

Air pollution and control

Pollution:

It refers to all the ways & means by which the environment or surroundings are polluted usually by human activities.

Types of Pollution:

- Air pollution
- Water pollution
- Noise pollution
- Marine pollution
- Radioactive pollution

Air pollution :

contamination of the air around us with pollutants that cause harm to living organisms, natural environment and atmosphere.

→ Air pollution is one of the most important environmental threat known to us, contributing to the mortality across the globe.

Scope & Significance:

→ AP can cause death, impair health, reduces visibility, bring about vast economic losses.

→ It can also cause intangible losses to historical monuments. Eg:- Taj

∴ Therefore, It is a matter of great importance that Engineers of all disciplines consciously incorporate in their designs sufficient constraints & safeguards to ensure that they do not contribute to atmospheric pollution.

→ Engineers must apply their problem-solving abilities to eliminate AP & restore natural environment for better living of all the living organisms.

Pollutants:

→ It refers to a substance that is present in undesirable quantity which causes effects deleterious to the surrounding environment.

→ Eg:- ozone, carbon dioxide, nitrogendioxide, particulate matter, sulphur dioxide, lead, radioactive materials, chemicals such as pesticides, infectious agents, mercury, sewage sludge etc.

Classification:

1. Based on origin → (i) Primary (ii) secondary air pollutants
2. Based on Nature → (i) organic (ii) Inorganic
3. Based on state of matter → (i) Particulates (ii) gasses & vapours

Primary air pollutants:

→ Pollutants are those emitted into the atmosphere as a result of some specific process & remain for a long time in the chemical form.

→ Eg :- Particulate matter such as dust, aerosols, pollens, sulphur compounds ($\text{SO}_2, \text{SO}_3, \text{H}_2\text{S}$), Nitrogen compounds (NO, NO_2), Carbon monoxide [CO], Carbon dioxide [CO_2], radioactive compounds and Lead etc.

Secondary Pollutants

- These are those emitted into the air
- these are the pollutants those formed in the atmosphere as a result of Photo chemical or Abn-Photo chemical reaction and may take place between two pollutants
- Eg :- ozone, Photochemical smog, Acid rain etc
- sulphuric acid [H_2SO_4] is formed by chemical reaction between sulphur dioxide (SO_2) and water vapour (H_2O) which cause acid rain.

Organic air pollutants

- These are organic in nature & mainly contain carbon & hydrogen
- Carbon monoxide & Carbon dioxide are excluded from this category as these contain only carbon & oxygen but no hydrogen
- Eg :- chlorinated HC, HC, aldehydes & alcohol etc

In-organic air pollutants

- These are the most common pollutants of the atmosphere & Contaminates in the form of simple in-organic compounds like CO , CO_2 , NO_2 , NO , SO_2 etc.

Particulates

- These are finely divided solids/powders. The larger Particles are tend to get settle quickly & are called settleable or dust fall particulates. The smaller particles remain suspended for a longer period are called suspended particulate material

Gasses:

- contaminates in the form of gases & behave much as the air itself without being settled out. Eg:- SO_2 , CO_2 , H_2S & NO_x

Sources of air pollution

1. Based on origin of sources

(a) Natural sources

(b) man-made sources

2. Based on spatial distribution of source BASED on spatial distribution

(a) Point source

(b) Non-point source

3. Based on position of source

(a) stationary source

(b) mobile source

Natural sources of air pollution

- Products from atmospheric reactions like oxidation, polymerization, Photochemical reaction etc.
- Aerosols - particulates → are finely divided solid or liquid particles of microscopic size held suspended and dispersed in atmosphere and causes visibility reduction, corrosion etc. Eg :- dust, smoke, mist, fog
- Micro-organisms → Infect plants & animals
- Pollens → are the small grains from the anthers of flowers which may cause allergic reactions
- Radioactive minerals (containing radioactive elements)
- Volcanic ash & ashes
- Grasses & odour from swamps & marshy lands

Note:

Radio active elements eg:- uranium & thorium

Swamps → a wetland

Man-made source of air pollution

- Combustion of fuels → CO_2 , SO_2 , NO_2 etc. accumulate in the atmosphere.
- Industries → Emit undesirable gases like SO_2 , CO_2 , NO_2 , NH_3 & CO (NH_3 - ammonia)
- Thermal power plants → mainly emit SO_2
- Automobiles → Exhaust contains Carbon monoxide (CO) methane, un-burnt carbon. CO is the main source of air pollution in congested cities.
- Agricultural activities → Crop spraying & field burning etc.
- Nuclear power plants → emit various radioactive substance

Point source of air pollution

This category includes stationary sources from an equipment or process that release pollutants directly into the atmosphere eg:-

- Power plants → Burning of Coal & oil produce SO_2
- Industrial boilers → Toxic air pollutants such as lead, arsenic & acid gases are released.
- Smelters → metals are separated from ores by Smelting (heating to a high temp to cause the metal to melt). This process produces contaminant laden laden air emissions eg. SO_2 gases
- wood & pulp ^{processors} → produce chlorine, persistent organic pollutants & chelating agents etc.
- Paper mills → CO_2 , nitrous oxides, SO_2 etc.
- Refinery → volatile organic compounds, SO_2 , NO etc.

Non-point source of air pollution

This category includes mobile sources such as

- Road traffic, aircraft emissions

This category also includes area sources such as

- Petrol refueling stations, fire extinguishers, aerosol spray cans etc.

The internal combustion engines of automobiles releases a variety of air pollutants which includes CO, NO₂, SO₂, suspended particles, benzene, formaldehyde, lead and polycyclic aromatic hydrocarbons etc.

Effects of air pollution:

→ The effect of air pollution on human health generally occurs as a result of contact b/w the pollutants and the body.

→ All the impurities in the inhaled air do not necessarily cause harm.

→ Depending upon the chemical nature of the pollutants some may be harmful when present in the air in small concentration or others only if they are present in high concentrations.

→ Factors affecting human health are as follows;

1. Nature of Pollutants

2. Concentration

3. Duration of exposure

4. State of Health of the receptor

5. Age group of the receptor.

<u>Pollutants</u>	<u>Sources</u>	<u>Effects</u>
1. Carbon monoxide [A colourless, odourless toxic gas]	Burning of fossil fuels emit carbon monoxide. Incomplete burning of coal, wood, gasoline furnaces and heaters @ home.	It causes dizziness, tiredness in humans. Serious health problems arise in heart patients.
2. Nitrogen dioxide [A reddish brown gas with strong smell]	It is formed from vehicular exhausts & power plants. It reacts with atmosphere to form ozone & acid rain.	It causes harm to the respiratory system in humans. Acid rain harms the plants & animals.
3. Sulfur dioxide [A corrosive gas with the smell of rotten eggs at high level]	Burning of coal & oil in power plants. Emmitates from chemical & paper factories. It may react with atmosphere to form acid rain and harms the plants & buildings.	It causes irritation in the eyes, nose, throat and harms the respiratory system in humans.
4. Lead [A bluish grey metal that is heavy and soft]	Automobile exhaust where unleaded gasoline is not used, Power plants and damage to the brain industries, The peeling out of paints in the houses & old water pipes.	Renal malfunction, anemia, damage to the brain, The peeling out of tissues.

5. Particulates

[solid, liquid or gas suspended in air with 0.00005 mm to 0.1 mm width]

Ozone

(It is a form of oxygen with 3 atoms formed by photodissociation of oxygen gas molecules in the atmosphere)

7. Toxic air pollutant

(includes arsenic, asbestos, nickel, mercury & molybdenum)

8. Ozone depleters in the stratosphere.

This includes chlorofluorocarbons (CFC), halons, chlorine, bromine

These are 2 types:
① Coarse particles
eg - dusts
② Fine particles eg - aerosols like smoke, soot, fly ash, asbestos, Pesticides.

It exists in both upper & lower parts of the atmosphere. It is formed by a complex chemical reaction that involves hydrocarbons, NOx and sunlight.

These are caused from chemical plants / burning of fossil fuels.

CFC's are used in refrigeration units & air conditioners as coolants, in aerosol spray cans as propellants, in insulation, packaging, as cleaners for various equipment & fire extinguishers.

Particulate matters injures the respiratory system of humans & causes frequent attacks of asthma, chronic bronchitis, lung cancer.

Ozone in the upper atmo. shields us from damaging rays of sun. ozone in lower atmo. is hazardous to health of patients with chronic respiratory ailments. It may kill seedlings, damage the foliage & make them susceptible to pests diseases & harsh weather.

many of toxic air pollutants are carcinogenic (cancer causing).

Depletion of ozone layer is a cause for skin cancer due to exposure of skin to UV radiation from sun. Formation of cataract in the eye, suppression of the immune system, harms plants & animals.

Effect on Plants

- have an adverse effect on plants
- cause a widespread damage to natural vegetation & Economic crops
- many species are susceptible to damage even at low concentrations.

Pollutants affecting Plants

- SO_x, NO_x, Ozone
- mercury, Hydrogen sulphide
- smog, Peroxyacetyl nitrate (PAN) etc.

Forms of damage to leaves

- Necrosis :- killing / collapse of tissue
- chlorosis :- loss / reduction of chlorophyll resulting in fading of the leaf's green colour to yellowish / pale green
- Abscission :- dropping of leaves
- Epinasty :- downward curvature of leaf due to the higher rate of growth on the upper surface.

Kinds of injury

- Acute injury short term ^{exposure} to high concentration occur under fumigation conditions. Effects are noted within few hours to few days - make visible markings on the leaves.

→ chronic Injury :

Long term ^{exposure} to low concentrations

→ Growth (or) Yield retardation :

Effect on growth of plants without visible markings, usually suppression of growth or yield occurs.

Sox Effect

a) Acute injury

→ The symptoms appear as 2-sided lesions that usually occur b/w the veins & occasionally along the margins of the leaves.

→ The colour of the necrotic area can vary from a light tan or near white to an orange-red or brown depending on the time, weather, plant

b) Chronic injury

→ The symptoms appear as a yellowing or chlorosis of the leaf & occasionally as a bronzing on the under surface of the leaves.

Other effects

→ Leaf injury & loss

→ Reduced growth & reproduction

→ Increase in susceptibility of plants to attack by insect herbivores

→ Cell metabolism disruption (membrane damage, degradation & photosynthetic effects)

NO_x effect

- seriously injure vegetation @ certain concentrations which includes
- ① Bleaching or killing plant tissue
 - ② causing leaves to fall
 - ③ Reducing growth rate

PAN effect

- PAN entry into the leaf through stomata. It affects the parenchymatous in the vicinity of stomata.
- The damage is reflecting in lower & upper surfaces of leaves
- It can inhibit the mobilization of starch in darkness due to suppression of phosphorylase reaction.
- Also inhibits CO₂ fixation during photosynthesis.

Effect on Animals

- Toxic pollutants in the air / deposited on soils or surface waters can impact wildlife in a number of ways.
- Like humans, animals can experience health problems if they are exposed to sufficient concentration of air toxic over time
- Air toxics are contributing to birth defects, reproductive failure & disease in animals

- Persistent toxic air pollutants [those that break down slowly in the environment] are of particular concern in aquatic ecosystems.
- Accumulate in sediments & may biomagnify in tissues of animals.
- Acid rain destroys fish life in lakes & streams.
- Excessive UV radiation coming from the sun through the ozone layer in the upper atmosphere which is eroded by some air pollutants may cause skin cancer in wildlife.
- Ozone in the lower atmosphere may damage lung tissues of animals.
- The cattle grazing on vegetation that has been contaminated with fluorine may develop fluorosis, even
- Symptoms of advanced fluorosis in animals includes lack of appetite, general ill-health due to malnutrition, lowered fertility, reduced milk production & growth retardation.
- Arsenic from dusts & insecticide sprays falling on the plants can similarly be accumulated by the plants & when such contaminated vegetation is eaten by cattle, they may suffer from arsenic poisoning, with leading symptoms like salivation, thirst, vomiting, uneasiness, feeble & irregular pulse & respiration.

Effects on materials

→ Effects

→ Air pollution cause damage to materials by 5 mechanisms

1. Abrasion → Solid particles of sufficient size and travelling at high velocities can cause abrasion.

2. Deposition & Removal → solid & liquid particles deposited on surface may not damage the material itself but it may spoil its appearance

3. Direct chemical Attack → Some air pollutants react directly & irreversibly with materials to cause deterioration

4. Indirect chemical Attack → Certain materials absorb some pollutants & get damaged when the pollutants undergo chemical changes.

5. Corrosion → The atmospheric deterioration of famous metal is by an electro-chemical process i.e Corrosion. This is due to the action of air pollutant facilitated by presence of moisture.

Factors influencing Atmospheric deterioration

1. moisture:

- The presence of moisture in the atmosphere greatly helps the corrosion process
- In case of SO_2 & various particulars, the rate of corrosion will increases with increase in relative humidity.

2. Temperature:

- It Affects the rate of chemical reaction and consequently affects the rate of deterioration.

3. Sunlight:

- It can cause direct deterioration of certain materials, in addition to producing damaging agents such as Ozone, PAN through a series of complex photo chemical reactions.

4. Air movement:

- wind direction is an imp factor to be considered in places where deterioration is caused by pollutants released from nearby factories
- wind speed is also an Imp factor in determining the impact of air pollutants on the receiving surfaces.

Effects:

- Corrosion of materials due to SO_2 in presence of O_2 & moisture is converted into H_2SO_4 acid.
- H_2SO_4 react with limestone, marble and other building materials to cause deterioration.
- Soiling and Eroding of building materials
- $\text{SO}_2, \text{O}_3, \text{H}_2\text{S}$ & aerosols damage protective Coating and paints of the surface.
- O_3 & PAN causes cracking of rubber & various electrical insulations
- Deterioration of Art work due to SPM
[Suspended particulate matter]

Types of Inversions

Inversion:

- It is defined as increase in temperature w.r.t altitude.
- It is also known as "Negative Lapse Rate".

Temperature Inversion:

- It takes place when a layer of warmer air covers the colder air at ground level.
- The warm air mass comes from another area & covers the cold air.

→ It acts like a lid over the cold ground level air.

Inversion types:

1. subsidence inversion
2. Radiation inversion
3. Combination of subsidence & radiation

Subsidence inversion:

→ It occurs at high level above Emission sources.

- It associated with high-pressure systems.
- It covers hundreds of thousands of square kms
- It contribute to long term air pollution.

Problems

- Persists for several days and greatly contribute to long term accumulation of pollutants.
- It gets broken by strong winds at that altitude.
- Elevation of base of inversion varies from about 200m to around 1000m.

Radiation Inversion

- surface layers of the atmosphere during the day receive heat by conduction, convection & radiation from the Earth's surface & are warmed
- This results in temp. profile in the lower atmosphere i.e represented by a negative Lysse rate.
- These types of inversions are intensified in River valleys
- It cause pollutants to be "trapped".
- It Breakup after sunrise
- It occurs in Winter Season in India.
- It most likely to occur during windless and cloudless nights.

Combination of Subsidence & Radiation:

- It is possible for subsidence and radiation inversions to appear in the atmosphere at the same time.
- Joint occurrence of these 2 types of inversions leads to special phenomena called "Trapping of Meme".

Photochemical Smog

- It is a brownish-gray haze caused by the action of solar ultraviolet radiation on atmosphere which is polluted with hydrocarbons and oxides of nitrogen.
- It contains anthropogenic air pollutants, ozone, nitric acid & organic compounds which are trapped near the ground by temperature inversion.
- These pollutants can effect human health and cause damage to plants.
- It often has an unpleasant odour due to some of its gaseous components.
- The term "Smog" is commonly used to represent a "near-ground haze" made of a combination of smoke & fog.
- It appears to be initiated by nitrogen oxides that are emitted into the air as a pollutant mainly from internal combustion engines.
- Absorbing the UV Energy of sunlight, it forms Nitric oxide (NO) to free atoms of oxygen (O) which then combine with molecular oxygen (O₂) to form ozone (O₃)



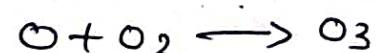
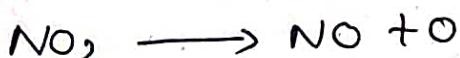
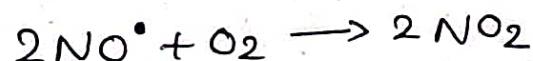
→ In the presence of hydrocarbons, certain other organic compounds, and sunlight, various chemical reactions take place to form "photochemical smog".

→ Unburned hydrocarbons are present in urban air as a result of uncompleted combustion & the evaporation of solvents & liquid fuels.

→ Substances including hydrocarbons & their derivatives that readily volatilize are termed "volatile organic compounds (VOC)".

→ The most reactive VOC's in urban air are hydrocarbons that contain a C=C bond, since they can add free radicals.

→ The following are the some of the reactions involved in photochemical smog formation



→ The major components of PCS are NO_2 , O_3 , PAN & chemical compounds that contain the -CHO group (aldehydes).

→ PANs and aldehydes can cause eye irritation and plant damage if their concentrations are sufficiently high.

Acid rain and smog are formed by the reaction between sulfur dioxide and nitrogen oxides.

Sulfur dioxide reacts with water to form sulfuric acid.

The sulfuric acid then reacts with oxygen to form sulfur trioxide.

The sulfur trioxide reacts with water to form sulfuric acid.

Sulfuric acid reacts with calcium carbonate to form calcium sulfate.

Calcium sulfate is insoluble in water so it precipitates.

When calcium sulfate precipitates it reacts with water to form gypsum.

Gypsum is a white crystalline mineral.

It is used in the manufacture of plaster of Paris.

Plaster of Paris is a white powder which is used in the construction industry.

It is also used in the manufacture of gypsum board.

Gypsum board is a type of drywall used in the construction industry.

It is made from gypsum and paper.

It is used in the construction industry to make walls and ceilings.

It is also used in the manufacture of gypsum board.