CHAPTER - I
INTRODUCTION

The term Environment, which etymologically, means surroundings and is considered as a composite term for the conditions in which organisms live. Thus, it consists of air, water, food and sun light which are the basic needs of all living beings and plant life to carry on their life functions. The environment also includes other living things, temperature, wind and electricity. In other words, environment consists of both biotic and abiotic substances. Environment creates favourable conditions for the existence and development of living organisms. Environment can be defined in a number of ways.

“Environment is the sum of all social, economical, biological, physical or chemical factors which constitute the surroundings of man, who is both creator and moulder of his environment.”

“Environment refers to the sum total conditions which surround man at a given point in space and time.”

“Environment is the representative of physical components of the earth where man is the important factor influencing the environment.

“Environment is a holistic view of the world as it functions at any time, with a multitude of special elements and socio-economic systems distinguished by quality. It attributes space and mode of behaviour of biotic and abiotic forms.”

1.1 ENVIRONMENT KEEPS CHANGING

The environment for any living organism has never been constant or static. It has always been changing, sometimes slowly and sometimes rapidly or drastically. Thus, like other organisms, man is also affected by the environment and these changes in environment may benefit or harm the man or other organisms living in it. Many species on earth could not cope up with changing environment. As a result of which, they have since vanished and many are on the brink of vanishing. For example, the giant dinosaurs of the past could not survive mainly because of some hostile conditions of their environment at that time. The main cause of it was probably the extinction of dinosaurs by the newly appeared tiny primitive mammals which sought for and ate dinosaur eggs. From the view point of primitive mammals, the environment was quite favorable and so they began to flourish, while environment was not favorable for the dinosaur and so they vanished.
1.1a MAN AND ENVIRONMENT

Natural environment is that part of the planet earth which is especially untouched and has not been invaded by man. But the question that arises-Is there any virgin environment which has not been approached by man?

But today the man equipped with a variety of skills and superior technology which has ruined the natural resources without understanding repercussions even on his own existence. So the scientists, climatologists and environmentalists have alarmed the modern man against the devastating impact of unscientific and reckless exploitation of natural environment and pleaded to save life existing on earth. Today numerous issues like quality of environment, ecological imbalance, disruption of earth’s natural ecosystems, environmental degradation, and depletion of protective ozone umbrella, chloro-fluoro carbons, ozone hole, global warming and sick environment have been raised.

No doubt, man is now awakened towards environmental problems and the public interest concerning the quality of environment has reached the emotional peaks. But can this tempo be sustained for long time? Or the civilized countries willing to slow down the pace of rapid industrialization and urbanization? Or we desirous to expand our resources on environment protection programmes which are allotted for other developments?

Today the modern technologies, their exceedingly high rate of rapacious exploitation of natural resources and uncontrolled development by developed countries are responsible for alarming situation of grave environmental crisis and ecological disturbance all over the globe. The western ideology has painted a saturnine picture of ecological imbalance before the developing countries.

1.1b MAN INTERFERES WITH THE ENVIRONMENT

Every living species of plants or animals influences its environment and in turn gets influenced by it. The magnitude of such influences is not usually high in these species because of the fact that due to natural checks their population cannot rise beyond certain limits and they also can not modify their own way of life. However, man is an exception. With increasing scientific knowledge, man is able to modify the environment to suit his immediate needs much more than any other organism. This enables man to improve the quality of his life.

Since the very beginning of human civilization, some thousand years ago, man started interfering with the environment. Man devasted by cutting trees for wood and for other household needs. Man removed stretches of forests for bringing land under
cultivation, only to find his water supply diminishing and his supply of soil eroding away. Man killed animals, the gentle ones, for food and the fierce ones, for safety. He had polluted the rivers with chemicals from factories, thereby making the water unfit for his needs. All these activities however did not affect the environment too seriously up to a fairly long time, because the population was not too high and life style was not so complex. The natural self purifying and self cleansing capacity of the environment was deteriorated.

After the scientific and industrial revolution in the recent past, there has been immense impact of man on the environment. Man has failed to realize that any new factor upsets the balance of the ecosystem as a whole. All the devastating effects of man’s effect to control nature have occurred because man was upset the balance relationship of the organisms that make up the environment.

Huge industrial installation in every year, introduction of faster mode of transport and sprouting up of large crowded cities (urbanization) are the main outcomes of the modern civilization. These and large number of many others are contributing to what is called environmental pollution. An example of which is also the widespread use of insecticides in USA during 1950 and 1963. The immediate effect was reduction in the population of pests and an increase in the yield of crops. But these insecticides also poisoned and killed birds who feed on insects. As a result, the next generation of pests multiplied even faster in the absence of their natural enemies, and damage to crops was much more. Increasing industrialization is also causing much danger to man’s life because it is also responsible for polluting the environment by man.

1.2 COMPONENTS OF ENVIRONMENT

Environment consists of the following three important components:

i. Abiotic or Non-Living Component.

ii. Biotic or Living Component.

iii. Energy Component.

The biotic component of environment consists of flora and fauna, man as the important factor. Abiotic and biotic component constitutes together the Biome.

The energy component includes solar energy, geochemical energy, thermochemical energy, hydro-electrical energy and nuclear atomic energy. Energy due to radiation and other sources also play an important role to maintain the real life of organisms.
1.3 FACTORS AFFECTING THE ENVIRONMENT

Topographic factors, Climatic factors and Edaphic factors are the three factors affecting the environment\(^1\).

(i) Topographic

Topographic factors include altitude (above sea level) plateaus, plains, lakes, rivers seas, marine region and valleys. The geographical aspects are depicted as a diagram which helps in the identification of defined area and the region is called topography. These factors are also called physiographic factors.

(ii) Climatic factors

Climatic factors that are responsible for environmental hazards are light, atmosphere, smog, temperature and humidity. They are also called area factors.

(iii) Edaphic Factors

Edaphic factors deal with the nature of soil, structures and formation of soil and its profile.

1.4 POLLUTION - DEFINITION

The word ‘pollution’, derived from the Latin word (meaning to defile or make dirty). It is the act of polluting the environment\(^2\). The term pollution is defined in various ways.

i. Pollution – The Nuisance or Nemesis is the deliberate or accidental contamination of the environment with the animal’s waste.

ii. Pollution means the addition of any foreign material like inorganic, organic, biological or radiological or any physical change occurring in nature which may harm or effect living organisms directly or indirectly, immediately or after a long time.

iii. Pollution includes all those activities conscious or unconscious of human beings, and the result thereof, in the short term or long term and his ability to derive full benefit there from.

iv. Pollution is the presence of excess substances or energy pattern which have been involuntarily produced or escaped by accidents, have foreseen effects on human health or do affect him.

1.4a AIR POLLUTION - DEFINITION

The World health organization (WHO) defined air pollution as “Limited to situations in materials in concentrations which are harmful to man and his environment”.

}\(^1\)\(^2\)
Air pollution can also be defined as “The imbalance in quality of air so as to cause adverse effects on the living organisms existing on earth”.

In 1974, H.C.Perkins defined air pollution as “The presence, in the outdoor atmosphere, of one or more contaminants such as fumes, dust, gases, mist, grit, colour, smoke, smog or vapours in considerable quantities and of duration which is injurious to human, animal or plant life or which unreasonably interferes with the comfortable enjoyment of life and property.

1.4b KINDS OF AIR POLLUTANT
There are two kinds of air pollutant. They are Primary pollutants and Secondary pollutants

(i) PRIMARY POLLUTANT
Primary pollutant originates from the source and directly pollutes the atmosphere. Examples are sulphur dioxide, oxides of nitrogen, hydrogen fluoride, chloride and pesticides.

(ii) SECONDARY POLLUTANT
These pollutants arise from the primary pollutants by chemical reaction. Examples are ozone and peroxyacetyl nitrate.

1.4c SOURCES OF POLLUTANTS
There are two sources of pollutants. They are Natural and Anthropogenic sources. Volcanic eruptions, dust storms, oceans, vegetation and accidental forest fires caused by lightning are natural sources. Anthropogenic sources emit large quantities of air pollutants than natural sources.

The major sources of pollutants are industry, motor vehicles and electric generating plants and it is given table 1.1. The major component of pollution by motor vehicles is carbon monoxide whereas the primary pollutants of industry, power generation and space heating are oxides of sulphur. Many air pollutants cause extensive damage to plants.
Table 1.1
Sources of general air pollutants and phytotoxic air pollutants

<table>
<thead>
<tr>
<th>Source</th>
<th>All major pollutants per cent</th>
<th>Phytotoxic pollutants per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>60</td>
<td>28</td>
</tr>
<tr>
<td>Industry</td>
<td>18</td>
<td>30</td>
</tr>
<tr>
<td>Generation of electricity</td>
<td>14</td>
<td>26</td>
</tr>
<tr>
<td>Space heating</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Refuse disposal</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

Increases in population and increasing use of technology lead to the release of some phytotoxic air pollutants. The environmental protection Agency (EPA)\(^6\) has estimated that the emission of carbon monoxide, hydrocarbons and particles will decrease in the next decade but oxides of sulphur and nitrogen will increase appreciably\(^7\). Ambient air quality limit values as prescribed by WHO are given in table 1.2.

Table 1.2
Ambient Air Quality Limiting values for maximum air emissions

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Maximum Value mg/Nm(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate matter</td>
<td>50</td>
</tr>
<tr>
<td>Volatile Organic Compound (including benzene)</td>
<td>20</td>
</tr>
<tr>
<td>Hydrogen sulphide</td>
<td>5-15</td>
</tr>
<tr>
<td>Oxides of sulphur (as SO(_2))</td>
<td>500-1,000</td>
</tr>
<tr>
<td>Oxides of Nitrogen, Gas-fire</td>
<td>320</td>
</tr>
<tr>
<td>Oil-fire</td>
<td>460</td>
</tr>
<tr>
<td>Odour</td>
<td>Not offensive at the receptor end.</td>
</tr>
</tbody>
</table>

1.4d RESPONSES OF PLANTS TO AIR POLLUTION

The adverse effect of air pollution is on vegetation. It injures and kills them. Air pollution affects the physiological processes\(^8\) such as decrease in growth without causing visible injury. Conifers are injured more than broad-leaved trees. The air pollutants are absorbed through stomatal pores on the leaves. The visible injuries are classified as acute or chronic. Acute injury refers to severe, traceable and sudden absorption of enough air
pollutants within a few hours to kill tissues following the collapse of cells and necrotic patterns developed.

Chronic injury causes absorption of an amount of pollutant, which does not kill tissues. It is characterized by leaf yellowing followed by senescence of leaves. It is associated with necrotic markings. It includes chlorosis in older needles. Acute injury is characterized by discoloration of needle tips or whole needles.

The response of vegetation to air pollution has shifted in emphasis from descriptions of symptoms to physiological explanations and ecological ramifications. The pollution alters the normal plant structure and function. It also alters organism physiology and cellular biochemistry. Levitt studied the stress phenomena in plants. He examined the plants in high saline conditions, water stress, low temperatures, heavy metal toxicity and resistance to sulphur dioxide in lichens. Naveen et al., (2010) reported the changes and strain produced by pollution may be either reversible (elastic) or permanent (plastic).

Plant resistance to stress is a consequence of two possible mechanisms such as, stress avoidance and stress tolerance. In the former, the plant excludes partially or completely the environmental stress and therefore avoids the specific strain induced by the stress. In the latter, the plant may experience internally the stress but not the debilitating effect of the strain. Stress tolerance is defined by Levitt as resistance through the plant’s ability to come to thermodynamic equilibrium with the stress without being killed. Stress tolerance may be subdivided into strain avoidance and strain tolerance. Normal plant activity is impaired in strain tolerance, but the plant survives (that is the strain is tolerated) as a consequence of either reparative or compensatory processes, which counter the incapacity effects of the strain. In strain avoidance, the plant does not exhibit any morphological or physiological strain even though the stress is experienced thermodynamically. It is represented in table 1.3.
Table 1.3
Harmful Effects of Air Pollutants

<table>
<thead>
<tr>
<th>POLLUTANT</th>
<th>HARMFUL EFFECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOLID</td>
<td>Toxic mist, chronic non-specific diseases, soil corrosion, land fillings</td>
</tr>
<tr>
<td>Particulates (fine grit, coarse, ash)</td>
<td></td>
</tr>
<tr>
<td>GASEOUS POLLUTANTS</td>
<td>Traps heat in the atmosphere leading to global warming, the green house effect.</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td></td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>Harmful to humans, affects respiration.</td>
</tr>
<tr>
<td>Oxides of sulphur</td>
<td>Acid rain washes away nutrients, harmful effects on plant and animal life.</td>
</tr>
<tr>
<td>Oxides of nitrogen</td>
<td>Toxic, produces an irritating effect. Affect lungs and causes bronchitis, photo-oxidation affects vegetation.</td>
</tr>
<tr>
<td>Hydrocarbons (Volatile organics)</td>
<td>React with nitric oxide to form complex varieties of secondary pollutants. Chief constituent of smog. Harmful radiation from outer space due to penetration of UV rays.</td>
</tr>
<tr>
<td>High gas temperature</td>
<td>Global Warming.</td>
</tr>
</tbody>
</table>

1.5 AIR POLLUTANT AND THEIR EFFECTS

Among the various gaseous pollutants, the major primary pollutants which are most significant are Oxides of nitrogen (NOₓ), Oxides of sulphur (SOₓ), Oxides of carbon (CO and CO₂), Hydrocarbons (CₓHᵧ) and Particulates. These pollutants are emitted by man made sources like transportation, fuel combustion, industrial operations, solid waste disposal and various other activities¹³, ¹⁴.

About 90.5 million tones of total pollutants are produced per year by transportation alone¹⁵. Carbon monoxide is the major individual primary pollutant with a tonnage matching with that of all pollutants together. However, greater the effect of a pollutant on the atmosphere, the larger the value of relative toxicity. Thus assigned by weighing factor which is based on proposed air quality standards for California. The unit
microgram per cubic meter, which is a mass of pollutant per volume of air, has also been introduced.

1.5.1 OXIDES OF NITROGEN (NO<sub>x</sub>)

1.5.1a SOURCES OF OXIDES OF NITROGEN

a. **Natural sources** are bacteria engaged in decomposition processes in the soil and oceans.

b. **Anthropogenic sources** are vehicles, coal and natural gas combustion and fertilizer and explosives manufacture and the use of fertilizers on the land. Acid precipitation, the major source of oxides of Nitrogen is the combustion under high temperature and pressure. This creates nitric oxide (NO) from N and O in the atmosphere. Oxides of nitrogen are a relatively harmless gas. In the atmosphere, oxides of nitrogen are oxidized to form NO<sub>2</sub>, a yellowish-brown gas which is an irritant. NO<sub>2</sub> is also involved in photochemical smog creation. NO<sub>X</sub>, which does not react photochemically, is usually removed from the atmosphere within a few days.

The oxides of nitrogen involved in air pollution, denoted by NO<sub>x</sub> are Nitrous oxide (N<sub>2</sub>O), Nitric oxide (NO), Nitrogen dioxide (NO<sub>2</sub>), Dinitrogen trioxide (N<sub>2</sub>O<sub>3</sub>) and Dinitrogen pentoxide (N<sub>2</sub>O<sub>5</sub>). Of these, nitric oxide is the principal compound. It is formed by the combustion of N<sub>2</sub> and O<sub>2</sub> during lightning discharges and by bacterial oxidation of ammonia in soil. About 95 per cent of the nitrogen dioxide is emitted as nitric oxide and the remaining 5 per cent as nitrogen dioxide. These oxides are largely emitted by automobiles and the electric power industry in developed countries. In metropolitan cities, vehicular exhaust is the most important source of nitrogen oxides (NOx). Various sources of oxides of nitrogen is tabulated in table 1.4.

**Table 1.4**

<table>
<thead>
<tr>
<th>Sources of Oxides of Nitrogen</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitric oxide</td>
<td>It is the main product of combustion of nitrogen and automobile exhaust produced by the combustion of gasoline. It is oxidized to nitrogen dioxide by oxygen slowly but rapidly by ozone.</td>
</tr>
<tr>
<td>Nitrous oxide</td>
<td>Present at concentration level of 0.25 ppm. Maximum level is 0.5 ppm. It is not the product of combustion.</td>
</tr>
<tr>
<td>Nitrogen dioxide</td>
<td>In atmosphere, nitrogen dioxide levels are about 0.001</td>
</tr>
</tbody>
</table>
It is the strong absorber of UV light and chief constituent of photochemical smog. It initiates photochemical reactions in troposphere. It is the main pollutants of Los Angel’s smog.

<table>
<thead>
<tr>
<th>Dinitrogen trioxide</th>
<th>It reacts with water vapour and oxygen to form nitric acid which combines with ammonia to form ammonium nitrate.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dinitrogen pentoxide</td>
<td>Form nitric acid with water and thus reduces the pH of the rain water.</td>
</tr>
</tbody>
</table>

Natural stratospheric oxides of nitrogen are also produced by the action of cosmic rays in the upper atmosphere. It was reported that the protons ejected from the sun in the solar storms produce oxides of nitrogen. It is comparable to cosmic ray contribution. Man made sources of oxides of nitrogen varies depending upon global areas. Oxides of nitrogen are 10 to 100 times greater in urban atmosphere as compared to rural areas. Major man made activities include combustion of coal, natural gas and gasoline which produce up to 50 ppm of nitrogen. Oxides of nitrogen are also produced as by products of some chemical industries like nitric acid and sulphuric acid industry. They are also formed during the manufacture of nylon intermediate.

Another potential and serious source of man made stratospheric oxides of nitrogen involves rising fiber balls associated with atmospheric nuclear explosion. Abundant fluxes of nuclear produced oxides of nitrogen are immediately transported to high latitudes by aerodynamic sources created by explosion itself.

**1.5.1b EFFECTS OF OXIDES OF NITROGEN**

Most of the oxides of nitrogen are not so dangerous, but the roles they play in the formation of photochemical oxidants constitute the most harmful effect. The nitrogen oxides affect plants, human health and the atmosphere.

**1.5.1c EFFECTS OF OXIDES OF NITROGEN ON PLANTS**

1. Higher concentrations of nitrogen dioxide damage the leaves of plants, retard the photosynthetic activity and cause chlorosis.
2. Plants exposed to 100ppm of nitrogen dioxide cause leaf spotting and breakdown of plant tissues.
3. Exposure to 100 ppm of nitric oxide checks the metabolic activities in plant tissues. Example: Bean and tomato plants on fumigation showed decreased activity of carbon dioxide absorption and photosynthetic rate.
4. Damage to vegetation probably results from the production of secondary pollutants such as ozone and smog.

5. Nitrogen dioxide is highly injurious to plants. Vegetative growth suppressed when they are exposed to 0.5ppm for 10 to 15 days. Sensitive plants show visible leaf injury, when exposed to 5 to 8 ppm of nitrogen dioxide for 1 to 3 hours.

**1.5.2 OXIDES OF SULPHUR (SO₃)**

**1.5.2a SOURCES OF SULPHUR DIOXIDE (SO₂)**

**Natural sources and Anthropogenic (or) manmade sources**

Natural sources (example, volcanoes) provide about 67 per cent of the oxides of sulphur pollution. This is mainly localized in some urban areas. Among man made sources, fossil fuel combustion accounts for 74 per cent, industries 22 per cent and transportation 2 per cent of the total oxides of sulphur emission. This clearly indicates that coal fired power stations are mainly responsible for the oxides of sulphur pollution, followed by industrial plants. The burning of fossil fuel in thermal power plants, manufacture of sulphuric acid and fertilizers, smelting industries and other processes like electric power plants account for 75 per cent of total sulphur dioxide emission. This automobile and refineries contribute to the rest 25 per cent.

**1.5.2b EFFECTS OF SULPHUR DIOXIDE**

Sulphur dioxide is a highly irritating gas, which adversely affects men, animals, plants and materials. It is perhaps the most damaging pollutant among the various gaseous air pollutants.

**1.5.2c EFFECTS OF SULPHUR DIOXIDE ON PLANT**

Plants are relatively more sensitive to sulphur dioxide than the man and animals. The threshold levels of sulphur dioxide injury in plants are quite low as compared to man and animals. Some of the effects of sulphurdioxide on plants are given below

i. Sulphur dioxide damages vegetable crops and affects plant growth and nutrient quality of plant products.

ii. Acute exposure to high levels of sulphur dioxide kills leaf tissues causing leaf necrosis. The edges and area between leaf veins are severely damaged.

iii. Its chronic exposure to plants causes bleaching of leaf pigments due to conversion of chlorophyll-a to pheophytin-a and reducing plant productivity.

iv. Concentration of sulphurdioxide as 1.00ppm is most injurious to trees causing chlorosis and dwarfing.
v. Susceptible species like cucumber, oats and spinach may be damaged by exposure to air containing 0.05 to 0.5ppm of sulphur dioxide for 8 hours. Cotton, wheat, barley and apple are most sensitive to sulphur dioxide.

vi. Plants get most injury from sulphur dioxide where their stomata are open in day time. Sulphur dioxide is absorbed through stomata into the mesophyll of the leaves. When its absorption exceeds a particular level, the cells become inactive and are killed, causing tissue collapse and drying of leaves. The cells are injured and the absorbed portion of the leaf becomes brownish red in colour and the green colour due to chlorophyll is bleached. The effect is commonly known as chlorosis. Thus, sulphur dioxide causes sub-lethal damage or destruction of the plant.

vii. High levels of sulphur dioxide reduce the pH of leaf tissues of some trees, increasing the total sulphur content of leaves and tree bark. It is also increased in the soil in the area near thermal power plants.

viii. Sulphur dioxide affects stomatal pores, stomatal frequency, chloroplast and transpiration through stomata. Sulphur dioxide is absorbed by pores which are oxidized to sulphuric acid or sulphate ions.

ix. Sulphuric acid mists and aerosols are extensively toxic to plants and soil fertility.

x. An observation indicates that plant exposure to 0.8 ppm of sulphur dioxide with smoke for 2.5 hours daily for two months causes reduction in root and shoot lengths, number of leaves per plant, where productivity biomass and number of grains per spike and its yield.

xi. Ozone enhances plant injury creating light flecks or stipples (Clusters of dead cells) on the upper leaf surface inhibiting photosynthetic activity of leaves.

xii. Ethylene even at 1ppm concentration shows adverse effects on vegetation.

xiii. Acetylene and propylene at 50 to 500 ppm shows extreme toxicity towards plants damaging growth of vegetation.

xiv. Ethylene hydrocarbons inhibit plant growth and damage leaf tissues and death of flowering plants.

1.5.3 PARTICULATE POLLUTANTS

Air-borne small, solid particles and liquids droplets are commonly known as particulates. They are present in air in excess and pose serious threat to air pollution problems. Size is the most important physical property of the particulates. They vary in size ranging from a diameter of 0.0002μ to 500 μ (μ or micron which is equal to 10^-6 meters) particles having a diameter of 20 are relatively large while the particles with least
diameter exist in aerosol. The life period of particulates vary from a few seconds to several months, which depend on their setting rate, size, density of particles and turbulence of air.

1.5.3a SOURCES OF PARTICULATES POLLUTANTS

Natural process injects 800 to 2000 million tons of particulate matter each year into the atmosphere. These processes include volcanic eruptions, blowing of dust and soil by wind, spraying of salt and various other solid particles by seas and oceans. Man made activities emit 450 million tons of particulates every year. For example, particulates in the form of dust and asbestos formed during construction, fly ash from power plants, smelters, mining process and smoke from incomplete combustion processes. According to an estimate,

1. Stationary combustion sources (Coal, wood, fuel oil and natural gas)
2. Industrial process and
3. Miscellaneous sources (Coal refuse burning, agricultural burning, forest fires and structural fires) contribute equally (nearly one-third) of total particulate emission by man made activities.

1. Natural sources
Volcanoes, wind erosion, meteors sea spray and forest fires.

2. Anthropogenic sources
   i. Combustion - coal and oil burned by power station and or heating, automobiles and refuse incineration.
   ii. Industrial processing - cement and brick works, iron foundries and metal processing mills.
   iii. Surface disturbance - house and road building can produce solid or liquid droplets. Usually composed of carbon and silica but particulates of iron, lead, manganese, cadmium, chromium, copper, nickel, beryllium and asbestos are also found.
   iv. Size ranges from less than 0.1 micrometer to 100 micrometer. Particles of diameter greater than 10 micrometer (dust, grit, fly ash and visible smoke) tend to settle down within the atmosphere rapidly after emission (terminal velocity) and is hence a most nuisance in places near the source. Particles with diameter less than 10 micrometer remain in the atmosphere longer and are hence more dependent on the state of the atmosphere for their dispersal. Particles with diameter less than 1 micrometer are very long-lived in the atmosphere. Typically a particle will remain
in the troposphere for a few days. It may however remain there for several years if injected into the stratosphere.

1.5.3b EFFECTS OF PARTICULATE POLLUTANTS

Particulate pollutants are present in troposphere and lower stratosphere where they stay for a long period. The layer about 1 to 100 meters high from the ground is most polluted in urban areas and industrial sites. These pollutants are absorbed on the water surface, soil, vegetation and buildings posing several health hazards on the living biota. Some of its effects are as follows

1.5.3c EFFECTS OF PARTICULATE POLLUTANTS ON PLANTS

i. Plants are adversely affected by gaseous pollutants and deposition of particulates on soil. This deposition of toxic metals on soil makes the soil unsuitable for plant growth.

ii. Several particulate pollutants fall on the soil by acid rain which tends to lower the pH of the soil making it more acidic and infertile.

iii. Particulates such as dust, fog soot deposited on plants leaves block the stomata of plants, thus inhibiting the rate of transpiration of minerals from the soil.

iv. Deposited particulates restrict the absorption of carbon dioxide, thereby reducing the rate of photosynthesis. It thus retards the growth of plants and crop production.

v. Metallic particulates pollutant along with atmospheric sulphur dioxide in soil killed vegetation in an area of 260 Km$^2$ and retard plant growth over 320 Km$^2$ of land in Sacraments valley of California.

vi. Dust mixed with mist or light rain formed a thick crust on the upper leaf surface which shielded the bright sunlight necessary for carbon assimilation.

vii. Some plants are much sensitive to the traces of toxic metals, where particulates inhibit the action of plant enzyme system.

viii. Arsenic is a cumulative, potent, protoplasmic poison which inhibits SH-group in enzymes. Arsenic is present in almost all types of soils in minute quantities and affects plant growth.

1.6 WATER POLLUTION- DEFINITION

Water pollution may be defined in a number of ways

a) Alteration in physical, chemical and biological characteristics of water which may be cause harmful effects on human and aquatic biota.
b) Addition of excess of undesirable substances to water that makes 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.

c) Any adverse change in conditions or composition of the water so that it becomes less suitable for the purpose for which it would be suitable in its natural state.

d) As the deterioration in physical, chemical and biological properties of water brought about mainly by human activities and natural resources.

Thus water pollution disturbs the normal uses of water for irrigation, agriculture, industries, public water supply and aquatic life. It is now considered not only in terms of public health, but also in terms of conservation, aesthetics and preservation of natural beauty and resources.

Actually it represents the state of deviation from the pure condition, where by its normal function and properties are affected. Any shift in the naturally dynamic equilibrium existing among environments segments that is hydrosphere, atmosphere, lithosphere or sediments gives rise to the state of water pollution.

1.6.1 SOURCES OF WATER POLLUTION

1. Natural process in which the decomposed vegetable, animal and weathered products are brought into main water resources. All these processes are inter dependent on each other and lead to deterioration of natural environment.

2. For instance, if organic waste is added to water, it will not only influence the chemical characteristics, but will also affect colour, odour and biological properties of water.

3. Anthropogenic process such as industrial, agricultural, urban, domestic, radioactive, mining sources, use of pesticides and fertilizers by man. These pollutants are constantly poured in water deteriorating it to such an extent it becomes unfit for living communities. Water, the most abundant and wonderful natural resource is extremely essential for survival of all living organisms. But today clean water has become a precious commodity and its quality is threatened by numerous sources of pollution which are as follows-

Sewage and Domestic wastes/Industrial effluents, Agricultural discharges/Fertilizers, Detergents, Toxic metals, Siltation, Thermal pollutants and Radioactive materials. Industrial effluents discharged into water bodies contain toxic chemicals, hazardous compounds, phenols, aldehydes, ketones, amines, cyanides, metallic wastes,
plasticizers, toxic acids, corrosive alkalies, oil, greases, dyes, biocides, suspended solids, non-biodegradable matter, radioactive wastes and thermal pollutants from numerous\textsuperscript{18}.

The principal type of industries which contribute to water pollution of rivers in India are chemicals and pharmaceuticals, coal washeries, soaps and detergents, pulp and paper, sugar, distilleries, dyeing, tanneries, steel mills and fertilizers\textsuperscript{19}. These effluents hence discharged through sewage system poison the biological purification mechanism of sewage treatment and pose several pollution problems.

The toxicity of various pollutants to aquatic environment is variable but all of them contaminate on the bottom of water systems where they poison the aquatic organisms. Most of the industrial effluents are insusceptible to degradation. Toxic metals are extremely lethal for living beings. Sulphuric acid waste from coal mines is a chronic pollutant which enhances hardness of water and corrodes concrete. It has also drastically affected the living biota. A recent estimate showed that volume of industrial waste will be comparable to that of domestic sewage in India by 2000 AD.

1.6.2 TYPES OF WATER POLLUTION

Water pollution can be classified mainly into four categories. These are

1) Physical pollution of water
2) Chemical pollution of water
3) Biological pollution of water
4) Physiological pollution of water

1. PHYSICAL POLLUTION OF WATER

The physical pollution of water brings about changes in water with regard to its colour, odour, density, taste, turbidity and thermal properties.

COLOUR

Colour change is not harmful unless it is associated with a toxic chemical but it may affect the quality of sunlight that penetrates to a given depth inhibiting plant and animal metabolites. Most of the trade wastes discharged into water systems have pronounced colours due to organic dye and inorganic complexes.

It has been reported that even a micro quantity (0.02 ppm) of magenta in water imparts a distinct red colouration. Tannery wastes when discharged into iron containing water streams form deep green or blue colouration because of the interaction of tannins with iron. Water also becomes intensely coloured due to interaction between naturally occurring components in water and trade effluents which make it unsuitable for various purposes.
TURBIDITY

Turbidity in water mainly arises from colloidal matter, fine suspended particles and soil erosion. Generally greater the turbidity, stronger is the sewage and the industrial effluent concentrations and worst are the effects. Hence, the degree of turbidity of a water course may be taken as a measure of the intensity of pollution. However, non-turbidity does not mean that water is unpolluted, because clear water may also be heavily contaminated with acids, and alkalies, which do not cause turbidity. Turbid water becomes unsuitable for industrial purposes and also for domestic use because Fe, Mn, Ni, Co, Pb, Sb, and Bi present in it may cause stains on clothes, sinks and baths.

Turbidity measurements are useful in the evaluation of the effects of pollution by waste waters and to follow the course of self purification of rivers and streams. Colloidal particles that are clay in natural waters and carbohydrates, proteins, fats in waste waters can be stabilized by having negative charges on their surfaces which can be neutralized by adding certain ions. Various coagulants like ferric chloride, ferric sulphate and ferric alum can check the turbidity of water.

TASTE

Unpleasant earthy or musty taste and odour are produced by industrial effluents containing Fe, Mn, free chlorine, phenols and aquatic actinomycetes. For example, even a 0.1 ppm of Fe can produce an inky taste, while phenol produces a bitter taste at 7 ppm. Manganese, oils, hydrocarbons, chlorophenols, petroleum products, synthetic detergents, pesticides produce characteristic tastes in water. The decomposed organic matter, algae, fungi, bacteria, and pathogens impart peculiar taste. However, these pollutants can be removed by conventional water purification techniques like chlorination, chemical precipitation and using activated carbon.

ODOUR

Odour pollution in water is caused both by chemical agents (like hydrogen sulphide, free chlorine, ammonia, phenols, alcohols, esters, hydrocarbons) and biological agents (such as algae, fungi, microorganisms). Lower the pH, higher will be the amount of H₂S produced and greater will be the odour nuisance. Certain organic and inorganic compounds of nitrogen, sulphur, phosphorous and putrified organic matters present in sewage cause foul odour in polluted water. Microorganisms like algae, oscillatoria and rivularia cause muddy colour, where as algae, anabaena produce a strong grassy odour. Protozoa Dinobryon imparts fishy odour to water. The liberation of essential oils is the main cause of odour pollution.
The odour from polluted water may be due to

a) Fishy odour due to organic amines (b) warmly smells probably due to phosphorus compounds (c) Rotten egg or putrid smell due to H₂S  (d) Earthy odour due to humans.Odour in water can be eliminated by using  (a) Chlorine, chlorine dioxide and ozone (b) Activated carbon  (c) Aeration  (d) Chloration.

**FOAM**

Foam is produced by soaps, synthetic detergents, syndets and untreated organic effluents from paper and pulp industries. Clean water can readily form foam. It decreases as the pollution increases.

**2. CHEMICAL POLLUTION OF WATER**

The chemical pollution of water causes change in acidity, alkalinity or pH, dissolved oxygen (DO) and other gases in water. It may be caused either by organic pollutants or inorganic pollutants or by both. The organic pollutants can be biodegradable or non-biodegradable.

**BIODEGRADABLE ORGANIC POLLUTANTS**

These pollutants include that Proteins from domestic sewage waste from creameries, tanneries and slaughter house. Fats from sewage, soap production, food processing and wool processing. Carbohydrates, sugars, starch from sewage, textile mills and paper mills. Polymers, resins, coal, oil and various other organic substances found in domestic and industrial wastes and those synthetic compounds which are non-toxic to some micro-organism.

**NON-BIODEGRADABLE ORGANIC POLLUTANTS**

These pollutants persist in the aquatic system for a long time. Examples, pesticides, fungicide, bactericides, herbicides, insecticides, nematocides, rodenticides and miticides. The use of these organic compounds in protecting agricultural product also poses serious water pollution problems because these toxic chemicals ultimately find their way into the nearby water course. Several gases, toxic metals and compounds have been included in inorganic pollutant, because they also degrade water quality seriously.

**3. BIOLOGICAL POLLUTION OF WATER**

Bacterial pollution in water is caused by the excretory products of warm blooded mammals including man, wild and domestic animals. Birds of various genera also degrade water. The main pollutants belong to coli form group and certain subgroups, faecal streptococci and miscellaneous organisms.
Biological pollution is also brought about by bacteria, viruses, algae, diatoms like protozoa, rotifers, crustaceans and plant toxins. Contaminated water supplies frequently create infections of the intestinal tract (like dysentery, cholera, typhoid and gastroenteritis), polio and infectious hepatitis. Generally, no control measure is adopted to check these pathogenic contaminants because it is a 24 hour problem to detect them. Instead analysis looks for a benign indicator like coli form bacteria, the presence of which alerts to faecal contamination.

4. PHYSIOLOGICAL POLLUTION OF WATER

Physiological pollution of water is caused by several chemical agents such as chlorine; sulphur dioxide, hydrogen sulphide, ketones, phenols, amines, mercaptans and hydroxyl benzene. Chlorination of water usually converts phenol to ortho or para chloro phenol which tastes like medicine and produces offensive odour. It is given below in table 1.5.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Pathological effects on Man</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead (Pb)</td>
<td>Anaemia, vomiting, loss of appetite, convulsions, damage of liver, brain and kidney.</td>
</tr>
<tr>
<td>Arsenic (As)</td>
<td>Disturbed peripheral circulation, mental disturbance, liver cirrhosis, hyper keratosis, lung cancer, ulcers in gastro-intestinal tract, kidney damage.</td>
</tr>
<tr>
<td>Mercury (Hg)</td>
<td>Abdominal pain, headache, diarrhea, chest pain, hemolysis.</td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>Growth retardation, diarrhea, bone deformation, kidney damage, anaemia, injury of central nervous system, hypertension, injury to liver.</td>
</tr>
<tr>
<td>Barium (Ba)</td>
<td>Excessive vomiting, diarrhea, paralysis, colic pain.</td>
</tr>
<tr>
<td>Element</td>
<td>Effects</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Cobalt (Co)</td>
<td>Diarrhea, low blood pressure, lung irritation, bone deformation, paralysis.</td>
</tr>
<tr>
<td>Chromium (Cr)</td>
<td>Gastro intestinal ulceration, disease in central nervous system, cancer nephritis</td>
</tr>
<tr>
<td>Selenium (Se)</td>
<td>Damage of liver, kidney and spleen, fever, nervousness, vomiting, low blood pressure, blindness and even death.</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>Vomting, cramps, renal damage.</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>Sporadic fever, hypertension, uremia, coma.</td>
</tr>
</tbody>
</table>

1.6.3 HARMFUL EFFECTS OF INDUSTRIAL EFFLUENTS

Industrial effluents cause deleterious effects on living organism and may bring about death or sub lethal pathology of kidneys, liver, lungs, brain and reproductive system. Effluents like methyl mercaptan and pentachloro phenol lower the photosynthetic rate of aquatic communities by hindering sunlight penetration into the water column. Disinfectants, which are added in water to control algal growth and bacteria may persist in water bodies and may cause mortality of fish, planktons and diatoms. It has been reported that free chlorine discharged by factories near Marzipur in Uttar Pradesh had caused heavy fish mortality in river so near Dehrionson in Bihar. Mercury like Toxic metals lead, arsenic, cadmium and cyanides has cropped seriously in water bodies. Mercury poisoning among aquatic organisms has resulted in crippling and often fatal diseases like Mina Mata in Japan (1950). Effluents sometimes contain up to 10 times the level of Hg in natural water (0.001 ppm - 0.00001 ppm). Natural addition of Hg to oceanic water is about 5000 tons per annum and further 5000 tons are added via human activities. Industrial effluents consisting of As, Pb and CN- cause cellular degeneration in brain which results in frigidity, coma, stupor and numbness. Effluents containing acids and alkalis make the water corrosive. Mineral constituents can be responsible for excessive hardness of water which then becomes unsuitable for domestic and industrial purposes.

Some of the trade wastes contain pathogenic bacteria. For instance the pathogen Anthrax bacilli are present in tannery wastes. Toxic effluents may inhibit the natural purification schemes of the water bodies. Floated effluents discharged into water system may severely alter the aquatic ecosystem by increasing the temperature of the
Industrial discharges impart colour, foul odour and turbidity to the receiving waters. They undergo putrefaction to form objectionable tastes. Mani Mahi in Baroda receives industrial and several petrochemical wastes and is badly polluted. Similarly river Cooum flowing through Madras has become so much polluted by sewage that even the zoo planktons have been unable to thrive in it. It is estimated that one litre of cooum water is having as much as 900 mg iron, 275 mg lead, 32 mg zinc and 1310 mg of nickel. In Ganga alone, about 315 industrial complexes are dumping their effluents. These are responsible for the ill health of 300 million people of Northern India. Some Indian Rivers and fresh water streams are heavily polluted by industrial effluents. It is shown in table 1.6.

**Table 1.6**

<table>
<thead>
<tr>
<th>River</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yamuna in Delhi</td>
<td>Indra prasath power station, DDT pesticide factories, sewage, fly ash and automobile workshop.</td>
</tr>
<tr>
<td>Kali at Meerut (UP)</td>
<td>Sugar mills, soap, silk, textile, rayon, tin and glycerine industries.</td>
</tr>
<tr>
<td>Dadora in Bareilly (UP)</td>
<td>Sewage, chemical mills, synthetic rubber factories.</td>
</tr>
<tr>
<td>Gomti, near Lucknow</td>
<td>Sewage, soap, paper and pulp mills</td>
</tr>
<tr>
<td>Hooghly near Calcutta</td>
<td>Paint, varnishes, chemical mills, power stations, textile, vegetable, ghee, oil, soap, matches, jute, rayon, shellac, sewage and polythene industries.</td>
</tr>
<tr>
<td>Darnodar near Bokaro</td>
<td>Fly ash from steel mills, fertilizers, pesticides, thermal power stations, suspended particles.</td>
</tr>
<tr>
<td>Bhadra in Karnataka</td>
<td>Paper and pulp industries, steel factories.</td>
</tr>
<tr>
<td>Ganga at Kanpur</td>
<td>Textile mills, domestic wastes, chemical mills, surgical industries, jute, tanneries and sewage.</td>
</tr>
<tr>
<td>Sone (Bihar)</td>
<td>Cement, paper and pulp mills.</td>
</tr>
<tr>
<td>Godavari</td>
<td>Paper and chemical mills.</td>
</tr>
<tr>
<td>Siwan</td>
<td>Sugar mills, cement and paper industries.</td>
</tr>
</tbody>
</table>
Cauvery | Tanneries, distilleries, sewage, paper and rayon mills.  
---|---  
Kulu | Tanneries, chemical and rayon mills.  
Cooum (Madras) | Automobile work shop and domestic sewage.  
Suwao in Bairampur | Sugar industries.  

### 1.6.4 ENVIRONMENTAL ISSUES IN TANNERY PROCESSING

The global production of about 24 billion M$^2$ of leather by 2005 presents a considerable challenge to the industry considering the harmful nature of some of the chemicals fixed in leather processing.

The tannery effluents $^{20}$ are characterized by high contents of dissolved suspended organic and inorganic solids giving rise to high oxygen demand and potentially toxic metal salts and chromium metal ion. The disagreeable odour emanating from the decomposition of porteous waste material and the presence of sulphide, ammonia and other volatile organic compounds are also associated with tanning activities.

Solid wastes generated in leather industries contribute mainly skin trimmings, keratin wastes, fleshing wastes, chrome shaving wastes and buffing wastes. It constitutes protein as the main component. If these protein and other chemicals, which are present in the chemical treated protein, are not utilized properly it will pose hazardous pollution problem to the environment.

Tanneries have greater opportunities to go for pollution prevention at the most in this fast growing era. Besides the sophisticated process equipment, machinery, computerized processing of chemicals and water addition system which are mostly not feasible for small scale Indian tanneries. There are several other possibilities to prevent, segregate, check and manage the pollution abatement right from the construction stage of a tannery without any substantial addition in financial input.

There is certain civil engineering and advanced construction technology, which if properly preplanned and are taken care of in the design aspects of a tannery before its construction, can certainly mitigate the waste water pollution up to a substantial extent.

It must be noted here that a preplanned construction of a tannery from the point of view of pollution abatement techniques can pay back to a tannery life long indirectly by reducing the over all pollution treatment expenses$^{21-24}$.  

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20
1.6.5 TANNERIES AS AIR POLLUTION SINK

Air pollution generated from the leather tanning activity can be related mainly to three different sources these are listed below along with their various environmental impacts. Decaying biological material generated from the tannery’s waste waters can cause some gaseous emissions.

The tanning industry treats generally important amounts of salted or non-salted hides and skins, generating large amounts of solid waste. The fact that, undesired and trimmed chunks of organic material are often left in a state of advanced decomposition, causes the generation of undesired and noxious odours. Additional odours could also come from poor solid waste management practices.

Gases are generated at some different tanning operations. Sources of odors from the tanning process are accidental sulphide emissions from dehairsting and waste treatment, ammonia emissions from unhairing and de-liming liquors and from the decomposition of proteins. In the finishing operations, emissions from solvents impose a workplace health problem. If efficient technology and controlled operations are used, these emissions would be avoided. Furthermore, Leather dust, produced during the buffing process, is conferred as a potential carcinogen for exposed workers. The gases emanating from the boilers and generators activities also cause problems.

Tanneries are proverbially known for generating malodour. Rehydration of salted hides and skins generally emit odour of volatile fatty and amino acids evolved in the course of biological decomposition in presence of water. In addition, toxicity of hydrogen sulphide along with acids, fats and carbohydrates, in liming, deliming and tanning processes is predominant within tanneries. The venting out of malodorous substances to ambient air and subsequent transports to further distance are responsible for atmospheric pollution. Hydrogen sulphide at 20 ppm (30 mg/m$^3$) in ambient air is lethal to human kind.

Ammonia escaping from deliming operation to atmosphere is odorous and pungent. Maximum admissible level of ammonia in air is 50 mg/ m$^3$. Phenolics (monohydric, dihydric and trihydric) are emitted into air during processing of hides in the post tanning and finishing operations. The permissible level of phenolics as phenol ($C_6H_5OH$) in water is 10.2 mg/litre. The concentration shall not exceed 0.3 mg/litre in drinking water. The toxicity of sulphidé, ammonia, phenol and chromium that are found in tannery waste water to fresh water has been reported.
A strong smell of hydrogen sulphide (H$_2$S) gas was evident at the primary sedimentation stage of the waste water treatment plant. Hydrogen sulphide was also evident, although only to a limited extent, within the tannery processing areas where alkaline beam house liquors combined with subsequent acidic streams within the internal drainage system. The plant chemist knew that the hydrogen sulphide was a highly toxic gas having a threshold limit value (TLV) of 15 mg/m$^3$ (100 ppm by volume) in air. In addition, air pollution is on the rise with the tanneries burning residuals (that is hair) from the tanning process into the atmosphere. The primary pollutants that leather tanning creates are heavy metals like chromium and cadmium, various organic chemicals and acids. The government tested the effluent runoff from leather tanneries and verified that the discharges were toxic.

The very toxic gas hydrogen sulphide (H$_2$S) has the odour of rotten eggs and is released when sulphide containing liquors or hides are acidified. This occurs in deliming and when alkaline effluent liquors mix with acidic streams. Concentration of 200 ppm hydrogen sulphide for one minute can cause loss of consciousness, 500 ppm causes a deep coma with convulsions and exposure for one minute at 900 ppm causes death. Most volatile organic compounds used in tanneries have a strong smell and many of them, including formaldehyde and glutaraldehyde are toxic when present in the air at low concentrations (there is a safety limit of 0.6 mg/m$^3$ for formaldehyde). All areas where volatile organic compounds may be present should be well ventilated and the air should be exhausted and treated appropriately. Prevention of waste production, as a method mentioned for solid waste and waste water, is an even more important method for polluted air. Compared to awareness of air pollution has only recently developed. As a result, data of produced polluted air are hardly available and methods for prevention or treatment have as yet not been developed on a wide scale. Research methods for treatment of polluted air are in progress.

1.7 SOIL POLLUTION-DEFINITION

Soil pollution is defined as the build-up in soils of persistent toxic compounds, chemicals, salts, radioactive materials or disease causing agents, which have adverse effects on plant growth and animal health.

1.7.1 SOURCES OF SOIL POLLUTION

Soil pollution usually results from different human activities, like waste dumping, use of agrochemicals, mining operations and urbanization.
i. WASTE DUMPS

Land gets dumping of industrial wastes and sludge are the major sources of soil pollution by toxic organic and inorganic chemical compounds and heavy metals. The fallout from industrial emissions for example the fly ash emitted by thermal power plants, can pollute surroundings lands. We must keep in mind that the particulates of the industrial emissions from the tall chimney always come back to the earth surface sooner or later.

ii. MUNICIPAL WASTES

Municipal wastes mainly include domestic and kitchen wastes, market wastes, hospital wastes, livestock and poultry wastes, slaughter house wastes and waste metals, and glass and ceramic wastes. Non-biodegradable materials like used polyethylene carry bags, waste plastic sheets, pet bottles persist in soil for long periods. Hospital wastes contain organic materials, chemicals, metal needles, plastic, glass bottles and vials. Dumping of domestic sewage and hospital organic wastes contaminate the environment with a variety of pathogens that can seriously affect human health.

iii. AGROCHEMICALS

Pesticides and weedicides are being increasingly applied to control pests and weeds in agricultural systems. Excess inorganic fertilizers and biocide residues are contaminating the soil as well as the surface and groundwater resources. Inorganic nutrients, like phosphate and nitrate are washed out to aquatic ecosystems and accelerate eutrophication there. Nitrate can also pollut drinking water. Inorganic fertilizers and pesticide residues change the chemical properties of soil and adversely affect the soil organisms.

iv. MINING OPERATIONS

Open cast mining (a process where the surface of earth is dug open to bring out the underground mineral deposits) completely devastates the top soil and contaminates the area with toxic metals and chemicals.

v. USE OF CHEMICALS

Excessive use of chemicals such as pesticides, insecticides and fertilizers is one of the prime factors causing soil pollution. These chemicals adversely affect the soil by increasing its salinity and making it imperfect for crop bearing. The excessive use of chemicals also adversely affects the micro organisms present in the soil, causing the soil to lose its fertility and resulting in the loss of minerals present in the soil, thus causing soil pollution.
vi. SOIL EROSION

Another common cause contributing to soil pollution is soil erosion. Soil erosion occurs when top soil moves from one place to another as a result of various natural and man-made factors, such as wind, water, deforestation and farming. The loss of top soil due to erosion results in a loss of soil fertility and a decrease in the soils capacity to retain water, thus ultimately causing the soil left behind after erosion to be rendered unfit to produce crops.

vii. SALTY WATER

While water is one of the most essential ingredients that are required for the normal growth of crops, the use of water with a high salinity, that is, water that contains higher amounts of salts such as sodium chloride (NaCl) adversely affects the soil as well as the crop growth. The salt present in the water accumulates in the top layer of the soil, resulting in decreased growth of crops and decreased yields and ultimately making the soil and the land unfit for crop yielding and agricultural practices.

viii. PESTICIDES

Pesticides affect soil quality. Pesticides decrease bio diversity in the soil because they do not just kill the intended pest. They often kill many of the other small organisms present which live in the soil are killed, the soil quality deteriorates and this has a knock on effect upon the retention of water. This is a problem for farmers particularly in times of drought. At such times, organic farms have been found to have yields 20 to 40 percent higher than conventional farms. Soil fertility is affected in other ways too. When pesticides kill off most of the active soil organisms, the complex interactions which result in good fertility breakdown. Plants depend on millions of bacteria and fungi to bring nutrients to the rootlets. When these cycles are disrupting, plants become more depend upon exact doses of chemical fertilizers at regular intervals. Even so, the fantastically rich interactions in healthy soil cannot be fully replicated by the farmer with chemicals. Pesticides pollute the soil directly by affecting the organisms that reside in it. Soil however, can act as a vector for the pollution of surface water and ground water. Organic pollutants enter the soil via atmospheric deposition, direct spreading on to land, contaminations by waste water and waste disposal.

ix. HEAVY METALS

Soil contamination by heavy metals such as cadmium, lead, chromium, copper, zinc, mercury and arsenic is a matter of great concern. Heavy metals are present naturally
in the soil, but the levels are increased by industry (non-ferrous industries, power plants, tanneries, iron, steel and chemical industries), agriculture (irrigation with polluted water, Use of mineral fertilizers), waste incineration, combustion of fossil fuels and road traffic. Pollution of agricultural soils by heavy metals may lead to reduced yields and elevated levels of these elements in agricultural products, and thus to their introduction into the food chain. Heavy metal deposits on grass land soils remain predominantly in the top few centimeters and are directly ingested with soil by grazing animals. Heavy metals are toxic and inhibit the soil’s micro organic activity. Their concentration in the soil can remain for decades or even centuries.

Reduction of heavy metal emissions is the most direct way to decrease the atmospheric deposition of these elements and their build-up in the soil. Despite the great increase in traffic, for example, a reduction in lead emissions has been achieved through incentives to use unleaded petrol. Nevertheless, emissions of heavy metals from industrial plants in central and Eastern Europe are still prevalent. Implementing complex measures that reduce soil acidification could more efficiently reduce heavy metals. On agricultural land, heavy metal quantities can be decreased by using low-metal content resources for fertilizers, replacing inorganic pesticides with organic products and similar methods.

x. TRANSPORT

This hazardous waste, produced by industries, different kinds of vehicles, building cause damage of soil. Harmful gases or smoke, for example from cars, factories can gradually destroy the soil. Use of the land in such a way as to cause excessive soil erosion. In these reasons for the recent 100 years 2 billion hectare fertile soil has been damaged.

1.7.2 SOIL POLLUTION AND PLANTS

Most of the atmospheric pollutants finally come down and settle on the ground surface, causing soil pollution. Pollutants also come back to soil when polluted water is used for irrigation. Many pollutants directly deposited on the soil as sewage, industrial effluent and chemical fertilizer. The soil pollution by various pollutants has far reaching effects on plants and vegetation.

i. EFFECTS OF SOIL ACIDIFICATION

The oxides of sulphur and nitrogen, chlorides, fluorides and ammonium emitted into the atmosphere in combustion from various industries come down as dry or wet deposition (Acid Rain) onto the soil and lower the pH. Increased acidity of soil results in
following effects. The activity of soil microbes, particularly of decomposers is reduced. The decomposition of organic matter and consequently nutrient cycling in the soil is reduced. It ultimately adversely affects the growth of plants. The bases in the soil are leached down due to soil acidity. As exchangeable bases become deficient in the soil, plant growth is reduced due to nutrient deficiency. The roots are damaged resulting in reduction in nutrient uptake by plants.

Increased acidity mobilizes heavy metals like Al, Cd, Zn, Hg, Mn and Fe. These spread rapidly in the soil along with soil water and reach concentrations toxic to plants. Consequently, plants species show specific metal toxicity symptoms. Aluminum toxicity generally damages root hairs and reduces nutrient uptake. Iron toxicity has general adverse effect on plant growth. In some soils, acidification increases weathering of silicate minerals destroying the mineral structure of the soil. This ends to poor growth of vegetation, in general. In some marginal soils and grass lands, acidification increases the supply of plant nutrients like sulphur and nitrogen. The vegetation is thus, benefited by soil acidification and plants may show better growth.

ii. EFFECTS OF PESTICIDES

Various pesticides, insecticides, fungicides etc are used in agriculture as foliar spray or are applied to soil in excess to the requirement causing soil pollution. These substances pollute the soil depending upon their volatility, biodegradability, persistence, leaching, chemical reactivity and adsorption on the soil particles. Many of these substances form cations are adsorbed on silicate clay micelle or humus molecules on the pH dependent exchangeable charge sites and are later adsorbed by the plants. Absorbed pesticides substances produce characteristic species specific toxicity symptoms in plants just like their aerial overdose. Fungicides reduce abundance of soil fungi actinomycetes and interfere with decomposition of soil organic matter adversely affecting the nutrient cycling. Pesticides increase the abundance of some bacterial species, particularly of magnifying bacteria while reduce the abundance of some susceptible bacteria. Insecticides reduce the abundance of predator soil microbes and consequently increase the abundance of their prey species. In general, species composition of the soil flora and fauna is changed by pesticide substances. The inorganic pesticides contain arsenic and sulphur. These substances cause toxicity symptoms like yellowing, necrosis, shot holes, and premature defoliation in plants.
iii. EFFECTS OF HERBICIDES

Various herbicides are used for weed control in agricultural practice. General effects of some common herbicide substances on the plants are as follows: The symptoms in response to a particular herbicide may be characteristic but their development depends upon the dose to which plants are exposed, rate of growth of plant, weather conditions and the plant species.


iv. EFFECTS OF SEWAGE AND ASH POLLUTION

Sewage matter is commonly used as fertilizers or deposited as waste on the soil. Effects of such pollution are mostly common to all plants. The organic matter in sewage decomposes and produces nitrogenous substances that become excessive in the soil and harm the vegetation. Decomposition of sewage may also release various toxic heavy metals that cause characteristic heavy metal toxicity symptoms in plants. Detergent substances may also be released from sewage causing characteristic injury to plants. Ash produced mainly from combustion of coal in thermal and industrial plants used for land filling or deposited on soil makes the soil unfit for vegetation. It may release many toxic substances in the soil causing characteristic plant injuries.

v. EFFECTS OF CHEMICAL FERTILIZERS

Chemical fertilizers are generally used far in excess of the requirements of the crop. The unutilized fertilizers cause soil pollution. Toxic concentrations of nitrogen fertilizers cause characteristic symptoms of nitrite or nitrate toxicity in plants, particularly in the leaves. Nitrogenous fertilizers generally cause deficiency of potassium, increased carbohydrates storage and reduced proteins, alteration in amino acid balance and consequently change in the quality of proteins. Ammonium fertilizers produce ammonia around the roots that may escape the soil and cause ammonia injury to plants, Ammonium and nitrate produce acids in the soil and increase soil acidity. Nitrate and nitrite bacteria are
reduced while ammonifying bacteria are increased in the soil disturbing the nitrogen cycle. Excessive potash in the soil decreases ascorbic acid and carotenoid in the plants. Super phosphates cause deficiency of Cu and Zn in plants by interfering with their uptake.

Excessive lime prevents the release of Co, Ni, Mn and Zn from the soil and their uptake by plants is reduced causing their deficiency symptoms. Excessive deposition of various substances released from chemical fertilizers into the soil generally causes their over absorption by plants. These over absorbed substances become accumulated in plant parts (bio accumulation) Nitrogen and sulphur are deposited in the leaves.

vi. EFFECTS OF INDUSTRIAL EFFLUENTS

Various inorganic and organic substances are present in the industrial effluents. These substances mostly remain tied up in the soil and are not readily available to plants. However, they affect various soil characteristics. Effluents affect the mineral structure, soil pH, exchangeable base status of the soil and thus indirectly affect the plants. The pH of the soil is disturbed making soil either acidic or alkaline. Various inorganic and organic chemicals are accumulated in the soil up to levels toxic to plants. In highly polluted soils, plants absorb and accumulate toxic substances (bio accumulation). These substances may or may not produce direct injury symptoms in plants but are passed on to higher trophic levels (bio magnification).

vii. SOIL DEGRADATION

Soil is the foundation for all ecology. Soil degradation can occur in the following ways:

1. Urbanization increases the rate of soil erosion, because tresses are felled to clear land for construction and bare soil is exposed during construction work.
2. Irrigation severely degrades soil quality over a period of time, due to wash off top soil.
3. Grazing livestock affects the soil by chemically changing the composition of the soil. Nutrients are absorbed, releasing ammonium sulphate which increased leaching and causes volatilization, both leading to loss of nitrogen from the nutrient cycle.
The other forms of soil pollution include dumping of domestic and industrial waste on land.

1. Chemicals such as fertilizers and pesticides used in the soil.
2. Radioactive wastes discharged from industries, research centers and hospitals.
3. Dumping of waste from mining and mineral processing industries.
4. Soil erosion due to deforestation.

Viii. SOIL CONTAMINATION AND HEALTH HAZARDS

Health hazards, resulting from exposure to certain inorganic and organic chemicals are not clearly known. This is particularly true in the case of long-term exposure to low concentrations of toxic contaminants. Subjects for epidemiological studies are usually restricted to workers who have been exposed to relatively high levels of specific pollutants in the work place. Based on these studies, some values have been arrived at for the limits of exposure to various toxic substances. Common contaminants affecting health, grouped as organic or inorganic are presented in table 1.7.

**Table 1.7**

<table>
<thead>
<tr>
<th>S.No</th>
<th><strong>Organic Contaminant</strong></th>
<th><strong>Major source</strong></th>
<th><strong>Sphere most affected</strong></th>
<th><strong>Primary health hazards</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DDT</td>
<td>Pesticide</td>
<td>Water, food chain</td>
<td>Nervous disorders, deceased blood cell count</td>
</tr>
<tr>
<td>2</td>
<td>Dioxin</td>
<td>Industrial pollution</td>
<td>Water, food chain</td>
<td>Damage to kidney, liver and nervous system, suspected carcinogen</td>
</tr>
<tr>
<td>3</td>
<td>PCB</td>
<td>Dielectric, heat transfer and hydraulic fluid</td>
<td>Food chain</td>
<td>Possibly carcinogen</td>
</tr>
<tr>
<td>4</td>
<td>Chloroform</td>
<td>Industries</td>
<td>Food, water</td>
<td>Toxic, liver and heart damage</td>
</tr>
<tr>
<td>5</td>
<td>Trihalomethanes</td>
<td>Pollution</td>
<td>Water</td>
<td>Possible carcinogen</td>
</tr>
</tbody>
</table>

Numerous synthetic organic chemicals are considered to be a potential threat to the health of many living organisms, including human. Of these, DDT and Mirex were developed as pesticides. PCBs (Poly Chlorinated Biphenyls) were developed as cooling agents for electrical transformers. The epidemiological evidence against these chemicals varies, but considering that they are poisonous and have some link to cancer or other degenerative diseases, public alarm is being unwittingly exposed to the chemicals is not unfounded.
1.8 IMPACTS OF ENVIRONMENT ON PLANTS

The plant species play an important role in monitoring maintaining the ecological balance by actively participating in the cycling of nutrients and gases like carbon dioxide, oxygen and air pollutants. Sensitivity and response of plants to air pollutants is variable. Some of the tree species are more sensitive and act as biological indicators of air pollution. The response of plants to air pollution at physiological and biochemical levels can be understood by analyzing the factors that determine resistance and susceptibility. It is possible to estimate the overall effect of a large number of pollutants as pollution by measuring changes in the plants. Levitt suggested stress avoidance and stress tolerance are two alternative underlying mechanisms underlying the resistance against major types of natural stresses. Stress avoidance denotes the ability of plants to exclude the stress, whereas in stress tolerance, the stress including agent acts internally but without a serious bearing on the functioning of the cells and tissues.

The international cooperative programme on the effects of air pollution on natural vegetation and crops assessed the impacts of air pollutants on crops, but in later years impacts on natural vegetation have also been considered.

The adverse effects of air pollution on vegetation causes injuries and kills them. Air pollution affects the physiological processes such as decrease in plant growth without causing visible injury. Conifers are injured more than broad-leaved trees. The air pollutants are absorbed through stomatal pores on the leaves. The visible injuries are classified as acute or chronic. Acute injury refers to severe, traceable and sudden absorption of enough air pollutants within a few hours to kill tissues. Following the collapse of cells, necrotic patterns develop. Chronic injury causes absorption of an amount of pollutant, which does not kill tissues. It is characterized by leaf yellowing followed by senescence of leaves. It is associated with necrotic markings. It is characterized by discoloration of needles tips or whole needles. The responses of vegetation to air pollution have shifted in emphasis from description of symptoms to physiological explanations and ecological ramifications. The pollution alters the normal plant structure and function. It also alters organism’s physiology and cellular biochemistry. Pillai studied the stress phenomena in plants. He examined the plants in high saline conditions and strain tolerance may be subdivided into strain avoidance and strain tolerance. Normal plant activity is impaired in strain tolerance, but the plant survives (that is the strain is tolerated) as a consequence of either reparative or compensatory process, which counter the incapacity effects of the strain. In strain avoidance the plant
does not exhibit any morphological or physiological strain even though the stress is experienced thermodynamically. The pollution problem is more complex now a day since it involves a large array of polluting substances in the air, water, soil and plants. The pollutants include gases, particulates and sometimes even agricultural chemicals. The accumulation of pollutants is greatest in the areas where there is highest concentration of people and industrial activity.
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