Air pollution

Air pollution is defined as any qualitative as well as quantitative change in normal composition of air which is injurious to human, plant or animal life or to property. Air pollutants can be classified into following types:-

On the basis of origin

1) Primary pollutant:-These enter the air directly from the source and persist in the form in which they are added to the environment e.g. NO, Hydrocarbons etc.

2) Secondary pollutant:-These develop from interaction of primary pollutants e.g. PAN, Ozone etc.

On the basis of source

1) Mobile sources: Automobile are line or mobile sources of air pollution. They add pollutants along narrow belts over long distances.

2) Stationary source: Industries are stationary sources of air pollution. They add pollutants to air at particular points from their tall chimneys. These pollutants affect restricted areas only.

3) Area source: Town and cities are the area sources of air pollution. They add smoke and gases from fire over wide areas.

Causes of air pollution (Table)

1) Suspended particulate matter (SPM):- is any solid or liquid droplet with diameter between 0.002 µm and 100 µm suspended in air.

I) Natural Source: - Volcanic eruptions, forest fires, dust storms, pollens, spores, cysts, bacteria, marshes etc.

2) Man made Sources: - Industries, burning of fossil fuels, mining activity, smelting, agricultural refuse etc.

II) Gaseous Pollutants

1) Natural Source:- Volcanic eruptions, electric storms, forest fires, etc.

2) Man made Sources:- Industries, Automobiles, Thermal power plants, Chlorofluorocarbons, Burning of domestic wood, waste treatment plants etc.

Table :-Causes of Air pollution

Pollutant	**Sources**
CO &CO_2	**Smoking, Burning of coal, gasoline, open fire, forest fire, Power plants,volcanoes**
Nitrogen oxides	**Automobiles, industries, lightening, fertilizer plants**
Sulphur oxides	**Combustion of fossil fuels, industrial processes like smelting**

Hydrocarbons	**Incomplete combustion, decay**
Ozone	**Photocopying machines, Phone, computers**
CFC	**Propellants in aerosol cans, refrigerators, air coolants, blowing agents in foams, packing materials, jet emission**
Pollen, Spores, Bacteria	**Organisms**
Radioactive	**Soil, nuclear plants, war explosions**
SPM	**Chemical plants, steel mills, mining, etc.**
Lead	**Leaded gasoline, Smelting, Batteries**

Effects

Effect on humans

Carbon monoxide (CO):- Inhaling carbon monoxide gas interferes with this oxygen transport system. In the lungs, CO competes with oxygen to bind with the hemoglobin molecule. Hemoglobin accepts Carbon monoxide 200 times more readily than it accepts oxygen and forms a complex called carboxyhemoglobin (COHb). Symptoms of Carbon monoxide poisoning commonly include headache, dizziness, weakness, vomiting, chest pain and confusion. The result is that vital organs, such as the brain, nervous tissues and the heart, do not receive enough oxygen to work properly. Large exposures can result in loss of consciousness, seizures or death.

Carbon dioxide(CO_2):-It causes headache and nausea.

Sulphur dioxide (SO_2):- Inhaling sulfur dioxide causes irritation to the nose, eyes, throat, and cause coughing, shortness of breath or a tight feeling around the chest. Short term exposure can be fatal especially for people with lung diseases. A single exposure to a high concentration can cause a long-lasting condition like asthma. Long term exposure can cause chronic bronchitis, emphysema and respiratory illness and even pre mature death. It also aggravates existing heart disease. Sulfur dioxide vapor can cause irritation or burns in eyes and skin. Direct contact with Liquid sulfur dioxide can severely injure the eyes or cause frostbite.

Oxides of nitrogen (Nox):- **NO_x** is a generic term for the nitrogen oxides and the most relevant for air pollution- nitric oxide (NO) and nitrogen dioxide (NO_2). Breathing air with a high concentration of NO_x can irritate airways in the human respiratory system. Coughing and wheezing are the most common complication of nitrogen oxides toxicity, but the eyes, nose or throat irritations, headache, dyspnea, chest pain, fever, bronchospasm, and pulmonary oedema may also occur. People with asthma, as well as children and the elderly are generally at greater risk for the health effects of NO_x. NO_x may cause DNA mutations.

Ground level Ozone:- Ground level or "bad" ozone is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight. Breathing ozone can trigger a variety of health problems including chest pain, difficulty in breathing, coughing, throat irritation, and airway inflammation. It also can reduce lung function and harm lung tissue. Ozone can worsen bronchitis, emphysema, and asthma. It makes the lungs more susceptible to infection even continues to damage the lungs even when the symptoms have disappeared. It can also cause chronic obstructive pulmonary disease (COPD).

Peroxyacyl nitrate (PAN): PANs are a component of photochemical smog, produced in the atmosphere when oxidized volatile organic compounds combine with nitrogen oxide. PANs reduces respiratory function and is a potent eye irritant. It can also cause impaired breathing and other lung problems e.g. emphysema. It is said to be mutagenic.

Suspended particulate matter (SPM): Inhaling of particulate matter can result into asthma, lung cancer, respiratory diseases, cardiovascular disease, vascular inflammation, atherosclerosis premature delivery, birth defects, low birth weight, and premature death. A large number of particulates are formed up of radioactive material such as uranium and thorium.

Hydrocarbons: are known to cause eye irritation, coughing, sneezing, drowsiness etc. Polyaromatic hydrocarbon are known to be highly carcinogenic and mutagenic

Lead: Symptoms may include abdominal pain, constipation, headaches, irritability, memory problems and tingling in the hands and feet. High levels of lead can cause increased chance of illness during pregnancy, harm to a fetus, including brain damage or death, fertility problems in both men and women, high blood pressure, digestive issues, nerve disorders, memory and concentration problem, muscle and joint pain.

Fluroide: An increased ingestion of fluoride can be harmful to animals. The symptoms of excessive fluoride ingestion include; lesions in the developing dentition, skeletal lesions, lameness, frequent diarrhea and weight loss.

Effects on vegetation

Carbon dioxide (CO_2):- Under elevated CO_2 most plant species show higher rates of photosynthesis, increased growth, decreased water use and lowered tissue concentrations of nitrogen and protein. Rising CO_2 over the next century is likely to affect both agricultural production and food quality. The effects of elevated CO_2 are not uniform; some species, particularly those of C_4 plants show less of a response to elevated CO_2 than do other types of plants. Rising atmospheric concentrations of CO_2 may therefore lead to changes in the composition of plant communities.

Carbon monoxide (CO):- It produces epinasty, chlorosis and abscission. No injury to plants occurs below exposure of 100 ppm for 1 week.

Sulphur dioxide (SO_2): The gas is a strong reducing agent. In low concentration, it is oxidized and used in protein synthesis of the plant. In SO_2 pollution, plants show initial reduction of photosynthesis and increased respiration. The gas reduces stomatal opening and thus causes general water stress in plants. SO_2 affects structural proteins in the cell membrane and thus changes the membrane permeability. SO_2 interferes with amino acid metabolism and reduces the synthesis of proteins and enzymes. It reduces the level of keto acids, ATP, sucrose and glutamate in plants and increases the level of glucose, fructose and glycolate. It inactivates many enzymes. In lichens, the gas induces photooxidation in the phycobiont part.

In angiosperms, young leaves and in conifers, needles are most sensitive to SO_2 pollution. In general, seedlings are more sensitive than older plants. The effect of the gas usually decreases with age of the plant and lesser morphological and physiological symptoms appear in older plants.

Most common visible symptom of SO_2 injury is water-soaked appearance of leaves which later become necrotic changing into brown spots. In some species, characteristic intraveinal chlorosis is caused. In general, SO_2 pollution results in abscission of older leaves and tip necrosis in flower and sepals.

Oxides of Nitrogen(NOx): NOx mostly affects the leaves and seedlings. Its effects decrease with increasing age of the plant and tissue. Conifers are found to be more sensitive to this gas during spring and summer than in winters. Older needles are more sensitive to the gas than young ones. The gas causes formation of crystalloid structures in the chloroplasts and swelling of thylakoid membrane. As a result the photosynthetic activity of the plant is reduced.

Most common visible injury symptoms are chlorosis in angiospermic leaves and tip burn in conifer needles. In angiosperms, most of the species produce water-soaked intraveinal areas that later become necrotic. Tip burn is common symptom in bracts, sepals and awns.

Peroxyacyl nitrate (PAN):- Young plants and young rapidly expanding leaves are more sensitive to this pollutant. PAN interacts with SO2 and O3 in complex manner producing variable impact conditions.

The common visible symptoms of exposure to PAN are chlorosis and necrosis in leaves. It also interferes with photosynthesis, respiration and absorption and synthesis of carbohydrates and proteins. It inhibits photorespiration, NADP reduction, carbon dioxide fixation, cellulose synthesis and the enzymes associated with photosynthesis and respiration.

Gound level Ozone : Middle aged leaves and young plants are more sensitive to ozone. This pollutant interacts with SO2, NO2, PAN and heavy metals in complex manner.

Common symptoms of ozone pollution are yellowing, flecking and blotching in leaves, premature senescence and early maturity. It interferes with pollen formation, pollination, pollen germination and growth of pollen tubes. Increase in the level of RNA, starch, polysaccharides is observed in ozone pollution. Ozone stimulates respiration and changes membrane permeability. In some species, it reduces the level of reducing sugars, ascorbic acid and ATP while in other species the effect is opposite to it.

Hydrocarbon (Ethylene): The sensitivities of species to different gases are variable. Ethylene injury symptoms develop in plants only in exposure to high concentrations and take several days to develop. Impact of ethylene on the plants increases with high temperature. In injuriously high concentrations of ethylene, growth of plants is stopped. In low concentrations, growth abnormalities appear. In conifers, yellow tips in needles and abscission of branches and cones is common. In angiosperms, common symptoms are epinasty or hyponasty, loss of bark, abscission of leaves and flowers, premature flower opening and fruit ripening.

Fluroide: It affects the cell wall composition, photosynthesis, respiration, carbohydrate synthesis, synthesis of nucleic acids and energy balance of the cell. Chlorophyll synthesis and cellulose synthesis are inhibited.

In conifer needles common visible injury symptoms are chlorosis later turning into necrosis of whole needle. Similar symptoms are common in angiospermic leaves also. In addition, the angiospermic leaves in many species also show leaf cupping, curling of leaf edges and ragged leaf margins. In sepals, petals, bracts and awns, tip and marginal necrosis are observed.

Suspended particulate matter (SPM): It inhibits gaseous exchange from the surfaces of plant parts. Such crust on the leaves also inhibits light penetration, stomatal openings are clogged and consequently reduces photosynthesis. Such crusts are especially thicker in conditions of dew, mist or light rains. In dry conditions, dust blowing with wind is highly abrasive and damages the cuticle of leaves. Cuticle is also damaged due to alkalinity of cement dust. Due to damaged cuticle plants become more susceptible to infection by pathogens. Necrotic spots also develop in many species due to soot deposition.

Effect on material

The costs for deterioration and soiling of different materials due to air pollution are huge and the damage to culture targets seriously endangers the cultural heritage. Deposition of sulfurous and sulfuric acids formed during the exposure on the metallic parts of equipment, building roofs, etc. results in corrosion which in turn results in heavy economic losses. Taj Mahal is turning yellow due to high levels of sulphur and nitrogen oxides. SO_2 deteriorates the leather. SO_2 can tarnish silver and copper contacts with sulfide films.
SO_2 can damage the protective covering of paints and expose the underlying layer to attack.

Ozone attacks the double bonds in the hydrocarbon polymer compounds, used in rubber. The side walls of the tyres and various forms of electrical insulation are especially affected. In fact tyre manufacturers add a special anti - ozone compound to all tyres sold in areas having a high ozone content. Ozone also fades fabrics. Nitrogen dioxide causes fading of textile dyes.

Effect on climate

Air pollution is held responsible for climatic changes occurring all over the world. The number of droughts have increased and erratic rainfall pattern is seen all over the world. The increase in global industries has led to a build-up of so called greenhouse gasses in the atmosphere, which prevent heat from escaping the planet, thus leading to global warming. SPM has affected the weather. Researchers believe that the increase in particulates in the atmosphere has resulted in global dimming which creates a cooling effect, counteracting the heating of the greenhouse gases. **Volcanic eruptions** have been linked with changes in the earth's climate. **Eruption of Mount Pinatubo** (1991), led to a world-wide temperature reduction of 0.5^0C which lasted several years.

Due to the higher levels of carbon dioxide released by human activity. An estimated 30-40% of carbon dioxide dissolves into the oceans, causing Ocean acidification which has harmful effects on ocean life such as coral bleaching. Halons and Freons deplete Ozone in stratosphere, which protects us from harmful UV radiations and also act as greenhouse gas.

Acid rain inhibit plant germination and reproduction. If trees vitality will reduce ultimately green house gases will increase thus promoting global warming and climate change.

Secondary pollutants produce photochemical smog. Smog can have damaging effects on a person's health and the environment. While smog can be seen as a haze over cities, it can also reach ground levels and cause visibility problems for drivers.

Thus, air pollutants are changing the climate.

Aesthetic loss:

Clear sky is aesthetically pleasant to human minds. Presence of smoke and dust irritates human mind.

Methods to Control Air pollution

I. Abatement methods: These aim at separation of pollutant from gases and conversion of pollutant into less harmful material.

1. Use of better fuel:- By using better fuel, production of air pollutants can be reduced like use of natural gas or LPG instead of coal; M85 (blending of methanol and gasoline), gasohol (ethanol blended with gasoline), Compressed natural gas (CNG), Liquefied petroleum gas (LPG) are better fuels.

2. Control at source:-The most effective method to control air pollution is prevent formation of pollutant or minimize their emission at source. It can be done by adopting following:-

a) Substitution of raw material:-The raw material sometimes contain an ingredient which is not essential but polluting. So, pollution can be reduced if that ingredient is removed. For instance-coal cleaning is done to remove the sulphur and reduce the ash content of coal.

b) Modification of process:-New or modified technique lowers the pollutant. As Double catalyst double absorber (DCDA) process was developed and it reduces SO2 emissions.

c) Equipment alteration:-Like replacing open hearth furnace with basic oxygen furnace in steel industry pose less air pollution. Technologies like Fluidised bed combustion and integrated gasification combined cycle (IGCC) increases combustion efficiency with reduced emissions. They are most promising coal clean technology.

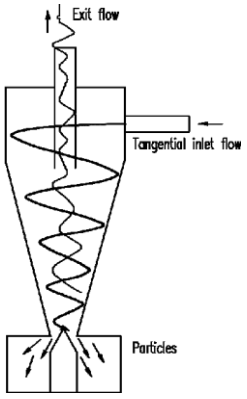
3. Control by device:- A large number of industries are liberating various types of gases and pollutants into the atmosphere. The control devices have been used to prevent these pollutants from being escaping into the atmosphere. Emission control is of two types-

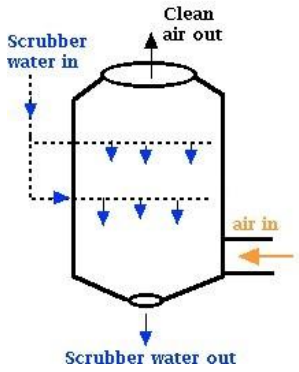
a) Particulate control type

i) Gravitational chamber:-These can remove large particles of more than 50 µm in size. The gas stream is made to flow through a large tank, at reduced velocity so that particles settle by gravity.

ii) Cyclone separator:- The cyclone consists of a vertically placed cylinder which has an inverted cone attached to its base. The particulate laden gas stream on entering the cylinder, gets transformed into a confined vortex, from which centrifugal forces drives the suspended particles to the walls of the cyclone. The clean gas is removed from a opening at the top, while the dust particles are collected at the bottom in a storage hopper by gravity. Cyclone efficiencies are greater than 90% for the particles with the diameter of 10 µm. (Fig)

iii)Fabric filters: The air pollution control equipment using fabric filters is known as bag house. Most baghouses use long, cylindrical bags (or tubes). Dust-laden gas or air enters the baghouse through hoppers and is directed into the baghouse compartment. Particulates get traped in baghouse and clean air exits at the top of baghouse. It can remove particulates as small as 1 µm with 100% efficiency(Fig).





iv)Wet scrubbers: These devices trap suspended particles by direct contact with spray of water or other liquid. In a spray tower, an upward flowing airstream is washed by downward sprayed water from a series of nozzle. Spray towers remove 90% of particles with size larger than 8 µm. Venturi scrubbers are the most efficient wet scrubbers (Fig).

v) Electrostatic precipitator: It is commonly used method to remove fine particulates from air. Electrostatic precipitator consists of vertical wires placed between parallel collector plates. Plates are grounded and wire are highly negatively charged. When air stream enters the unit, it is gets electric charge, which causes it to move under the action of electric field to grounded collecting surface. It can particulates as small as 1 µm with 99% efficiency. They are used mostly in power plants.

b) Gaseous control type: Gaseous emissions can be controlled by following methods:

i) Combustion: In this method emissions are burnt at high temperature for sufficiently long time so that combustion is complete and intermediate products of combustion are not produced.

ii) Absorption: It is a process in which effluent gases are passed through absorbers which removes one or more pollutants from the gas stream. It can be achieved through dry or wet scrubbers. E.g. Limestone or lime is used to absorb SO_2 from flue gas.

iii) Adsorption: In this gas is passed through adsorption columns containing silica gel or activated carbon or any other suitable reagent.

iv) Condensation :-In this process gas stream gets cooled in condensation traps which are arranged either in series or parallel at decreasing temperature. The components are separated by fractional condensation.

v) By stacks:- The concentration of pollutant is affected by atmospheric dispersion or how the pollutant is diluted with clean air. Therefore the height of chimneys should be raised to such a height that pollutant get spread evenly over a large area.

vi) Switching to new emission standards i.e. Bharat stage VI (BS-VI) will address the problem of pollution control. It will bring clean diesel fuel to India, PM emissions will reduce by 82% and NOx emissions by 68% from BS-IV levels.

4. Control of vehicular pollution:

a) To check pollutant emission from vehicular exhaust: It can be achieved by tuning up of engine, use of stratified charge engine without catalytic convertor, fitting of thermoreactor to exhaust tailpipe.

b) To control evaporation from fuel tank and carburettor by collection of vapours with activated charcoal, developing low-volatile gasoline and subjecting the gasoline in tank to slight pressure.

c) Use of filter to capture and recycle the escape gases in engine.

5. Plantation: Trees should be grown in all available spaces. Besides absorbing CO_2 and giving us oxygen, there are certain plants like *Ficus sp., Phaseolus vulgaris* etc. which can fix CO; some plants like Pinus, Juniper, Quercus can metabolize oxides of nitrogen; Alfalfa plants can take sulphur dioxide, Dracena absorbs formaldehyde etc.

II) Avoidance of pollutant: This can be done by following ways:-

1. Sustainable mobility:-It involves promoting practices such as walking, cycling and use of public transport. These can be achieved by advocating accessible and proper city design planning and management measures such as parking fees.

2. Renewable resources like solar energy, hydro energy etc., should be used. Electric or solar cars should be encouraged.

3. Nuclear explosions and wars should be stopped.

4. Population growth should be under control.

5. Crazy Consumerism and unsustainable lifestyle has to be stopped.

6. Awareness to masses

7. Proper implementation and compliance with environmental laws.