Introduction

Definition of clean air – Source and Classification of Air Pollutants – Physiochemical and Microbiological Characteristics of Air Pollution – Unit Measurement of Pollutants - Sampling Techniques – Effects of Air Pollution on man, animal, vegetation and properties – Indoor Air Pollutants – Monitoring Atmospheric Pollution.

The atmosphere is a dynamic system that absorbs a wide range of solids, liquids, and gases from both natural and manmade sources. These substances travel through air, disperse and react with one another and with other substances both physically and chemically.
Clean air contains 78.09% nitrogen by volume and 20.94% oxygen. The remaining 0.97% is composed of a gaseous mixture of carbon dioxide, helium, argon, krypton, nitrous oxide and xenon, as well as small amounts of organic and inorganic gases. Various amounts of contaminants enter the atmosphere through both natural and manmade processes that exist upon the earth.

Air pollution is defined as any atmospheric condition in which certain substances are present in such concentrations that they can produce undesirable effects on man and his environment. These substances include gases, particulate matter, radioactive materials and many others.

A substance is said to be an air pollutant only when its concentration is relatively high compared with the background value and causes adverse effects

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Concentration of an air pollutant

The concentration of a pollutant is expressed in a number of ways involving units of weights or volume per unit weight or volume of air. Four concentration scales are used to describe the concentrations of either gaseous or particulate pollutant.

(1)Mass Concentration: ratio of the mass of pollutant to the mass of air plus mass of pollutant.
(2)Volume Concentration: ratio of the volume of pollutant to the volume of air plus volume of pollutant.
(3)Volume Concentration: yppm $= yp * 10^6$
(4)Mass Volume Concentration: ratio of the mass of pollutant to the volume of air and pollutant combined.

Classification of air pollutant

They are divided into two categories: primary pollutants and secondary pollutants

Primary pollutants are those that are emitted directly from the sources.

Examples of primary air pollutants:
1. Finer particles (less than 100~ in diameter)
2. Coarse materials (greater than 100~ in diameter)
3. Sulphur Compounds
4. Oxides of nitrogen
5. Carbon Monoxide
6. Halogen Compounds
7. Organic Compounds
8. Radioactive Compounds

Finer aerosols include particles of metal, carbon, tar, resin, pollen, bacteria etc.
Secondary air pollutants are those which are produced in the air by the interaction among two or more primary pollutants, or by reaction with normal atmospheric constituents, with or without photo activation.

Examples:
1. Ozone
2. Formaldehyde
3. PAN (peroxy acetyl nitrate)
4. Photochemical smog
5. Formation of acid mists due to reaction of sulphur dioxide and dissolved oxygen when water droplets are present in the atmosphere.

Air pollutants are also classified as follows:
1. Natural Contaminants
Examples: natural fog, pollen grains, bacteria and products of volcanic eruption
2. Aerosols (particulates)
Examples: dust, smoke, mists, fog and fumes.
3. Gases and vapours.

Air Contaminants No	Group	Examples
1. Sulphur Compounds		SO_2, SO_3, H_2S, mercaptans
2. Nitrogen Compounds		NO, NO_2, NH_3
3. Oxygen Compounds		O_3, CO, CO_2
4. Halogen Compounds		HF, HCl
5. Organic Compounds		Aldehydes, hydrocarbons
6. Radioactive Compounds		Radioactive gases

Natural Contaminants

Pollen is important among natural contaminants because of its peculiar properties. Pollen grains are discharged into the atmosphere from weeds, grasses and trees. They are over 10 to 50 micron in size. They cause allergy among individuals and some people may develop bronchitis, bronchial asthma and dermatitis.

Aerosols

It refers to the dispersion of solid or liquid particles of microscopic size in gaseous media such as dust, smoke or mist. Their diameters range from .01micron to 100 micron. The following are various aerosols

.Dust

Dust is produced by the crushing, grinding of organic and inorganic materials. They are over 200 micron in diameter. They do not tend to flocculate except under electrostatic forces. They do not diffuse but settle under the influence of gravity.

Smoke

It consists of finely divided particles produced by incomplete combustion. It consists of carbon particles and other combustible materials. The size of particles is less than 1micron.

Mists

It refers to a low concentration dispersion of liquid particles of large size. It is a light dispersion of minute water droplets suspended in the atmosphere. Size of particles ranges from 500micron to 40micron.

Fog

It is the dispersion of water or ice in the atmosphere near the earth's surface reducing visibility to less than half km. in natural fog the size of particles ranges from 40-1micron.

Fumes

These are solid particles generated by condensation from the gaseous state and accompanied by the chemical reaction such as oxidation.

Gases and vapours

Sulphur dioxide

Main source of sulphur dioxide is the combustion of fuels, especially coal. Its concentration in the atmosphere depends upon the sulphur content of the fuel used for heating and power generation. Another source is metallurgical operation. Many ores like Zinc, Copper and Lead are primarily Sulphites. Sulphuric acid plants and paper manufacturing plants release sulphur dioxide into the atmosphere. The open burning of refuse and municipal incinerators also contribute sulphur dioxide to the atmosphere.

Hydrogen Sulphide:

It is a foul smelling gas; sources include anaerobic biological decay processes on land. Volcanoes and natural water springs emit H2S to some extent. Another source is craft pulp industry which uses asulphide process for manufacturing paper. The other industrial sources are petroleum refineries, coke oven plants and some chemical operations.

Hydrogen Fluoride

Major sources are the manufacture of phosphate fertilizers, Aluminum industry, brick plants, pottery and Ferro enamel works. Small amounts are also emitted from metallurgical operations like open hearth steel furnace.

Chlorine and Hydrogen Chloride:

Hydrogen Chloride is evolved industrial chemical processes. As Chlorine is used in water purification plants, in sewage plants and in swimming pools, equipment failure leads to leakage of Chlorine into the atmosphere. The main effects of Chlorine are respiratory irritation from Chlorine, corrosion by Hydrogen Chloride and damage to vegetation.

Oxides of Nitrogen:

The highest concentration of Nitrogen oxides in gaseous emissions occurs in effluents from industries where nitric acid is produced in chemical reactions. The next concentration is in Automobile exhausts. Out of seven oxides of Nitrogen, Nitric acid and Nitrogen dioxide arise from human activities and are classified as pollutants.

Carbon Monoxide:

It is an odorless and colorless gas, formed by incomplete combustion of carbonaceous materials. Source of CO, is combustion due to Automobile exhaust. It is a highly poisonous gas and is classified as an asphyxiant. Some industrial operations like electric and blast furnaces, petroleum refining operations, gas manufacturing plants and coal mines are contributors of CO to the atmosphere.

Ozone:

It is poisonous and smelly. It exists in great abundance under natural conditions in the upper atmosphere.

Aldehydes:

There are produced by the combustion of gasoline, diesel oil, fuel oil and natural gas. Incomplete oxidation of motor fuel and lubricating oils leads to its formation.

Organic vapours:

There include chemical compounds like paraffins, olefins, acetylenes, aromatic hydro carbons, chlorinated hydrocarbons etc. They are produced by combustion process and petroleum process.

Radioactive Gases:

Major source is the nuclear power reactor and related fuel handling facilities. Other sources are experimental accelerators, testing of nuclear bombs in the atmosphere, agricultural and medical use of radioactive isotopes.

Sources of Air Pollutants

Air pollutants are classified by source as stationary or mobile. They are further classified as

1. Point sources
2. Area sources
3. Line sources

Stationary Sources	
Point Sources	Area Sources
Industrial processing	Residential Heating
Power plants	Institutional / Commercial heating
Fuel combustion	Onsite incineration
Solid water disposal	Open burning
Miscellaneous	Evaporative losses
	Miscellaneous

Mobile Sources	
Line Sources	Area Sources
Highway vehicles	Motor vehicles
Railroad locomotives	Rail yard locomotives
Channel vessels	Port vessels
	Aircraft
	Miscellaneous

Effects of Air Pollution on human health

Air pollution is one of the greatest environmental evils. The effect of air pollution occurs as a result of contact between the pollutants and the body or through inhaling the air.

The health effects of Air pollution are given below:

1. Eye irritation
2. Nose and throat irritation
3. Irritation of the respiratory tract
4. Gases like Hydrogen sulphide, Ammonia and Mercaptons.cause odour nuisance even at low concentrations.
5. Increase in mortality rate and morbidity rate
6. A variety of particulates like pollens initiate asthmatic attacks.
7. Chronic pulmonary diseases like bronchitis and asthma are aggravated by a high concentration of SO2, NO2, particulate matter and photo chemical smog
8. Carbon monoxide combines with haemoglobin in the blood and increase stress on those suffering from cardio vascular and pulmonary diseases
9. Hydrogen fluoride causes diseases of the bone and motting of teeth
10. Carcinogenic agents cause cancer

11. Dust particle cause respiratory diseases.
12. Certain heavy metals like lead may enter the body through the lungs and cause poisoning.

Effect of air pollution on animals

In the case of animals, the danger is in the ingestion of forage which has been contaminated with pollutants. The three pollutants responsible for most livestock damage are fluorine, arsenic and lead. These pollutants originate from industrial sources or from dusting and spraying.

Fluorine

Of all farm animals, cattle and sheep are the most susceptible to fluorine toxicosis. Horses appear to be resistant to fluorine poisoning. Lack of appetite, rapid loss in weight, decline in health and vigour, lameness, periodic diarrhea, muscular weakness and death, characterize the acute form of fluorine poisoning.

Fluorine is a cumulative poison under conditions of continuous exposure to sub-acute doses. Symptoms of fluorosis include lack of appetite, general ill health due to malnutrition, lowered fertility, reduced milk production and growth retardation. The symptoms developed in other species include mottling, staining and wearing of the teeth, bony overgrowths on the skeleton, stiffness and general ill health from malnutrition and starvation.

Arsenic

It occurs as an impurity in many ores and in coal. Arsenic in dusts or sprays on plants can lead to poisoning of cattle. In acute cases the symptoms are severe salivation, thirst, vomiting, uneasiness, feeble and irregular pulse and respiration. Arsenic appears to have a depressing effect upon the central nervous system. The animal becomes dull, and exhibits a lack of appetite with a resulting weight loss. Chronic poisoning can result in paralysis and death.

Lead

Lead contamination of the atmosphere takes place on account of industrial sources like smelters, coke ovens and other coal combustion processes. Chronic lead poisoning is observed in horses that are gazing on forage near smelters, lead mines and in orchards that has been sprayed.

Effect of air pollution on plants

Air pollution has an adverse effect on plants.

Air pollutants affecting plants

1. Sulphur dioxide
2. Fluoride compounds
3. Ozone
4. Chlorine

5. Hydrogen chloride
6. Nitrogen oxides
7. Ammonia
8. Hydrogen sulphide
9. Hydrogen cyanide
10. Mercury
11. Ethylene
12. PAN (peroxy acetyl nitrate)
13. Herbicides
14. Smog

The above pollutants interfere with plant growth and the phenomenon of photosynthesis. Smog, dust etc reduce the amount if light reaching the leaf and also by clogging the stomata reduce carbon dioxide intake to some extent and thus interfere with photosynthesis.

Damage to leaves takes several forms.

1. Necrosis: it is the collapse of tissue
2. Chlorosis: it is the reduction of the green plant pigment, chlorophyll.
3. Abscission :it is the dropping of leaves
4. Epinasty: it is the downward curvature of the leaf due to higher rate of growth on the upper surface.

Kinds of injury to plants

Acute injury

It results from short time exposure to relatively high concentrations.

Chronic injury

It results from long term loe level exposure and causes chlorosis or leaf abscission.

Growth or yield retardation

The injury is in the form of an effect on growth without visible markings.

Effect of air pollution on materials

Air pollutants cause damage to materials by five mechanisms:

1. Abrasion: solid particles of sufficient size can cause abrasive action
2. Deposition and removal: solid and liquid particles deposited on surface may not damage the material but it may spoil the appearance.
3. Direct chemical attack: some air pollutants react directly and irreversibly with materials to cause deterioration.
4. Indirect chemical attack: certain materials absorb some pollutants and get damaged when the pollutants undergo chemical changes.

5. Corrosion: the atmospheric deterioration of ferrous metals is by an electrochemical process. This is due to the action of air pollutants facilitated by the presence of moisture.

Materials	Principal air pollutants	Effects
Metals	SO2, acid gases	Corrosion, spoilage of surface, loss of metal, tarnishing
Building Materials	SO2, acid gases, particulates	Discoloration, leaching
Paint	SO2, H2S, particulates	Discoloration
Textiles and Textile dyes	SO2, acid gases, NO2, Ozone	Deterioration, reduced tensile strength and fading
Rubber	Oxidants, Ozone	Cracking, weakening
Leather	SO2, acid gases	Disintegration, powdered surface
Paper	SO2, acid gases	Embrittlement
Ceramics	Acid gases	Change in surface appearance