classification of chemical compounds and their characteristics is essential for the proper understanding of the behaviour of waste, as it moves through the waste management system. The products of decomposition and heating values are two examples of chemical characteristics. If solid wastes are to be used as fuel, or are used for any other purpose, we must know their chemical characteristics, including the following:

(i) Lipids: This class of compounds includes fats, oils and grease, and the principal sources of lipids are garbage, cooking oils and fats. Lipids have high heating values, about 38,000 kJ/kg (kilojoules per kilogram), which makes waste with high lipid content suitable for energy recovery. Since lipids become liquid at temperatures slightly above ambient, they add to the liquid content during waste decomposition. Though they are biodegradable, the rate of biodegradation is relatively slow because lipids have a low solubility in water.

(ii) Carbohydrates: These are found primarily in food and yard wastes, which encompass sugar and polymer of sugars (e.g., starch, cellulose, etc.) with general formula $(CH_2O)_x$. Carbohydrates are readily biodegraded to products such as carbon dioxide, water and methane. Decomposing carbohydrates attract flies and rats, and therefore, should not be left exposed for long duration.

(iii) Proteins: These are compounds containing carbon, hydrogen, oxygen and nitrogen, and consist of an organic acid with a substituted amine group (NH_2). They are mainly found in food and garden wastes. The partial decomposition of these compounds can result in the production of amines that have unpleasant odours.

(iv) Natural fibers: These are found in paper products, food and yard wastes and include the natural compounds, cellulose and lignin, that are resistant to biodegradation. (Note that paper is almost 100% cellulose, cotton over 95% and wood products over 40%.) Because they are a highly combustible solid waste, having a high proportion of paper and wood products, they are suitable for incineration. Calorific values of oven-dried paper products are in the range of 12,000 - 18,000 kJ/kg and of wood about 20,000 kJ/kg, i.e., about half that for fuel oil, which is 44,200 kJ/kg.

(v) Synthetic organic material (Plastics): Accounting for 1 – 10%, plastics have become a significant component of solid waste in recent years. They are highly resistant to biodegradation and, therefore, are objectionable and of special concern in SWM. Hence the increasing attention being paid to the recycling of plastics to reduce the proportion of this waste component at disposal sites. Plastics have a high heating value, about 32,000 kJ/kg, which makes them very suitable for incineration. But, you must note that polyvinyl chloride (PVC), when burnt, produces dioxin and acid gas. The latter increases corrosion in the combustion system and is responsible for acid rain.

(vi) Non-combustibles: This class includes glass, ceramics, metals, dust and ashes, and accounts for 12 – 25% of dry solids.

(vii) Heating value: An evaluation of the potential of waste material for use as fuel for incineration requires a determination of its heating value, expressed as kilojoules per kilogram (kJ/kg). The heating value is determined experimentally using the Bomb calorimeter test, in which the heat generated, at a constant temperature of 25 C from the combustion of a dry sample is measured. Since the test temperature is below the boiling point of water (100 C), the combustion water remains in the liquid state. However, during combustion, the temperature of the combustion gases reaches above 100 C, and the resultant water is in the vapour form. Table 2.3 shows the typical inert residue and heating values for the components of municipal solid waste.

(viii) Ultimate analysis: This refers to an analysis of waste to determine the proportion of carbon, hydrogen, oxygen, nitrogen and sulphur, and the analysis is done to make mass balance calculation for a chemical or thermal process. Besides, it is necessary to determine ash fraction because of its potentially harmful environmental effects, brought about by the presence of toxic metals such as cadmium, chromium, mercury, nickel, lead, tin and zinc.

Muncipal Solid Waste : A typical Ultimate Anaysis

Element	Range (%dry weight)
Carbon	25-30
Hydrogen	2.5-6.0
Oxygen	15-30
Nitrogen	0.25-1.2
Sulphur	0.02-0.12
Ash	12-30

(ix) **Proximate analysis:** This is important in evaluating the combustion properties of wastes or a waste or refuse derived fuel. The fractions of interest are:

1. Moisture content, which adds weight to the waste without increasing its heating value, and the evaporation of water reduces the heat released from the fuel;
2. Ash, which adds weight without generating any heat during combustion;
3. Volatile matter, i.e., that portion of the waste that is converted to gases before and during combustion;

4. Fixed carbon, which represents the carbon remaining on the surface grates as charcoal. A waste or fuel with a high proportion of fixed carbon requires a longer retention time on the furnace grates to achieve complete combustion than a waste or fuel with a low proportion of fixed carbon.

Muncipal Solid Waste: A typical Proximate Anaysis

Components	Value, percent	
	Range	Typical
Moisture	15-40	20
Volatile matter	40-60	53
Fixed carbon	5-12	7
Glass, metal, ash	15-30	20

ELECTRONIC WASTE OR **E-WASTE**

Electronic waste or E-waste describes discarded electrical or electronic devices. Used electronics which are destined for reuse, resale, salvage, recycling, or disposal are also considered e-waste. In formal processing of e-waste in developing countries can lead to adverse human health effects and environmental pollution.

Electronic scrap components, such as CPUs, contain potentially harmful materials such as lead, cadmium, beryllium, or brominated flame retardants. Recycling and disposal of e-waste may involve significant risk to health of workers and communities in developed countries and great care must be taken to avoid unsafe exposure in recycling operations and leaking of materials such as heavy metals from landfills and incinerator ashes.

Environmental impact

The processes of dismantling and disposing of electronic waste in developing countries led to a number of environmental impacts as illustrated in the graphic. Liquid and atmospheric releases end up in bodies of water, groundwater, soil, and air and therefore in land and sea animals – both domesticated and wild, in crops eaten by both animals and human, and in drinking water.

One study of environmental effects found the following:

- Airborne dioxins – one type found at 100 times levels previously measured
- Levels of carcinogens in duck ponds and rice paddies exceeded international standards for agricultural areas and cadmium, copper, nickel, and lead levels in rice paddies were above international standards
- Heavy metals found in road dust – lead over 300 times that of a control village's road dust and copper over 100 times.

E-Waste Component	Process Used	Potential Environmental Hazard
Cathode ray tubes (used in TVs, computer monitors, ATM, video cameras, and more)	Breaking and removal of yoke, then dumping.	Lead, barium and other heavy metals leaching into the ground water and release of toxic phosphor.
Printed circuit board (image behind table – a thin plate on which chips and other electronic components are placed).	De-soldering and removal of computer chips; open burning and acid baths to remove metals after chips are removed.	Air emissions and discharge into rivers of glass dust, tin, lead, brominated dioxin, beryllium cadmium, and mercury.
Chips and other gold plated components.	Chemical stripping using nitric and hydrochloric acid and burning of chips.	PAHs, heavy metals, brominated flame retardants discharged directly into rivers acidifying fish and flora. Tin and lead contamination of surface and groundwater. Air emissions of brominated dioxins, heavy metals, and PAHs.
Plastics from printers, keyboards, monitors, etc.	Shredding and low temp melting to be reused.	Emissions of brominated dioxins, heavy metals, and hydrocarbons.
Computer wires.	Open burning and stripping to remove copper.	PAHs released into air, water, and soil.

Hazardous Effects

E-Waste Component	Electric Appliances in which they are found	Adverse Health Effects
Americium	The radioactive source in smoke alarms.	It is known to becarcinogenic.
Lead	Solder, CRT monitor glass, lead-acid batteries, some	Adverse effects of lead exposure include impaired cognitive function, behavioral

	formulations of PVC. A typical 15-inch cathode ray tube may contain 1.5 pounds of lead,[5] but other CRTs have been estimated as having up to 8 pounds of lead.	isturbances, attention deficits, hyperactivity, conduct problems, and lower IQ. These effects are most damaging to children whose developing nervous systems are very susceptible to damage caused by lead, cadmium, and mercury.
Mercury	Found in fluorescent tubes(numerous applications), tilt switches (mechanical doorbells,thermostats), and ccfl backlights in flat screen monitors.	Health effects include sensory impairment, dermatitis, memory loss, and muscle weakness. Exposure in-utero causes fetal deficits in motor function, attention, and verbal domains. Environmental effects in animals include death, reduced fertility, and slower growth and development.
Cadmium	Found in light-sensitive resistors, corrosion-resistant alloys for marine and aviation environments, and nickel-cadmium batteries. The most common form of cadmium is found in Nickel-cadmium rechargeable batteries. These batteries tend to contain between 6 and 18% cadmium. The sale of Nickel-Cadmium batteries has been banned in the European Union except for medical use. When not properly recycled it can leach into the soil, harming microorganisms and disrupting the soil ecosystem. Exposure is caused by proximity to hazardous waste sites and factories and workers in the metal refining industry.	The inhalation of cadmium can cause severe damage to the lungs and is also known to cause kidney damage. Cadmium is also associated with deficits in cognition, learning, behavior, and neuromotor skills in children.
Hexavalent chromium	Used in metal coatings to protect from corrosion.	A known carcinogen after occupational inhalation exposure. There is also evidence of cytotoxic and genotoxic effects of some chemicals, which have been shown to inhibit cell proliferation, cause cell membrane lesion, cause DNA single-strand breaks, and elevate Reactive Oxygen Species (ROS) levels.
Sulphur	Found in lead-acid batteries.	Health effects include liver damage, kidney damage, heart damage, eye and throat irritation. When released into the environment, it can create sulphuric

		acid through sulphur dioxide.
Brominated Flame Retardants (BFRs)	Used as flame retardants in plastics in most electronics. Includes PBBs, PBDE, DecaBDE,OctaBDE, PentaBDE.	Health effects include impaired development of the nervous system, thyroid problems, liver problems effects: similar effects as in animals as humans. PBBs were banned from 1973 to 1977 on. PCBs were banned during the 1980s.
Perfluorooctanoic acid (PFOA)	Used as an antistatic additive in industrial applications and found in electronics, also found in non-stick cookware (PTFE). PFOAs are formed synthetically through environmental degradation.	Studies in mice have found the following health effects: Hepatotoxicity, developmental toxicity, immunotoxicity, hormonal effects and carcinogenic effects. Studies have found increased maternal PFOA levels to be associated with an increased risk of spontaneous abortion (miscarriage) and stillbirth. Increased maternal levels of PFOA are also associated with decreases in mean gestational age (preterm birth), mean birth weight (low birth weight), mean birth length (small for gestational age), and mean APGAR score.[92]
Beryllium oxide	Filler in some thermal interface materials such as thermal greaseused on heatsinks for CPUs andpower transistors, magnetrons, X-ray-transparent ceramic windows, heat transfer fins in vacuum tubes, and gas lasers.	Occupational exposures associated with lung cancer, other common adverse health effects are beryllium sensitization, chronic beryllium disease, and acute beryllium disease.[94]
Polyvinyl chloride (PVC)	Commonly found in electronics and is typically used as insulation for electrical cables.	In the manufacturing phase, toxic and hazardous raw material, including dioxins are released. PVC such as chlorine tend to bioaccumulate. Over time, the compounds that contain chlorine can become pollutants in the air, water, and soil. This poses a problem as human and animals can ingest them. Additionally, exposure to toxins can result in reproductive and developmental health effects.

RADIOACTIVE WASTE

Radioactive waste is waste that contains radioactive material. Radioactive waste is usually a by-product of nuclear power generation and other applications of nuclear fission or nuclear technology, such as research and medicine. Radioactive waste is hazardous to all forms of life and the environment, and is regulated by government agencies in order to protect human health and the environment.

Radioactivity naturally decays over time, so radioactive waste has to be isolated and confined in appropriate disposal facilities for a sufficient period until it no longer poses a threat. The time radioactive waste must be stored for depends on the type of waste and radioactive isotopes. Current approaches to managing radioactive waste have been segregation and storage for short-lived waste, near-surface disposal for low and some intermediate level waste, and deep burial or partitioning / transmutation for the high-level waste.

Impacts of Radioactivity on the Environment

Radioactive elements like thorium, strontium, iodine, plutonium, phosphorus, carbon, manganese, radium, cobalt, zinc etc.; existing as radioactive isotopes of different designation numbers, when present in the natural environment, disintegrate, releasing ionised radiations or rays. These emitted radiations are very powerful and contain enormous energy. These rays are even capable of penetrating through thick steel sheets.

The rate at which a radioactive isotope decays is measured in half-life. The term half-life is defined as the time it takes for one-half of the atoms of a radioactive material to disintegrate. Half-lives for various radioisotopes can range from a few microseconds to billions of years. See the table below for a list of radioisotopes and each of unique their half-lives.

Radioisotope	Half-life
Polonium-215	0.0018 seconds
Bismuth-212	60.5 seconds
Sodium-24	15 hours
Iodine-131	8.07 days
Cobalt-60	5.26 years
Radium-226	1600 years
Uranium-238	4.5 billion years

The radiations emitted by radioactive isotopes are of three kinds:

(i) Alpha particles

These are slow moving ionising particles, possessing weak penetration power, and can be stopped even by 8 cm of air or by thin sheets; are deflected by electric and magnetic fields, but are strongly ionising with a doubly ionised helium nucleus.

(ii) Beta particles

These are high velocity electrons, which can penetrate thin aluminium sheets; and are strongly deflected by electric and magnetic fields.

(iii) Gama and X-rays. These are very high frequency photons, which can penetrate several cm thick lead, and are not deflected by magnetic fields.

Sources of Environmental Radiation:

Sources of environmental radiation are both natural and manmade.

(i) Natural (Background) Radiation:

This includes cosmic rays that reach the surface of the earth from space and terrestrial radiations from radioactive elements present in the earth's crust. Many radioactive elements such as radium 224, uranium 235, uranium 238, thorium 232, radon 222, potassium 40 and carbon 14 occur in rocks, soil and water.

(ii) Man-made Radiation:

This includes mining and refining of plutonium and thorium production and explosion of nuclear weapons, nuclear power plants, nuclear fuels and prepa-ration of radioactive isotopes. Production of nuclear weapons involves the tests of nuclear arms. These tests produce large amount of radioactive elements into the environment and make other materials also radioactive. They include strontium 90, cesium 137, iodine 131 and some others.

The radioactive materials are transformed into gases and fine particles which are carried to distant places by wind. When rain drops, the radioactive particles fall on the ground, it is called nuclear fallout. From the soil radioactive substances are taken by plants, thence they reach humans and animals through food chains. Iodine 131 damages white blood corpuscles, bone marrow, spleen, lymph nodes, skin cancer, sterility and defective eye sight and may cause lung tumors. Strontium 90 accumulates in the bones and may cause bone cancer and tissue degeneration in most animals and man.

The radioactive materials are washed from land to water bodies where the aquatic organisms absorb them. From these organisms radioactive materials may reach man through food chains.

(a) Atomic Reactors and Nuclear Fuels:

The operation of a nuclear power plant releases large amounts of energy. This energy is used in large turbines, which produce electricity. Both the fuel elements and coolants contribute to radiation pollution. Wastes from atomic reactors also contain radioactive materials. The biggest problem is the disposal of these radioactive wastes. If these wastes are not properly disposed off, can harm the living organisms wherever they may be dumped. Inert gases and halogens escape as vapours and cause pollution as they settle on land or reach surface waters with rain.

(b) Radio Isotopes:

Many radioactive isotopes such as 14C. 125I, 32P and their compounds are used in scientific research. Waste waters containing these radioactive materials reach water sources like rivers through the sewers. From water they enter human body through food chains.

(c) X-rays and Radiation Therapy:

Human beings also voluntarily receive radiation from diagnostic X-rays and radiation therapy for cancer.

(d) People working in power plants, nuclear reactors, fuel processors or living nearby are vulnerable to radiation exposure.

Effects of Radioactive Pollution:

Harmful Effects:

When human body is subjected to these ionised radiations, large scale hazards, like cancers, shortening of life span, deformations, and genetic changes may occur, depending upon the quantum of radiation/exposure; although, however smaller and calculated doses of such radiations are used on human body for medical diagnosis through X-rays, etc. ; for detecting the mal-functioning of different organs of the body.

The effects of radiation were first noted in 1909 when it was found that uranium miners suffer from skin burn and cancer due to radiations from the radio-active mineral. Different organisms show different sensitivity to ionising radiations. For example, tests have shown that pine trees are killed by radiations in which oak trees continue to thrive comfortably.

It has also been reported that high altitude plants have developed polyploidy as a protective mechanism against radiations. Parts of coastal areas in South India have a high degree of background radiation which was formerly considered to be quite harmful to human beings.

The cells which actively grow and divide are quickly damaged. This category includes the cells of skin, intestinal lining, bone marrow, gonads and embryo. Radiations have both immediate or short-range and delayed or long-ranged effects.

(i) Short Range (Immediate) Effects:

They appear within days or a few weeks after exposure. The effects included loss of hair, nails, subcutaneous bleeding, change in number and proportion of blood cells, changed metabolism, and proportion of blood cells, etc.

(ii) Long Range (Delayed) Effects:

They appear several months or even years after the exposure. The effects are caused by development of genetic changes, mutations, shortening of life span, formation of tumor, cancers, etc. The effect of mutations can persist in the human race.

All organisms are affected by radiation pollution. Some organisms preferentially accumulate specific radioactive materials. For example, oysters accumulate 65Zn, fish accumulate 55Fe, marine animals accumulate 90Sr.

Control of Radioactive Pollution:

The following preventive measures should be followed to control radioactive pollution:

(i) Leakage of radioactive materials from nuclear reactors, industries and laboratories using them should be totally stopped.

(ii) Radioactive wastes disposal must be safe. They should be changed into harmless form or stored in safe places so that they can decay in a harmless manner. Radioactive wastes only with very low radiation should be discharged into sewerage.

(iii) Preventive measures should be taken so that natural radiation level does not rise above the permissible limits.

(iv) Safety measures should be taken against accidents in nuclear power plants.

LAND OR SOIL POLLUTION

Types of Soil Pollution Soil pollution may be any chemicals or contaminants that harm living organisms. Pollutants decrease soil quality and also disturb the soil's natural composition and also lead to erosion of soil. Types of soil pollution can be distinguished by the source of the contaminant and its effects of the ecosystem. Types of soil pollution may be agricultural pollution, Industrial wastes and urban activities.

Agricultural Pollution

- Agricultural processes contribute to soil pollution.
- Fertilizers increase crop yield and also cause pollution that impacts soil quality.
- Pesticides also harm plants and animals by contaminating the soil.
- These chemicals get deep inside the soil and poison the ground water system.
- Runoff of these chemicals by rain and irrigation also contaminate the local water system and is deposited at other locations.

Industrial Waste

- About 90% of oil pollution is caused by industrial waste products.
- Improper disposal of waste contaminates the soil with harmful chemicals.
- These pollutants affect plant and animal species and local water supplies and drinking water.
- Toxic fumes from the regulated landfills contain chemicals that can fall back to the earth in the form of acid rain and can damage the soil profile.

Urban Activities

- Human activities can lead to soil pollution directly and indirectly.
- Improper drainage and increase run-off contaminates the nearby land areas or streams.
- Improper disposal of trash breaks down into the soil and it deposits in a number of chemical and pollutants into the soil. These may again seep into groundwater or wash away in local water system.
- Excess waste deposition increases the presence of bacteria in the soil.
- Decomposition by bacteria generates methane gas contributing to global warming and poor air quality. It also creates foul odors and can impact quality of life.

Causes of Soil Pollution

Soil Pollution is a result of many activities by mankind which contaminate the soil. Soil pollution is often associated with indiscriminate use of farming chemicals, such as pesticides, fertilizers, etc. Pesticides applied to plants can also leak into the ground, leaving long-lasting effects. Read about the dangers of pesticides. In turn, some of the harmful chemicals found in the fertilizers (e.g. cadmium) may accumulate above their toxic levels, ironically leading to the poisoning of crops. Heavy metals can enter the soil through the use of polluted water in watering crops, or through the use of mineral fertilizers. Faulty landfills, bursting of underground bins and seepage from faulty sewage systems could cause the leakage of toxins into the surrounding soil.

Causes of Soil Pollution

Soil Pollution is a result of many activities by mankind Acid rains caused by industrial fumes mixing in rain falls on the land, and could dissolve away some of the important nutrients found in soil, as such change the structure of the soil. Industrial wastes are one of the biggest soil-pollution factors. Iron, steel, power and chemical manufacturing plants which irresponsibly use the Earth as a dumping ground often leave behind lasting effects for years to come. Fuel leakages from automobiles, which get washed by rain, can seep into the nearby soil, polluting it. Deforestation is a major cause for soil erosion, where soil particles are dislodged and carried away by water or wind.

As a result, the soil loses it structure as well as important nutrients found in the soil. Some the causes of soil pollution can be as follows:

- Industrial effluents like harmful gases and chemicals.
- Use of chemicals in agriculture like pesticides, fertilizers and insecticides.
- Improper or ineffective soil management system.
- Unfavorable irrigation practices.
- Improper management and maintenance of septic system.
- Sanitary waste leakage.
- Toxic fumes from industries get mixed with rains causing acid rains.

- Leakages of fuel from automobiles are washed off due to rains and are deposited in the nearby soil.
- Unhealthy waste management techniques release sewage into dumping grounds and nearby water bodies.
- Use of pesticides in agriculture retains chemicals in the environment for a long time. These chemicals also effect beneficial organisms like earthworm in the soil and lead to poor soil quality.
- Absence of proper garbage disposal system leads to scattered garbage in the soil. These contaminants can block passage of water into the soil and affects its water holding capacity.
- Unscientific disposal of nuclear waste contaminate soil and can cause mutations.

- Night soil contamination due to improper sanitary system in villages can cause harmful diseases.

Effects of soil pollution

The main reason for soil contamination is due to the presence of anthropogenic activities. These waste products are made of chemicals that are not originally found in nature and hence lead to soil pollution. Soil pollution is typically caused by industrial activity, chemicals used in agriculture and improper disposal of waste. Soil contamination leads to health risks due to direct and indirect contact with contaminated soil. Soil pollution causes huge disturbances in the ecological balance and the health of the organisms is under risk. The effects of pollution on soil are quite disturbing and can result in huge disturbances in the ecological balance and health of living beings on earth.

Effects of soil pollution

Normally crops cannot grow and flourish in a polluted soil. However if some crops manage to grow, then these crops might have absorbed the toxic chemicals in the soil and might cause serious health problems in people consuming them. Sometimes the soil pollution is in the form of increased salinity of the soil. In such a case, the soil becomes unhealthy for vegetation, and often becomes useless and barren. When soil pollution modifies the soil structure, deaths of many beneficial soil organisms (e.g. earthworms) in the soil could take place. Other than further reducing the ability of the soil to support life, this occurrence could also have an effect on the larger predators and force them to move to other places, in the search of food.

Effects of soil pollution

People living near polluted land tend to have higher incidences of migraines, nausea, fatigue, skin disorders and even miscarriages. Depending on the pollutants present in the soil, some of the longer-term effects of soil pollution include cancer, leukemia, reproductive disorders, kidney and liver damage, and central nervous system failure. These health problems could be a result of direct poisoning by the polluted land (e.g. children playing on land filled with toxic waste) or indirect poisoning (e.g. eating crops grown on polluted land, drinking water polluted by the leaching of chemicals from the polluted land to the water supply, etc).

Effects of soil pollution

Long term effects of soil pollution The long term effects of soil pollution are many and can be difficult to deal with, depending on the nature of the contamination. How Soil Gets Polluted Soil is a sort of ecosystem unto itself, and it is relatively sensitive to foreign matter being applied to it. That's good for us in the case of wanting to add soil amendments, fertilizer and compost to make the soil healthier, but not so good when it comes to soil pollution. There are many different ways that soil can become polluted, such as:

There are many different ways that soil can become polluted, such as:

- Seepage from a landfill
- Discharge of industrial waste into the soil
- Percolation of contaminated water into the soil
- Rupture of underground storage tanks
- Excess application of pesticides, herbicides or fertilizer
- Solid waste seepage
- The most common chemicals involved in causing soil pollution are:
- Petroleum hydrocarbons
- Heavy metals
- Pesticides
- Solvents

Soil pollution happens when these chemicals adhere to the soil, either from being directly spilled onto the soil or through contact with soil that has already been contaminated. As the world becomes more industrialized, the long term effects of soil pollution are becoming more of a problem all over the world. It is thought that a full 150 million miles of China's farmland is contaminated. Even when soil is not being used for food, the matter of its contamination can be a health concern. This is especially so when that soil is found in parks, neighborhoods or other places where people spend time. Health effects will be different depending on what kind of pollutant is in the soil.

It can range from developmental problems, such as in children exposed to lead, to cancer from chromium and some chemicals found in fertilizer, whether those chemicals are still used or have been banned but are still found in the soil. Some soil contaminants increase the risk of leukemia, while others can lead to kidney damage, liver problems and changes in the central nervous system. Those are just the long term effects of soil pollution. In the short term, exposure to chemicals in the soil can lead to headaches, nausea, fatigue and skin rashes at the site of exposure. When it comes to the environment itself, the toll of contaminated soil is even direr. Soil that has been contaminated should no longer be used to grow food.

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PESTICIDES ON SOIL POLLUTION

Pesticides are designed to kill bugs that are harmful to plants. Pesticides kill specific pests on plants such as slugs, beetles and flying insects. The chemicals used in most pesticides can kill more than just garden pests; they can kill the helpful organisms that live in the soil. Some of these chemicals can remain in the soil for years, effectively keeping necessary microorganisms from working the soil.

Common chemical pesticides that are used in gardens and by large-scale crop producers include the following:

- Basic Copper Sulfate
- Silica Gel
- Sodium Fluoride
- Carbon Disulfide
- Hydrogen Cyanide
- Methylchloroform
- Fenthion
- Boric Acid

Unfortunately, many pesticides can kill more than just their intended targets, namely the necessary micro-organisms in the soil. When chemicals are used for a period of time on plants in an area, they will eventually leach into the soil. Once in the soil they can kill the micro-organisms living in the soil that break down organic material and aid in plant growth. It can take years before micro-organisms can once again live in soil that has had toxic chemicals applied to it.

Effects of soil pollution

Soil pollution causes huge disturbances in the ecological balance and health of living organisms at an alarming rate. Some the effects of soil pollution are:

- Disturbance in the balance of flora and fauna inhabiting in the soil.
- Contaminated soil decreases soil fertility and hence there is decrease in the soil yield.
- Reduced soil fertility hence decrease in soil yield.
- Loss of natural nutrients in soil.
- Reduced nitrogen fixation.
- Loss of soil and nutrients.
- Increased soil erosion.
- Imbalance in the flora and fauna of the soil.

- Increase in soil salinity, makes it unfit for cultivation.
- Creation of toxic dust.
- Foul odor due to industrial chemicals and gases.
- Alteration in soil structure can lead to death of organisms in it.
- Reduction in soil fertility.
- Loss of the natural nutrients of the soil.
- Imbalance is the flora and fauna of the soil.
- Salinity increases in the soil making it unfit for cultivation.
- Crops grown on polluted soil cause health problems on consumption,
- Soil pollution creates toxic dust.

- Foul odor due to chemicals and gases can lead to problems like headaches, nausea, etc.
- Pollutants in soil cause alteration in soil structure, causing death of many soil organisms. This can affect the food chain.

Effects on humans

- Soil pollution has major consequences on human health. Consumption of crops and plants grown on polluted soil cause health hazards. This could explain small and terminal illness.
- Long term exposure to polluted soil affects the genetic make-up of the body and may congenital illnesses and chronic health diseases.
- Chronic exposure to heavy metals, petroleum, solvents and agricultural chemicals can be carcinogenic.
- Exposure to benzene for a long term is associated with higher incidence of leukemia. Mercury causes higher incidences of kidney damage. Cyclodienes are linked to liver toxicity.

Effects on humans

- Organophosphates can lead to chain of responses leading to neuromuscular blockage.
- Chlorinated solvents induce damages to liver, kidney, depression of the central nervous system.

On plant growth

- The balance of ecological system is affected due to contamination of the soil. • Plants are mostly unable to adapt to the change in the chemistry of the soil in short time period.
- The microorganisms found in the soil decline and create additional problems of soil erosion.
- Fertility of the soil decreases due to soil pollution, making it unsuitable for agriculture and local vegetation to survive.
- Soil pollution is hazardous to health. • Polluted lands cannot support most forms of life.

On soil fertility

- The chemicals present in the soil due to pollution are toxic and can decrease the fertility of the soil, thereby decreasing the soil yield.
- Agriculture on contaminated soil produces fruits and vegetable that lack quality nutrients.
- Consumption of these may be poisonous and cause serious health problems to people consuming them.

Toxic dust

- Emissions of toxic gases and foul odor from the landfills pollute the environment and causes serious health effects on some people.
- The foul odor causes inconvenience to people.

On soil fertility

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Toxic dust

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- The foul odor causes inconvenience to people.

On soil structure

- Soil pollution can lead to death of many soil organisms like the earthworms which can lead to alteration in the soil structure.
- This can force other predators to move to other places in search of food.

Control of soil pollution

A number of ways have been suggested to curb the pollution rate. Attempts to clean up the environment require plenty of time and resources. Some the steps to reduce soil pollution are:

- Ban on use of plastic bags below 20 microns thickness.
- Recycling of plastic wastes.
- Ban on deforestation.
- Encouraging plantation programmes.
- Encouraging social and agro forestry programmes.
- Undertaking awareness programmes.
- Reducing the use of chemical fertilizer and pesticides.
- Recycling paper, plastics and other materials.

Control of soil pollution

- Ban on use of plastic bags, which are a major cause of pollution.
- Reusing materials.
- Avoiding deforestation and promoting forestation.
- Suitable and safe disposal of including nuclear wastes.
- Chemical fertilizers and pesticides should be replaced by organic fertilizers and pesticides.
- Encouraging social and agro forestry programs.
- Undertaking many pollution awareness programs.

Module 4

NOISE POLLUTION

The sound which gives pleasure and comfort to the listener is called sweet sound. But, the sound which is uncomfortable and causes mental strain is called noise.

Noise can therefore, also be defined as that unwanted sound pollutant which produces undesirable physiological and psychological effects in an individual, by interfering with one's social activities like work, rest, recreation, sleep, etc.

CHARACTERISTICS OF SOUND AND ITS MEASUREMENT

By our knowledge of physics, we are aware that sound is produced in the environment by alternating pressure changes in the air, and is caused by the vibrations of solid objects or separation of fluids, as they pass over, around, or through holes in solid objects. These vibrations cause the surrounding air to undergo compression, then refraction, again compression, then rarefaction, and so on. Such alternating compression and rarefaction of the surrounding air produces sound waves which propagate in the form of sinusoidal path.

LEVELS OF NOISE

The sound pressure of the faintest sound that can be heard by a normal healthy individual is about 20 micro-pascal (μ-pa). On the other hand, the loudest sound produced by a Saturn rocket at the lift off stage is about 200 Pa. This variation in sound pressure (varying from 20 μ-pa to 200Pa) is usually avoided by expressing sound pressure on a scale based on the log of the ratio of the measured sound pressure and a reference standard pressure. Measurements on this scale are called levels.

LEVELS OF NOISE

The sound level (L) is, thus, represented as

$$L = \quad (bels)$$

.....1

Where, Q = Measured quantity o sound pressure, or sound power, or sound intensity.

Q_o = Referrence standard quantity of sound pressure, or sound power, or sound intensity, as the case may be

L = Sound level in bels (B)

The unit of sound level obtained in Eq. 1 is bels (B), and since it turns out to be a rather large unit, a smaller unit of decibels (dB) is

LEVELS OF NOISE

The noise is measured in terms of decibel. The ratio of the sound produced to the sound distinguishable by the ear is designated as decibel.

Hence, when sound level is expressed in decibels, Eq. 1 reduces to

L = (dB) ….. 2

(i) Sound pressure level

The reference standard quantity Q_0 in the above equation is taken to be equal to 20 μ pa, when sound pressureis measured. Then Eq. 2 reduces to

$$\text{Sound pressure level } L_p = 10.\log_{10}\left(\frac{P_{rms}}{20\ \mu\text{Pa}}\right)^2$$

(Sound measuring instruments measures the r.m.s)

$$L_p = 20.\log_{10}\left(\frac{P_{rms}}{20\ \mu\text{Pa}}\right) \quad \ldots\ldots 3$$

The sound pressure level so measured are reported as dB re : 20 μ Pa.

(ii) Sound power level

Similarly, the reference standard quantity Q_0 in the above equation is taken to be equal to 10^{-12} watts, when sound power is measured. In that eventually Eq. 2 reduces to

$$\text{Sound power level } L_w = 10.\log_{10}\left(\frac{W}{10^{-12}}\right)$$

The sound pressure level so measured are reported as dB re : 10^{-12} W.

(iii) Sound intensity level

Similarly, the reference standard quantity Q_0 in equation is Eq.2 is taken to be equal to 10^{-12} W/m^2, when the sound intensity level is measured. The sound intensity level is thus given by

$$\text{Sound intensity level } L_I = 10.\log_{10}\left(\frac{I}{10^{-12}}\right)$$

Out of the three terms given above, sound pressure level on reference scale 20 μPa, is usually adopted to express sound levels in decibels.

The addition of such sound levels cannot be done by simple arithmetic addition, because of the log scale involved. Hence, if you consider 50 decibel noise and want to add another 50 decibel noise, it will not make up 100 decibel noise, but will make up only 53 decibel noise, as calculated below:

$$50 \text{ decibel} = 20.\log_{10}\left(\frac{P_{rms}}{20}\right)$$

$$\left(\frac{P_{rms}}{20}\right) = \text{Antilog}\left(\frac{50}{20}\right) = 316.227$$

$$\text{or} \quad P_{rms} = 6324.55 \text{ μPa}$$

Therefore = 50 decibel + 50 decibel in r.m s

$$= \sqrt{(6324.26)^2 + (6324.26)^2}$$

$$= 8944.26 \text{ μPa}$$

$$= \log_{10}\left(\frac{8944.26}{20}\right)$$

$$= \mathbf{53 \text{ decibel}}$$

CAUSES OF NOISE POLLUTION

Noise pollution can be caused by several phenomenon including industrial activity, and social activity (such as explosion of fire crackers, loud parties), and surface travel. The many causes of noise pollution are discussed below:

1. ***Fire crackers:*** Fire crackers are exploded to make huge sound during celebrations and festive occasions. It is common sight to witness the firing of crackers at live concerts. These high levels of sound is extremely problematic for people, especially elderly and sick people.

2. *Transportation vehicles:* Noise pollution is severest in the cities. All forms of machine powered vehicles cause noise pollution. The different modes of transportation (land, air and water), produces enough sound and collectively causes massive disturbance to the human mind and body. During the last few decades, the world is moving at unprecedented speed. People use surface transportation vehicles such as cars, vans, buses, trams, bullet trains. There are metro rails in major cities. Long distances are very often covered in an airplane or a bullet train. Airports and railway stations are busy throughout day and night. Far away places can be reached in hours. People take the water route to travel via motor shops, boats, yacht, and helicopters. Many people even own private air-crafts. The ever-increasing usage of various modes of transport is the major cause for noise pollution.

3. ***Microphones and Loud Speakers:*** Loud speakers and microphones are used during social, political and other special events. Large public gatherings are held. To make sure that the announcements and speeches are audible a large audience, microphones and loud speakers ate used. Though these public gatherings are generally held for welfare and entertainment of the public, the nearby residents suffer from loud noise.

4. ***Factories and industries:*** In large cities, there are large number of factories, mills and industries. Industries such as steel industry, shipping industry, aircraft, wires, switch gears and automobiles cause industrial noise. These industrial sites produce immense environmental noise to disturb the habitats of nearby residential areas. Large scale industries are often sites as a major cause of NIHL – Noise Induced Hearing Loss. They are constantly exposed to noise of the working machinery. Their auditory system is at risk. Long-term exposure to industrial noise may lead to hearing disability.

5. ***Domestic household appliances:*** A majority of domestic household appliances that we use in everyday life causes noise pollution. Home theaters and televisions are played non-stop. The air cooler is supported by a large and powerful fan. The mixer grinders are used in grinding food materials. The juicer extracts juices from the fruits. The air purifier is used to purify the air. Washing machines are used for washing clothes. Loud music are played on advanced music systems. The smart phone keeps ringing.

6. *Building and construction sites near residential areas*: The building and construction activity involves use of sound producing equipment such as cement-mixer, road-roller, crane, etc. Cement mixers uses a revolving drum to mix cement, sand, small stones and water to create concrete. The sound of cement mixers are annoying.

7. Office Equipment: In offices, a wide variety of equipment is used. Many of the office equipment make noise. Paper shredders are used to cut papers. Printers are widely used for printing texts and pictures. A manual type writer, is used for typing. Fax machines are used to send or receive scanned texts or images through telecommunication lines. Phones keep ringing. And people keep talking to business partners, and clients over phone. When doors are opened and shut hard, it makes noise.

All the above activities produce enough noise to disturb the health and mind of human-beings and other living bodies.

EFFECTS OF NOISE POLLUTION

Effect on Human beings

Noise pollution affects the human mind and body negatively. The ill-effects of noise pollution are many. It is the major cause for several ailments. The quality of human life gets disrupted. The lives of the children, the aged or the ailing people become miserable.

Loss of hearing and deafness: Noise above the tolerable threshold is the leading cause for loss of hearing and deafness.

Cardiac disturbance: Noise increase the risk of cardiac disturbance including coronary artery disease or ischemic heart disease (IHD).

Sleeplessness: Noise may make people restless and tired. It may cause disrupted sleeping pattern or may keep people away from sound sleep. In the long-term, due to tiredness and lack of sleep, the immune system may get compromised.

Headache: Human mind can tolerate sound only to a limited extent. Excess noise causes headache.

***Stress, tension and aggressiveness*:** Loud noises can be very stressful. Constant exposure to irritating sound may cause stress and tension. The behavior of people often becomes aggressive. Other than psychological imbalance, is causes physical illness such as increased blood pressure, cardiac disturbance and insomnia.

Irregular blood pressure: For good health, it is very important to maintain normal pressure in the arteries both during the heartbeat and between the heartbeat. Noise may contribute to fluctuations in the levels of blood pressure.

Mental imbalance and nervous debility: Mental illness is among the worst negative effects of noise pollution. People may find it difficult to cope with their normal routine life. Human mind cannot accept sound beyond a certain level. Excess sound may lead to mental imbalance and nervous disability.

Psychological imbalance: It may also cause psychological imbalance.

Difficulty in talking: Due to excessive noise, it becomes very difficult to talk on roads or inside malls.

Effect on Animals

Noise pollution is hazardous for animals, both wild and domestic. It impairs hearing. Sometimes, it changes the reproductive behavior of the animals. Noise disrupts the communication among animals. Some animals cannot live in noisy atmosphere resulting in loss of habitat. In the presence of noise, some animals raise the level of their voice. For example, many marine animals raises their voice when large ships passes near them. The increased voice further adds to the noise already present. Marine animals are sensitive to noise.

CONTROL MEASURES

1. ***Source Control:*** This includes source modification such as acoustic treatment to machine surface, design changes, limiting operational timings, etc

2. ***Transmission path intervention:*** This includes containing the source inside a sound insulating enclosure, constructing a noise barrier or provision of sound absorbing materials along the path.

3. ***Receptor control:*** This includes protection of the receiver by altering the work schedule or provision of personal protection devices such as ear plugs for operating noisy machinery. The measure may include dissipation and deflection methods.

4. Oiling: Proper oiling will reduce noise from the machine.

PREVENTION OF NOISE POLLUTION

Some effective measures should be taken to solve the problem. The following measures can be taken to prevent noise pollution:

1. Better town planning

Better town planning and ensuring that residential towns are set up at places away from heavy industrial units can help in combating the problem of noise pollution.

2. Smooth roads

Significant control over noise pollution caused by transportation vehicles can be controlled by making smooth roads, and by disallowing heavy carriage vehicles on roads near residential units.

3. Public awareness

To prevent and control noise pollution it is necessary to create public awareness. Only law is not sufficient. People must be made aware of the harmful consequences and irreversible injuries caused of noise pollution such as deafness, mental illness, etc.

4. Proper regulations

There should be minimum use of sound producing instruments. There should be proper regulations for the use of loudspeakers, microphones, and other devices that produce noise beyond that are beyond the toleration limits of human-beings.

5. Noise related restrictions

The Pollution Control Board and the High Court have already taken effective measures to bring sound pollution under control. Adequate measures should be taken to ensure that noise related restrictions are not violated.

6. Anti-pollution laws

Anti-pollution laws should be enacted and enforced.

7. Fire crackers and electric horns

Ban on fire crackers should be imposed and electric horns should be replaced by bulb horns. Further, use of horns in residential areas should be monitored and regulated.

8. Usage of quieter machinery

Usage of quieter machinery should be encouraged.

Module 5

IMPACT OF POLLUTANT

LOCAL POLLUTION

Major environmental issues are forest and agricultural degradation of land, resource depletion (such as water, mineral, forest, sand, and rocks), environmental degradation, public health, loss of biodiversity, loss of resilience in ecosystems, livelihood security for the poor.

The major sources of pollution in India include the rapid burning of fuelwood and biomass such as dried waste from livestock as the primary source of energy, lack of organised garbage and waste removal services, lack of sewage treatment operations, lack of flood control and monsoon water drainage system, diversion of consumer waste into rivers, cremation practices near major rivers, government mandated protection of highly polluting old public transport, and continued operation by Indian government of government owned, high emission plants built between 1950 and 1980.

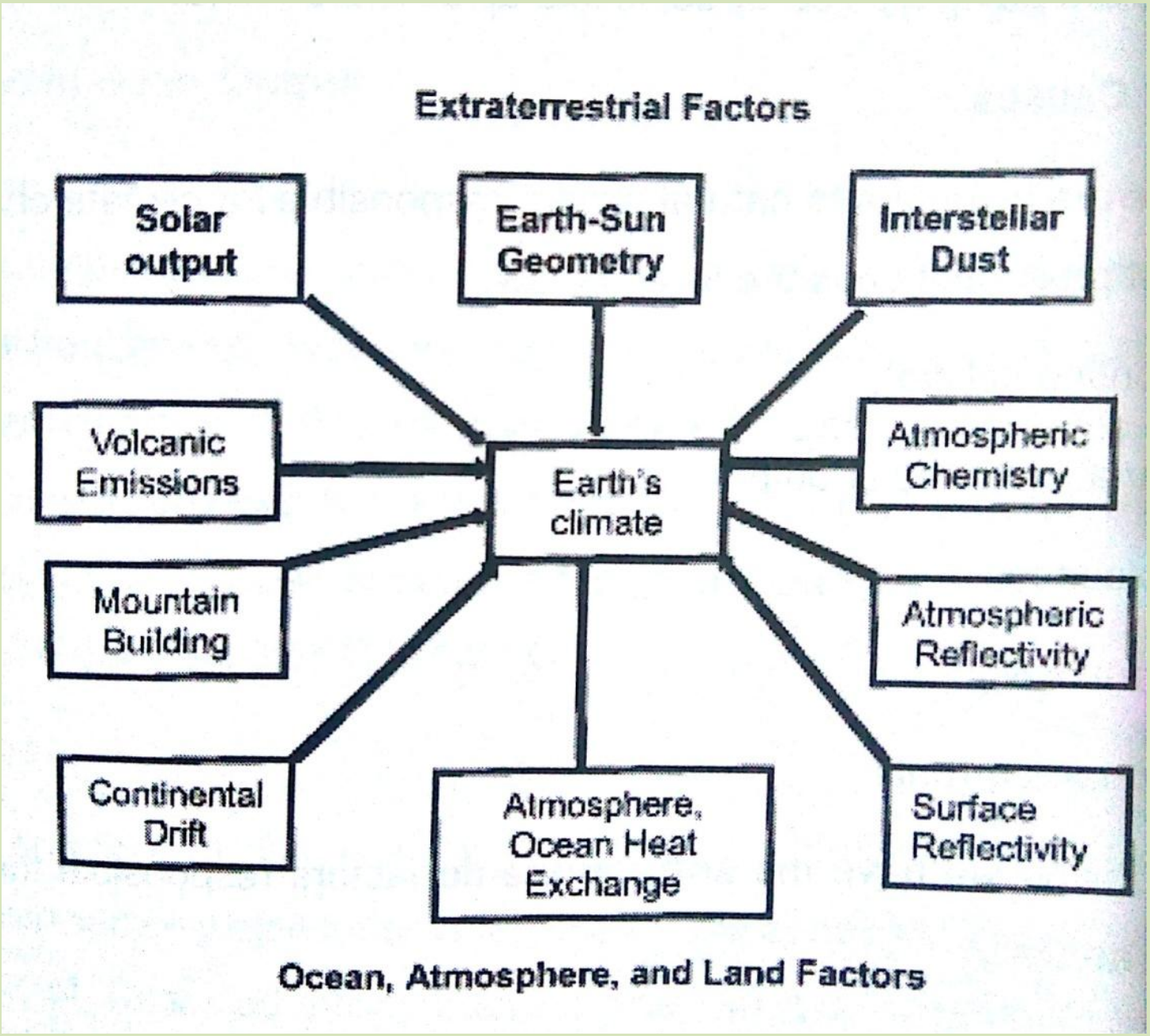
GLOBAL POLLUTION

The next scale of air pollution is its effect on global dimensions, such as the destruction of stratospheric ozone due to emissions of CFC's (chlorofluorocarbon compounds). This issue was given a lot of attention in the period 1985–1995, as it was revealed that the destruction of stratospheric ozone leads to higher UV-light intensities and a higher incidence of skin cancer. For more information, see Antarctic ozone hole.

From 1990 onwards, the increase in the concentrations of radio active substances (compounds which alter the radioactive balance of the Earth; greenhouse gases; but also aerosols, and water in liquid form, as clouds) and the connected climatic consequences brought about new research in air pollution.

CLIMATE CHANGE

The history of our planet has been characterized by frequent changes in climate. The basic components that influence the state of the Earth's climatic system are the extra terrestrial factors and the ocean, atmosphere and land factors. The ocean, atmosphere and land factors includes the volcanic emissions, mountain building, continental drift, atmosphere-ocean heat exchange, surface reflectivity, atmospheric reflectivity and atmospheric chemistry.


Extraterrestrial Factors
Solar output
Earth-Sun Geometry
Interstellar Dust
Volcanic Emissions
Earth's climate
Atmospheric Chemistry
Mountain Building
Atmospheric Reflectivity
Continental Drift
Atmosphere, Ocean Heat Exchange
Surface Reflectivity
Ocean, Atmosphere, and Land Factors

Causes of Climate Change

The phrase global warming is often used synonymously with the term climate change, but the two terms have distinct meanings. Global warming is the combined result of anthropogenic emissions of greenhouse gases and change in solar irradiance, while climate change refers to changes caused by global warming in weather (temperatures, precipitation, frequency of heat waves, etc.) and other climate system components, such as Arctic sea ice extent. The earths climate is dynamic and always changing through a natural cycle. What the world is more worried about is that the changes that are occurring today have been speeded up because of man's activities. These changes are being studied by scientists all over the world.

Natural Causes

There are a number of natural factors responsible for climate change and the most prominent once are listed below.

1. Continental drift
2. Variations in solar output
3. Volcanoes
4. Earth's tilt
5. Ocean currents

In addition we have the anthropogenic factors responsible for climate change as well.

1. Continental drift

The continents that we are familiar with today were formed when the landmass began gradually drifting apart, millions of years back. This drift also had an impact on the climate because it changed the physical features of the landmass, their position and the position of water bodies. The separation of the landmasses changed the flow of ocean currents and winds, which affected the climate. The drift of the continents continues even today; the Himalayan range is rising by about 1 mm every year because the Indian land mass is moving towards the Asian land mass, slowly but steadily.

2. Variations in Solar Output

Since, Sun is the only source of energy for running the earth's climate, any change in its output will result in changes in the reception of insolation and the generation of heat energy. Scientists have long tried to link sunspots to climatic change. Numerical climatic models predict that a change in solar output of even 1 percent per century would alter the earth's average temperature by between 0.5^{o} C to 1.0^{o} C.

3. Volcanoes

Volcanic eruptions of high magnitude is throwing gas and ash which reduce the amount of solar radiation reaching the earth's surface, lowering temperatures in the lower levels of the atmosphere.

4. Earth's tilt

The earth's axis is tilted at an angle of 23.5^{o} to the perpendicular plane of its orbital path. For one half of the year when it is summer, the northern hemisphere tilts towards the sun. In the other half when it is winter, the earth is tilted away from the sun. If there was no tilt we would not have experienced seasons. Changes in the tilt of the earth can affect the severity of the seasons – more tilt means warmer summers and colder winters; less tilt means cooler summers and milder winters.

5. Ocean currents

Oceans are a major component of the climate system. They cover about 71% of our planet and absorb about twice as much of the sun's radiation as the atmosphere or the land surface. Ocean currents move vast amounts of heat across the planet – roughly the same amount as the atmosphere does. Since, the oceans are surrounded by land masses, the heat transport through the water is through channels. Ocean currents have been known to change direction or slowdown. Much of the heat that escapes from the oceans is in the form of water vapor. This contributes to the formation of clouds, which shade the surface and have a net cooling effect thus influencing the climate.

Anthropogenic Causes

However, more recent impacts on climate change have been human induced. Consumerism has increased by leaps and bounds, creating mountains of waste. Also, our population has increased to an incredible extent. All this has contributed to a rise in greenhouse gases in the atmosphere. These manmade greenhouse gases are detrimental to our environment and they prevent heat from escaping into space. During the 20^{th} century , the average global temperature increased by $0.6^{o}C$.

Effects of climate change

Climate change has far-reaching consequences and touches on all life-support systems. Some of the important effects of climate change have been discussed below.

1. Increase in global surface temperature
2. Ocean acidification
3. Melting of glaciers
4. Change in pattern of rainfall
5. Occurrence of drought, heat vaves and floods
6. Rise in sea level
7. Effects on biodiversity
8. Spread of vector borne diseases

1. Increase in global surface temperature

Most of the observed temperature increase since the middle of the 20th century was caused by increasing concentrations of greenhouse gases, which has resulted from human activity such as fossil fuel burning and deforestation.

2. Ocean acidification

Ocean acidification is the phenomenon of ongoing decrease in the pH of the Earth's oceans. Carbon dioxide (CO_2) emitted to the atmosphere by human activities is being absorbed by the oceans, making them more acidic. Between 1751 and 1994 surface ocean pH is estimated to have decreased from approximately 8.179 to 8.104 When the ocean becomes acidic, the scientists have observed that the process by which corals extract calcium carbonate from seawater to build their protective shells had slowed by 21% over the past 16 years. Also aquatic life will not survive at low pH.

3. Melting of glaciers

Glaciers contain almost all of the fresh water present on earth. When the temperature raises slightly, the outer edges of the formed glacier and fresh snow will melt. Now it has been noticed that glaciers have melted more than normal over the past century. It is due to the increase in temperature that glaciers are melting more than they actually should. When a glacier melts fully, it exposes the earth below. Glaciers absorb approximately 20% heat from the sun, reflecting back 80%. When the earth gets exposed this percentage gets reversed. This in turn causes a further increase in temperature.

4. Change in pattern of rainfall

The changes in the world's raifall patterns have already shown significant effects on ecosystems, agriculture and humans. Unusually high rainfall is due to climate change, is a significant cause of floods.

5. Occurrence of drought, heatves and floods

Climate change leads to increasing frequency of extreme weather events evident around the globe. On the other hand droughts are becoming longer, header and more frequent. Thus the changes in temperature and precipitation patterns increase the frequency, duration and intensity of these extreme weather events.

6. Rise in sea level

Sea level rise is caused by the expansion of sea water as it warms up in response to climate change and the widespread melting of land ice. It was estimated that during the 20th century, sea level rose about 15-20 centimeters, with the rate at the end of the century greater than over the early part of the century.

A small increase in sea level can have a dramatic impact on many coastal environments. Over 600 million people live in coastal areas that are less than 10 meters above sea level, and two-thirds of the world's cities that have populations over five million are located in these areas. For these reasons, those living on several small island nations could be forced to evacuate in the 21st century.

7. Effects on biodiversity

Due to human induced climate change earlier blooming of treese, and lengthend seasons are already occurring. From studying biological systems, scientists have found that about 80 percent showed changes in breeding season patterns, migration pattern changes, animal and plant distribution shifts due to climate change.

8. Spread of vector borne diseases

By 2100, it is estimated that average global temperatures will have risen by 1.1 – 3.5^{o} C, increasing the likelihood of many vector-borne diseases in new areas. Changes in climate affect the distribution of vector species which, in turn, will increase the spread of disease, to new areas which lack a strong public health infrastructure. Malaria and dengue fever are among the most important vector-borne diseases in the tropics and subtropics.

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OZONE LAYER DEPLETION

The ozone layer is basically naturally occurring gas in the region of stratosphere where ozone particles are accumulated. Ozone layer is also naturally broken down but there is a balance between its formation and natural depletion. As a result the total amount of ozone remains constant. But ozone layer thickness varies with altitude and seasonal change. Ozone concentration is highest between 19 - 23 km . Most of ozone is formed at equator where there is maximum sunshine but with winds it travels at high altitude and get accumulated in stratosphere

OZONE LAYER DEPLETION

The ozone layer is a layer in Earth's atmosphere which contains relatively high concentrations of ozone (O3). This layer absorbs 93-99% of the sun's high frequency ultraviolet light, which is potentially damaging to life on earth. Over 91% of the ozone in Earth's atmosphere is present here. It is mainly located in the lower portion of the stratosphere from approximately 10 km to 50 km above Earth, though the thickness varies seasonally and geographically. The ozone layer was discovered in 1913 by the French physicists Charles Fabry and Henri Buisson.

Causes of Ozone Depletion

1. Chlorofluorocarbons

Ozone depletion occurs when the natural balance between the production and destruction of stratospheric ozone is disturbed. Although natural phenomenon can cause ozone depletion but human activities such as CFCs are now accepted as major cause of depletion. All ozone depleting chemicals contain chlorine and bromine. CFCs are highly volatile and non combustible so they are very quickly evaporated and can easily reach in stratosphere where ozone is present here they start depleting ozone molecules. These CFCs have also adverse affects on human health.

2. Unregulated Launches of Rockets

Another major cause of large scale ozone depletion is Rocket launches. It has been studied that unregulated rocket launches can result in much more ozone depletion than CFCs. It is estimated that if rocket launches will be let unregulated then it would cause huge ozone loss by the year 2050 than the CFCs have done.

3. Global Warming

Global warming also leads to ozone layer depletion. Due to global warming and green house effect most of the heat is trapped in troposphere which is the layer below the stratosphere. As we all know ozone is present in stratosphere so heat don’t reaches troposphere and it remain cold as recovery of ozone layer requires maximum sunlight and heat so it leads to depletion of ozone layer.

4. Nitrogenous Compound

Nitrogenous Compounds emitted by human activities in small amount like NO, N_2O and NO_2 are considered to be greatly responsible for the depletion of ozone layer

Effects of Ozone Depletion

Ozone depletion is affecting the human health and environment negatively, as it allows the penetration of UV radiations to reach the Earth. These radiations can cause severe diseases in humans such as skin cancer, eye damage and genetic mutations etc. . Furthermore the ozone depletion is affecting the aquatic life, biogeochemical cycles, air quality and also contributing in Global warming.

1. Effects on Eyes

The major cause of blindness in this world is cataracts. There would be 0.3% - 0.6% increase in risk of cataract if there will be 1% decrease in Ozone level. Eye lens can be damaged by oxidative agents. Oxidative oxygen produced by UV radiation can severely damage eye lens and cornea of eye is also badly damaged by UV radiation . Photokeratitis, cataract, blindness all are caused due to UV rays.

2. Effects on Skin

Exposure to UV radiations can cause skin cancer. UV radiations alter the structure of bimoleculs and thus lead to different diseases. Skin is the most often exposed part of body to UV radiations There are two types of skin cancer, Melanoma and Non-melanoma. Melanoma is most serious form of cancer and is often fatal, while non-melanoma is most common type and less fatal. Depletion of ozone layer leads to both Sun burn and skin cancer . UV radiations are also responsible for breast cancer and leukemia. Epidemiological studies of Melanoma indicate that the incidence of melanoma is increasing in those countries having high ratio of cases.

2. Effects on Skin

As UV radiations can penetrate more easily in thin skin so there is greater number of incidence is found in thin skinned people. It is found that the incidence of Melanoma is more in children than adults. The chance of incidence of melanoma is correlated with UV exposure furthermore the survival chance of melanoma is less in boys as compared to girls. As the intensity of radiation increases in summer so the risk of melanoma in thin skinned people is increased in summer and it is more in females as compared to males as their skin is thinner than males .

2. Effects on Skin

There is considerable relationship between melanoma risk and intermittent sun exposure and sunburn history. There is also a direct relationship between air travelling and melanoma incidence. However the studies revealed that genetic factors contribute more for having melanoma disease than behavioral aspects. The epidemiological studies of non melanoma skin carcinoma (NMSC) indicates that its risk is more in young females in lower limbs and sunbathing increases its risk five times in trunk region.

3. Effects on Human Immunity

Exposure to UV radiations can also result in suppression of immune response to skin cancer, infectious diseases and other antigens. The immuno supression is due to changes in skin photoreceptors and antigen presenting cells that are brought by UV radiations. More increase in depletion of ozone results in more decrease in immune system.

4. DNA Damage and Lung Diseases

Short exposure to UV-B radiations can cause the DNA damage because UV radiations can disturb biomolecules such as lipids, proteins and Nucliec acids. Due to UV-B radiations there would be cryptic transposable elements which may lead towards the mutations which is more dangerous than the immediate DNA damage.

4. DNA Damage and Lung Diseases

The ultimate cause of this whole mechanism is found to be the prolonged exposure to UV radiations. It is estimated that there is increase of 2% of incidence of these cancers by 1% depletion of ozone layer. Exposure to UV radiations equally affects lungs. Bronchitis, obstruction of lungs, Emphysema, asthma all can be resulted from UV radiations exposure.

5. Effects of Hydrogen Peroxide on Human Health

Due to stratospheric ozone layer depletion UV radiations are penetrating in earth atmosphere which result in the production of reduced oxygen. Highly reactive species like hydrogen peroxide is produced which has bad effects on human health. It is ideal photochemical maker due to its long life and stability. Hydrogen peroxide is toxicant and it pollutes drinking water especially in lakes and makes water toxic and unfit for drinking.

6. Effect of Food Shortage on Human Population

Depletion of ozone layer is also causing the problem of food shortage to humans. UV radiations are disturbing developmental and physiological processes which is decreasing the productivity of crops. As humans are heavily dependent on crops for food so there is a great chance if depletion of ozone layer is not checked it may cause seriously shortage of food to humans.

DEFORESTATION

Deforestation is the conversion of forest to an alternative permanent non-forested land use such as agriculture, grazing or urban development. Deforestation is primarily a concern for the developing countries of the tropics as it is shrinking areas of the tropical forests causing loss of biodiversity and enhancing the greenhouse effect. Thirty per cent of the earth's land area or about 3.9 billion hectares is covered by forests. It was estimated that the original forest cover was approximately six billion hectares.

Causes of deforestation

The main causes of deforestation are:

1. Agriculture;
2. Shifting cultivation;
3. Demand for firewood;
4. Demand of wood for industry and commercial purposes;
5. Urbanization and developmental projects;
6. Other causes.

(1) Agriculture

The expanding agriculture is one of the most important causes of deforestation. Man has always modified the natural ecosystems in such a way that environment becomes more favorable for crop growth whether using traditional or modern methods of agriculture. As demands for agricultural products rises, more and more land is brought under cultivation and for that more forests are cleared, grasslands and even marshes, and lands under water are reclaimed. Thus there is much more ecological destruction than gain in term of crop yield. The forest soil after clearing are unable to support farming for long periods due to exhaustion of nutrients. Once the soils become unfit for cultivation, the area suffers from to soil erosion and degradation.

(2) Shifting cultivation

Hunting and gathering has been the main form of sustenance practiced in the earlier periods of human history. Shifting cultivation is a 12000-year old practice and a step towards transition from food collection to food production.

(3) Demand for firewood

Firewood has been used as a source of energy for cooking, heating etc. Almost 44% of the total global wood produced fulfils the fuel requirements of the world. Close look at the pattern of utilization of wood produced will show that the developed countries utilize 16% of their share for fuel requirements. India consumes nearly 135-170 Mt (Million tonnes) of firewood annually and 10-15 ha of forest cover is being stripped off to meet the minimum fuel needs of urban and rural poor.

(4) Wood for industry and commercial use

Wood, the versatile forest produce, is used for several industrial purposes, such as making crates, packing cases, furniture, match boxes, wooden boxes, paper and pulp, plywood, etc. 1.24 lakh ha of forest have been cut for various industrial uses. Unrestricted exploitation of timber as well as other wood products for commercial purposes is the main cause of forest degradation. The paper industry accounts for about 2% of country's annual consumption of wood and 51% this requirement is met by bamboo wood. This has led to the depletion of bamboo stocks in most of the peninsular India. For example the apple industry in the Himalayan region has led to the destruction of fir and other tree species, for making wooden boxes used for transporting apples. Similarly, plywood crates were used for packing particularly tea and other produce.

(5) Urbanisation and developmental projects

Often urbanisation and developmental activities lead to deforestation. The process of deforestation begins with building of infrastructure in the form of roads, railway lines, building of dams, townships, electric supply etc. Thermal power plants, mining for coal, metal ores and minerals are also important causes of deforestation.

(6) Other causes

Recent developments everywhere in world have caused large scale environmental degradation, especially in tropical forest areas. The large amounts of resources –living and nonliving (minerals, river, land) found in these forests have attracted both industry and other developmental agencies, which have severely depleted forest cover. Forests may sometimes suffer from natural calamities such as overgrazing, floods, forest fires, diseases and termite attack.

Consequences of Deforestation

Deforestation affects both physical and biological components of the environment.

1. Soil erosion and flash flood
2. Climatic change
3. Loss of biodiversity

(1) Soil erosion and flash flood

A shrinking forest cover coupled with over exploitation of ground water has accelerated erosion along the slopes of the lower Himalayas and Aravali hills, making them prone to landslides. Destruction of the forests has altered rainfall pattern. In 1978 India suffered some of the worst flooding in its history. There was two days of heavy rainfall and 66,000 villages were inundated, 2,000 people drowned, and 40,000 cattle were swept away. In 2008 Bihar state suffered worst flood in the river kosi. Several lives were lost and a huge number of cattle were swept away. Lack of forest cover has resulted in water flowing off the ground, washing away the top soil which is finally deposited as silt in the river beds. Forests check soil-erosion, landslides and reduce intensity of flood and drought.

(2) Climatic change

Forests enhance local precipitation and improve water holding capacity of soil, regulate water cycle, maintain soil fertility by returning the nutrients to the soil through leaf fall and decomposition of litter. Forests check soil-erosion, landslides and reduce intensity of flood and droughts. Forests, being home of wildlife are important assets of aesthetic, touristic and cultural value to the society. Forests have profound effect on the climate. Forest absorbed carbon dioxide from the atmosphere and help in balancing carbon dioxide and oxygen in the atmosphere. The forests play a vital role in maintaining oxygen supply in the air, we breathe.

(2) Climatic change

They also play a vital role in the regulation of water (water cycle) in the environment and act as environmental buffers regulating climate and atmospheric humidity. Heat build-up in the atmosphere is one of the important problems of the century known as green house effect is the partly caused by the result from deforestation. The entire Himalayan ecosystem is threatened and is under severe imbalance as snow –line has thinned and perennial springs have dried up. Annual rainfall has declined by 3 to 4%. Chronic droughts have begun even in areas like Tamilnadu and Himachal Pradesh where they were not known earlier.

(3) Biodiversity

"Biodiversity" include all variety of life forms. Biodiversity - (biological diversity) is a measure of variation, the number of different varieties, among living things. Biodiversity can be expressed in number of ways, which includes the number of genetic strains (differences) within species and the number of different ecosystem in an area. The most common expression of biodiversity is the number of different species, within a particular area (local biodiversity), or in a specific habitat (habitat biodiversity) or in the world (global biodiversity). Biodiversity is not static. It changes over the time during evolution new species have come up while some species become extinct.

There are several causes for biodiversity loss:-

1. Hunting, poaching and commercial exploitation.
2. Elimination and disturbance of wildlife habitats.
3. Selective destruction of habitat/ life forms.
4. Domestication.
5. Introduction of new alian species in new area which threaten the indigenous species.
6. Use of pesticides.
7. Pests, medical research and zoos. All the above factors adversely affect biodiversity.

(4) Extinct species

Ultimate fate of every species is extinction but after industrialization this rate has increased tremendously. The extinct species only exist in museums and photographs. The most noted example of extinct species is passenger pigeon.

LAND DEGRADATION

Land degradation is defined as the long-term loss of ecosystem function and productivity caused by disturbances from which the land cannot recover unaided. Land degradation occurs slowly and cumulatively and has long lasting impacts on rural people who become increasing vulnerable.

Causes of land degradation

1. Deforestation: The removal of trees and other vegetation (for firewood, commercial logging or to clear land for farming and settlements).

2. Overgrazing: Allowing farm animals to eat all the covering vegetation until the soil is exposed and the plants cannot regenerate themselves.

3. Poor land management: This can be inappropriate farming methods for the type of land/soil; farming that is too intensive (forcing the land to produce food crops year after year without letting it 'rest' to build up the nutrients again; using chemical or no fertilizers rather than natural fertilizers such as animal dung or organic matter).

4. Fires: This includes bush and veld fires, caused by people, which strip the soil of the plant material that prevents soil erosion.

5. Pollution: This is caused by dumping scrap metal, plastics and packaging and building rubble.

6. Mining: This damages the soil and the underlying structure of the land. Chemicals used or mined themselves pollute soil and water courses.

7. Neglect: Failing to look after local plants, trees and biodiversity. Neglect means that the soil will not be naturally fertilized and protected, so it cannot in turn nurture other life.

6 Consequences of Land degradation

The impacts of land degradation and decertification include a reduction in crop and pasture productivity and fuelwood and non-timber forest products, which are closely linked to poverty and food insecurity. The damage to soil, loss of habitat, water shortages, and siltation reduce biodiversity and ecosystem services and have economic consequences. Land degradation manifests itself in many forms; among them are soil erosion, increased sediment loading of water bodies, loss of soil fertility, salinity, reduced ground cover, and the reduced carrying capacity of land.

Module 6

ENVIRONMENTAL IMPACT ASSESSMENT

Population explosion coupled with rapid industrial growth are utilising our resources at faster rate which is totally unsustainable. Currently our nature has shown lot of stress and there is need to preserve the environment. Today there is worldwide recognition that man cannot ignore the quality of the environment and the concept of environmental management come as a response to the increasing seriousness of the human impact on our environment. Harmony between man and environment is the essence of environmental management.

Some of the environmental management tools are given below:

1. Environmental Management System (EMS)
2. Eco Labelling
3. Life Cycle Assessment (LCA)
4. Waste minimisation programmes
5. Environmental Impact Assessment (EIA)
6. Environmental Risk Analysis
7. Environmental Auditing

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

It is the process of identification, evaluation and mitigation of potential impact of proposed projects, plans and programs prior to decision making/commitment made relative to the following:

1. Physical / chemical components
2. Biological components
3. Cultural components
4. Socio – Economic components

EIA can be also defined as “systematic and well documented procedure to identify, describe and assess the direct and indirect effects of a development projects on different environmental / social / cultural / economic factors for environmentally compatible and sustainable development.

Objective of EIA

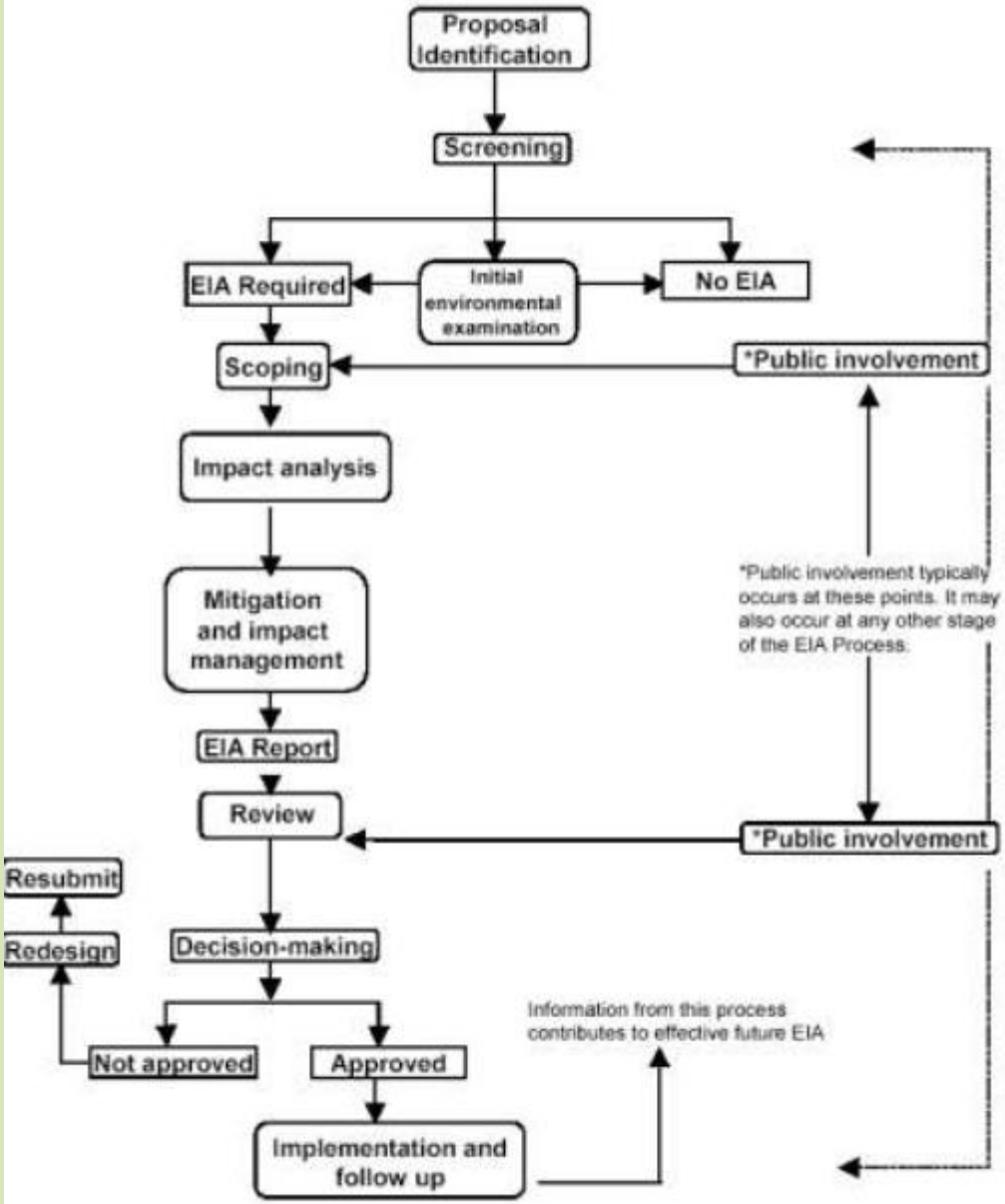
1. Predict environmental impacts of projects
2. Find ways and means to reduce adverse impacts
3. Refine / shape the proposed project to suit the local environment
4. Predict the predictions and options before the decision makers

PROCEDURES OF EIA IN INDIA

Typically the EIA process begins with screening to ensure that time and resources are directed at the development proposals that really matters. The processes involved in EIA are listed below:

1. Project description
2. Screening
3. Scoping and consideration of alternatives
4. Baseline studies
5. Impact prediction, assessment, and mitigation measures
6. Preparation of EIA report
7. Public hearing
8. Reviewing the EIA report and decision making.
9. Monitoring the clearance conditions.

The same is given in the form of a flowchart shown beleow.



Generalized EIA Process Flow-Chart

1. Project description

It is the condensed description of all aspects of the project showing project boundary, site layout so on and so forth. The submission of a project proposal signifies the commencement of the EIA process.

2. Screening

This is the process of scrutinizing the application seeking whether a project requires environmental clearance as per the statutory notification.

3. Scoping and consideration of alternatives

This stage identifies the key issues and impacts that should be further investigated. Since developmental projects vary widely, terms of reference cannot be standardized. All the available options / alternatives with respect to project site or cutting edge technology also should be considered for the developmental project. For every project, possible alternatives should be considered.

4. Baseline studies

Baseline data describes the existing environmental status of the identified study area. This includes primary data and collected secondary data if available. The term baseline refers to the collection of background information on the biophysical, social and economic settings of the proposed project area.

5. Impact prediction, assessment and mitigation measures

Predicting the magnitude of impacts of a developmental project and evaluating their significance is core to the whole EIA process. The predictions of impacts should be based on the available environmental baseline data of the project area and such predictions are described quantitatively or qualitatively.

Mitigation step in EIA recommends the action to reduce and avoid the potential adverse environmental consequences of developmental activity. Finally the alternatives should be ranked for selecting the best environment friendly and economically viable one. Analysis of alternative is done to establish the preferred or most environmentally sound, financially feasible option for achieving project objectives. Mitigation is done to avoid, minimize or offset predicted adverse impacts thus by enhancing the environmental and social benefits of a project.

6. Preparation of EIA report

An EIA report should provide clear information to the decision maker on the different environmental scenarios without the project, with project, and with project alternatives.

7. Public hearing

After the completion of EIA report, it is a pre-requisite that the public must be informed and consulted on the proposed development. The state pollution control board or the district collector or his nominee shall conduct the public hearing before the proposals are sent to Monistry of Environment and Forest (MoEF) for obtaining environmental clearance.

8. Receiving the EIA report and decision making

After going through the EIA report and public hearing report, the decision whether the proposed project is apporoved, rejected or need further change, is taken by the Expert Appraisal Committee (EAC).

9. Monitoring of environmental clearance condition

The industry or proponent is required to file once in six months a report demonstrating the environmental compliance, if the project is approved. Monitoring the environmental clearance condition is carried out during both the construction and the operation phase of the development project.

EIA METHODS

Following are the tools commonly used in Environmental Impact Assessment process:

1. Baseline studies
2. The ICID Check-list
3. Matrices
4. Network diagrams
5. Overlays
6. Mathematical modeling
7. Expert advice
8. Economic techniques

1. Baseline studies

Baseline studies using available data and local knowledge will be required for scoping. Once key issues have been identified, the need for further in-depth studies can be clearly identified and any additional data collection initiated. *The ICID Check-list* will be found useful to define both coarse information required for scoping and further baseline studies required for prediction and monitoring. Specialists, preferably with local knowledge, will be needed in each key area identified. They will need to define further data collection, to ensure that it is efficient and targeted to answer specific questions, and to quantify impacts. A full year of baseline data is desirable to capture seasonal effects of many environmental phenomena. However, to avoid delay in decision making, short-term data monitoring should be undertaken in parallel with long-term collection to provide conservative estimates of environmental impacts.

2. The ICID Check-list

A comprehensive and user-friendly checklist is an invaluable aid for several activities of an EIA, particularly scoping and defining baseline studies. "The ICID Environmental Check-List to Identify Environmental Effects of Irrigation, Drainage and Flood Control Projects" is recommended for use in any irrigation and drainage EIA. The Check-list has been prepared for non-specialists and enables much time-consuming work to be carried out in advance of expert input. It includes extensive data collection sheets. The collected data can then be used to answer a series of questions to identify major impacts and to identify shortages of data. A matrix indicates which data are linked to which questions.

Hydrology	1-1 Low flow regime	
	1-2 Flood regime	
	1-3 Operation of dams	
	1-4 Fall of water table	
	1-5 Rise of water table	
Pollution	2-1 Solute dispersion	
	2-2 Toxic substances	
	2-3 Organic pollution	
	2-4 Anaerobic effects	
	2-5 Gas emissions	
Soils	3-1 Soil salinisation	
	3-2 Soil properties	
	3-3 Saline groundwater	
	3-4 Saline drainage	
	3-5 Saline intrusion	
Sediments	4-1 Local erosion	
	4-2 Hinterland effect	
	4-3 Sediment yield	
	4-4 River morphology	
	4-5 Channel regime	
	4-6 Sedimentation	
	4-7 Estuary erosion	
Ecology	5-1 Project lands	
	5-2 Water bodies	
	5-3 Surrounding area	
	5-4 Valleys & shores	
	5-5 Wetlands & plains	
	5-6 Rare species	
	5-7 Animal migration	
	5-8 Natural industry	
Socio-economic	6-1 Population change	
	6-2 Income & amenity	
	6-3 Human migration	
	6-4 Resettlement	
	6-5 Women's role	
	6-6 Minority groups	
	6-7 Sites of value	
	6-8 Regional effects	
	6-9 User involvement	
Health	7-1 Water & sanitation	
	7-2 Habitation	
	7-3 Health services	
	7-4 Nutrition	
	7-5 Relocation effect	
	7-6 Disease ecology	
	7-7 Disease hosts	
	7-8 Disease control	
	7-9 Other hazards	
Imbalances	8-1 Pests & weeds	
	8-2 Animal diseases	
	8-3 Aquatic weeds	
	8-4 Structural damage	
	8-5 Animal imbalances	

2. The ICID Check-list

The results sheet from the Check-list is reproduced in a table. The very simple layout of the sheet enables an overview of impacts to be presented clearly which is of enormous value for the scoping process. Similarly, data shortages can be readily seen. The process of using the ICID (International Commission on Irrigation and Drainage) Check-list may be repeated at different stages of an EIA with varying levels of detail. Once scoping has been completed, the results sheet may be modified to omit minor topics and to change the horizontal classification to provide further information about the impacts being assessed. At this point the output from the Check-list can be useful as an input to *matrices*. The ICID Check-list is also available as a WINDOWS based software package. This enables the rapid production of a report directly from the field study.

3. Matrices

The major use of matrices is to indicate cause and effect by listing activities along the horizontal axis and environmental parameters along the vertical axis. In this way the impacts of both individual components of projects as well as major alternatives can be compared. The simplest matrices use a single mark to show whether an impact is predicted or not. However it is easy to increase the information level by changing the size of the mark to indicate scale, or by using a variety of symbols to indicate different attributes of the impact.

Proposed Action / Resources	Immigration of Labour	Dam Construction	Transmission Line	Reservoir Filling	Heavy Metal Discharge	Growth of Aquatic Weeds	Relocation of Inhabitants
Health	5 / 8	4 / 6		5 / 8	4 / 7	6 / 6	
Spawning of Fish		3 / 4		3 / 6	3 / 7	5 / 5	
Archaeological Artifacts	4 / 6			8 / 8			
Tourism			7 / 6	7 / 6			
Downstream Water Pollution		7 / 7		7 / 8	2 / 4		
Social and Economic Aspects							8 / 7
Forestry		4 / 2					
Fishery		2 / 5			2 / 5		
Navigation				6 / 5			
Aquatic Plants				6 / 6			
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3. Matrices

The greatest drawback of matrices is that they can only effectively illustrate primary impacts. *Network diagrams*, described below, are a useful and complementary form of illustration to matrices as their main purpose is to illustrate higher order impacts and to indicate how impacts are inter-related.

Matrices help to choose between alternatives by consensus. One method is to make pair-wise comparisons. It provides a simple way for a group of people to compare a large number of options and reduce them to a few choices. First a matrix is drawn with all options listed both horizontally and vertically. Each option is then compared with every other one and a score of 1 assigned to the preferred option or 0.5 to both options if no preference is agreed.

4. Network diagrams

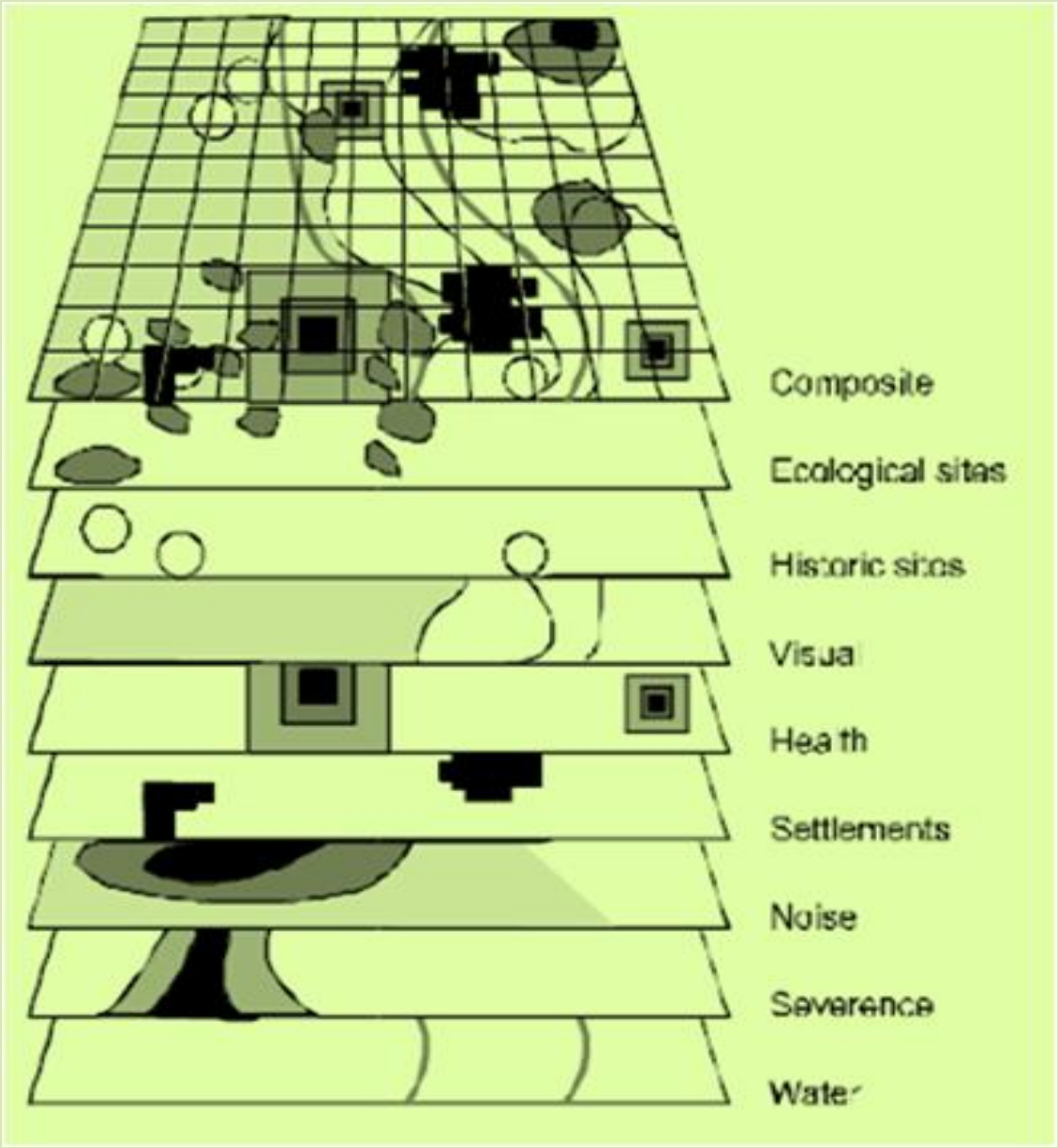
A network diagram is a technique for illustrating how impacts are related and what the consequences of impacts are. For example, it may be possible to fairly accurately predict the impact of increased diversions or higher irrigation efficiencies on the low flow regime of a river. However, there may be many and far reaching secondary or tertiary consequences of a change in low flow. These consequences can be illustrated using network diagrams. For example, reduced low flows are likely to reduce the production of fish which may or may not be of importance depending on the value (either ecological or economic) of the fish.

4. Network diagrams

If fish are an important component of diet or income, the reduction may lead to a local reduction in the health status, impoverishment and possibly migration. Also, reduced low flow coupled with increased pollution, perhaps as a result of increased agricultural industry, may further damage the fish population as well as reduce access to safe water.

5. Overlays

Overlays provide a technique for illustrating the geographical extent of different environmental impacts. Each overlay is a map of a single impact. For example, saline effected areas, deforested areas, limit of a groundwater pollution plume etc can be analysed and clearly demonstrated to non experts. The original technique used transparencies which is somewhat cumbersome. However, the development of Geographic Information Systems (GIS) can make this technique particularly suitable for comparing options, pinpointing sensitive zones and proposing different areas or methods of land management.


Composite
Ecological sites
Historic sites
Visual
Heath
Settlements
Noise
Severance
Water

6. Mathematical modeling

Mathematical modeling is one of the most useful tools for prediction work. It is the natural tool to assess both flow quantities and qualities (eg salt/water balances, pollution transport, changing flood patterns). However, it is essential to use methods with an accuracy which reflects the quality of the input data, which may be quite coarse. It should also be appreciated that model output is not necessarily an end in itself but may be an input for assessing the impact of changes in economic, social and ecological terms.

7. Expert advice

Expert advice should be sought for predictions which are inherently non-numeric and is particularly suitable for estimating social and cultural impacts. It should preferably take the form of a consensus of expert opinion. Local experience will provide invaluable insight. Expert opinions are also likely to be needed to assess the implications of any modeling predictions. For example, a model could be developed to calculate the area of wetlands no longer annually flooded due to upstream abstractions. However, the impact on wetland species or the reduction in wetland productivity resulting from the reduced flooding may not be so precisely quantifiable but require a prediction based on expert opinion.

8. Economic techniques

Economic techniques have been developed to try to value the environment and research work is continuing in environmental economics. It is important to stress that environmentally sound development brings long term economic benefits. Unfortunately, short term gains are often given priority.

8. Economic techniques

The most commonly used methods of project appraisal are cost-benefit and cost-effectiveness analysis. It has not been found easy to incorporate environmental impacts into traditional cost-benefit analysis, principally because of the difficulty in quantifying and valuing environmental effects. An EIA can provide information on the expected effects and quantify, to some extent, their importance. This information can be used by economists in the preparation of cost-benefit calculations. Cost effectiveness analysis can also be used to determine what is the most efficient, least-cost method of meeting a given environmental objective; with costs including forgone environmental benefits. However, defining the objective may not be straightforward.

CASE STUDIES