Air pollution

- Air pollution may be defined as the excessive discharge of undesirable foreign substances into the atmospheric air, thereby adversely affecting the quality of air and causing damage to human, plants and animal lives.
- Air pollution is most crucial from the public health point of view, because every individual person breathes approximately 22,000 times a day, inhaling 15-22kg of air daily . Polluted air causes physical ill effects, besides undesirable aesthetic and physiological effects.

Causes of air pollution

The causes of air pollution are summarized below:

1. Population explosion
2. Industrialization
3. Urbanization
4. Automobiles
5. Natural phenomena : volcanic eruptions, radioactivity, forest fires, etc.

Air pollutants

On the basis of the physical state, there are four major groups of air pollutants:

A. Gases

Gases mix freely with air without settling down . These gases are:

i) Oxides of sulphur (SO_x)

Sulphur dioxide (SO_2) and sulphur trioxide (SO_3) are important forms of primary pollutants in atmosphere . The mixture of SO_2 and SO_3 is commonly represented as SO_x .

Sulphur dioxide (SO_2)

- It is emitted from thermal power plants, in which sulphur containing coal and diesel are fired. Other sources are petroleum industry , oil refineries, sulphuric acid plants and sulphide ore-roasting plants.

$$S + O_2 \longrightarrow SO_2$$

$$2SO_2 + O_2 \longrightarrow 2SO_3$$

$$SO_2 + H_2O \longrightarrow H_2SO_3$$

(sulphurous acid)

Sulphur dioxide (SO_2)

- The presence of this gas in the atmosphere causes cardiac (heart) diseases, respiratory diseases , eye irritation , throat troubles , etc. to man .
- Some effects in atmosphere on plant cells are membrane damage, chlorophyll destruction , metabolism inhibition , growth-yield reduction, etc.

Sulphur trioxide (SO_3)

- It is formed by the oxidation of sulphur dioxide under the influence of sunlight . Even 1ppm of SO_3 in air causes severe breathing discomfort and irritation to the respiratory tract.

$$SO_2 + O_3 \longrightarrow SO_3 + O_2$$

$$SO_3 + H_2O \longrightarrow H_2SO_4$$

(sulphuric acid)

- Secondary pollutants such as H_2SO_4 produced from the sulphur dioxide can damage the building materials.

Controls of SO_x Emission

There are following four possible methods to the removal and control of SO_x emission:

- Removal of SO_x from fuel gas.
- Removal of sulphur from fuel burning.
- Use of low sulphur fuels.
- Substitution of others energy sources for fuel combustion.

ii) Oxides of nitrogen (NO_x)

- Oxides of nitrogen like NO, NO_2 are produced from the combustion of fuels (coal, petrol, diesel, etc.) .
- Other sources are acid manufacture , explosive industries , etc. Because of continuous increase in the number of vehicles, power plants, industries, etc. The pollution due to nitrogen oxides is increasing day-by-day.

$$N_2 + O_2 \xrightarrow{< 2000^oC} 2NO$$

$$2NO + O_2 \longrightarrow 2NO_2$$

Oxides of nitrogen contd…

- Nitrogen oxides are among the most toxic substances . NO is biochemically relatively inert. However NO_2 is about four times toxic than NO.
- In high NO_2 areas respiratory illness among children have been reported. It is unpleasant in odour and leads to irritation of eyes and even lung's congestion.
- Exposure of plants for long time to the high concentration of NO_2 cause leaf spotting, breakdown of plant tissues ,etc.

Oxides of nitrogen contd….

- No direct effect of NO_X have been noticed among building materials . However secondary pollutants such as HNO_3 produced from nitrogen oxide can damage the building materials.

$$4NO_2 + 2H_2O + O_2 \longrightarrow 4HNO_3$$

(Nitric acid)

Control of NO_X

- Fuel burn out completely at relatively low temperatures in excess of air . The low temperature prevents the formation of NO and therefore control its emission.
- Use of selective catalytic converter for catalytic reduction . For example NH_3 , CO , etc. may reduce NO_X in exhaust gas .

$$6NO + 4NH_3 \longrightarrow N_2 + 6H_2O$$

$$NO + 2\,CO \longrightarrow N_2 + 2CO_2$$

iii) Oxides of carbon (CO and CO_2)

Carbon monoxide (CO)

- Carbon monoxide (CO) is released by the partial combustion of fuel in automobiles, industries, and oil refineries . Cigarette and bidi smoke and domestic heat appliances are other sources of CO.
- The basic chemical reaction yielding CO are as follows.

$$2C + O_2 \longrightarrow 2CO$$

$$CO_2 + C \longrightarrow 2CO$$

$$CO_2 \rightleftharpoons CO + O$$

Oxides of carbon contd….

- Carbon monoxide is non-irritating gas . Mostly it is referred as silent killer as it is highly toxic . Carbon monoxide react with red pigment haemoglobin to form carboxy-haemoglobin.

$$Hb + CO \longrightarrow Hb.CO$$

(carboxyhaemoglobin)

- As a result blood can not absorb oxygen and thus the transport of oxygen to the various part of body decreases . Thus the air containing CO may be fatal to us.

Control of CO emission

- Modification of internal combustion engines for reducing the amount of pollutants formed during fuel combustion.
- Development of exhaust system reactors which will complete the combustion process and emit CO_2 , a more acceptable material into atmosphere.
- Development of pollution free power sources to replace the internal combustion engines.

Carbon dioxide (CO_2)

- Carbon dioxide is released into the atmosphere in the form of smoke which is produced by burning fuels such as coal, wood , petroleum products , and gaseous fuels.
- The excess of CO_2 in the atmosphere causes respiratory disorders and suffocation.
- CO_2 gas in the atmosphere perform major role of heating up of atmosphere due to trapping of infrared rays (from sun) . This is called green house effect.
- To control emission of CO_2 consumption of fossil fuels such as coal , petroleum , etc. should be minimized.

iv) Hydrocarbons

- Sources of HC are petroleum 55% , coal 3.3% , wood 2.2% , refuse burning 28.3% , solvent evaporation 11.2%.
- High concentration of hydrocarbons affect lungs and cause swelling when they enter the lungs.
- Inhalation of aromatic hydrocarbon vapours cause greater ill effects like irritation to mucus membrane , respiratory problems, lung cancer , affect nervous system and may even lead to death.
- Hydrocarbons are also responsible for the photochemical smog.

Control of hydrocarbons

- Hydrocarbons can be controlled in the atmosphere by removal of chemical and photochemical reactions.

B) Particulates

- Small solid particles and liquid droplets are known as particulates. These are present in atmosphere in fairly large numbers and sometimes cause a serious air pollution problem.
- The sources of particulates are volcanic eruptions, blowing of dust particles by wind , spraying of salts and others solid particles by the seas and ocean, etc.
- The contribution from man-made activities are fly ash from power plants , smoke from incomplete combustion process, etc.

Particulates contd..

- Due to the very small size of particulates , they have ability to penetrate into the deep air passage and may remain for years in the innermost region of the lungs and there is no effective mechanism for particle removal.
- Particulates have harmful effects on human health such as chronic bronchitis , asthma , respiratory disorder , kidney damage and cancer. They have adverse effect on climate by in-balancing radiation and heat . They have harmful effect on materials such as damage to building, sculpture , etc.

Control of particulates

The techniques of remedies of particulates are as follows :

- Cyclone collectors
- Electrostatic precipitators
- Wet scrubbers
- Settling chambers

C) Deforestation

- Green plants use CO_2 for the manufacture of food by photosynthesis and give out O_2 , Thereby purifying the atmospheric air .
- Plants also control hydrogen sulphide , nitric acid and chlorine . Thus plants help in controlling the air pollution .
- Excessive cutting of trees , consequently, causes indirectly air pollution.

D) Internal combustion engines

- One of the major man-made air pollutant is the internal combustion engine for running motorcars, buses, planes, trucks, scooters, etc. When fuel like kerosene , diesel , petrol is burnt , a lot of smoke is released into the atmosphere.
- Following ways can reduce the air pollution due to the internal combustion engines :

Internal combustion engine contd…

- By using engine with better design .
- By using suitable catalyst in the fuel.
- By mixing the exhaust gases with more air.
- By improving the quality of gasoline by adding tetraethyl lead (TEL) .
- By using catalytic converter in automobile engine.

Control of air pollution

The best way to control air pollution is to reduce or to prevent the formation of pollutant at the source itself . Various air pollution control methods are :

- The air pollution due to oxides of nitrogen , oxides of sulphur and oxides of carbon can be controlled by …….(see above)
- The air pollution due to hydrocarbons can be controlled by …….(see above)
- The air pollution due to particulates can be controlled by …….(see above)
- The air pollution due to internal combustion engines can be controlled by …….(see above)

Control of air pollution contd…

- Effluents from industries must be treated before discharging into the atmosphere.
- The use of tall stacks or chimneys reduce the concentration of air pollutants at the ground level. The gases discharged through the stacks get diluted and are dispersed into the atmosphere.
- Alternate source of energy such as solar energy , electricity , bio-gas can be used .
- Regular maintenance of vehicles is necessary.

Control of air pollution contd…

- Intensive afforestation is necessary to control air pollution. Public awareness about air pollution and it's effect is one effective means to reduce air pollution.
- The amount of smoke produced by households can be reduced by use of smokeless chulhas , solar cookers and biogas.
- It is desirable to have a suitable "buffer zone" between industrial units and houses in order to facilitate dilution of air pollutants to such a degree that it is harmless to children also.

Q. What are particulates? Classify particulates, and discuss in brief its effects on human .

Particulates or particulate matter is the sum of all solid and liquid particles suspended in air . This complex mixture includes both organic and inorganic particles.

Particulates are classified as follows:

1. Dust –Main sources of dust are mines and quarries, power houses, vehicular traffics , house cleaning dust , natural winds, etc.
2. Smoke – The major sources of smoke emission are rails , open fires , industrial power plants, diesel engines, automobiles , furnaces, hearths, etc.

Classification of particulates contd…

3. Smog – It is a mixture of smoke (from coal combustion) and fog in suspended droplet from.

4. Fly ash – It is the fine ash from pulverized fuel (coal) burned in power stations.

5. Asbestos (the fibrous silicate mineral) – Widely used in industry for its mechanical strength and resistance to heat especially as thermal insulation materials and in high temperature applications, where the high chemical stability of the silicate serves well.

Classification of particulates contd…

6. Lead – It is known to be toxic to human metabolism but, still it is widely used in our society .Lead content in human blood exceeding a 40 ppm is considered dangerous. One symptom of lead poisoning is anaemia . It enters the body either as inorganic lead (Pb^{2+}) ion or as tetraethyl lead.

Classification of particulates contd…

7. Mercury – The toxicity of mercury depends very much on its state. Pure mercury is not particularly poisonous ; in fact ingestion of small amount of mercury (e.g. from the dental amalgam) produces no noticeable ill effects, since the metal apparently passes through the body without undergoing chemical change . On the other hand, mercury vapour is dangerous.

8. Cadmium – Cadmium produced from the industrial processes is very toxic to the living organism, even in low concentration of less than 1 mg/L .

Effects of particulates on human

1. Due to very small size of particulates, they may penetrate into the deep air passage and may remain for years in the innermost regions of the lungs, which have no effective mechanism for particle removal.
2. On man, atmospheric dust causes allergic and respiratory disease , silicosis, if dust contains silica.
3. The incidence of cancer is being increasingly related with smoke.

Effects of particulates on human contd…

4. Photochemical smog causes:

- Irritation of eyes and lungs.

- May damage plants.

- Irritation to nose and throat.

- Increased chances of asthmatic attack and mortality.

Effect of particulates on human contd…

5. It is known that lead ions inhibit at least two enzymes that catalyze the reactions for biosynthesis of haemoglobin . Consequently, one symptom of lead poisoning is anaemia .

6. Mercury vapour causes irritation and destruction of lung tissues. Mercury in vapour form adversely affect the neurological behavior of humans.

Water Pollution

- Water found in the environment is used directly by man for providing food and drink , personal and domestic hygiene , recreation, agriculture, transport and industry.
- The word polluted water is defined as water that does not meet even the minimum standards for any function and purposes for which it would be suitable in its natural state.
- The concept of water pollution may alternatively be defined as “any alternation in the physical (e.g. temperature), chemical and biological properties of water as well as contamination with any foreign substance, which would constitute a health hazard or otherwise decreases the utility of water. ”

Sources of water pollution

1. Domestic sewage: The release of huge quantities of domestic wastes by drains into the canals and rivers cause the pollution of rivers. The sewage contains human feces, , urine , kitchen wastes , street wastes and organic substances that provide nutrition for bacteria and fungi.

2. Industrial wastes : Water gets polluted by acids, alkalis, detergents, soaps, phenols , cyanides, copper, zinc , lead, mercury , pesticides, insecticides and fungicides, etc. which are released from chemical industries . Pollution is also caused by the wastes of industries like leather tanneries, sugar, paper, breweries , slaughter houses , textiles, steel mills , soap, distilleries , oil refineries , pharmaceuticals, etc. Water containing toxic substances damage the biological activity and kills useful organisms.

Sources of water pollution contd…

3. Run-off from land and fields : Residual pesticides, fungicides , insecticides etc. are washed down into rivers , lakes etc. and pollute them.

4. Suspended particles : The surface water , sometime contains a high concentration of suspended solids (organic as well as inorganic), bacteria , viruses , protozoa , algae, etc. This makes water unfit for industrial as well domestic purposes.

5. Oil from oil spills or leakage from tankers carrying petroleum and washing of automobiles also pollute our rivers.

Sources of water pollution

6. Atomic explosion and processing of radioactive materials near the sources of water cause water pollution.

7. Waste from fertilizer plants containing nitrates, phosphates, ammonia, etc. are released in water and they all cause water pollution.

8. Clay , ores, fine particles of soil on which water travels are also added to water sources and they all cause water pollution.

9. Agricultural discharge such as pesticides , insecticides , plants nutrients, fertilizers , herbicides, farm wastes, etc. cause water pollution.

Sources of water pollution contd…

10. By bacteria, viruses , algae and diatoms (like protozoa): These cause bacterial pollution , which is due to the presence of mammals like dead bodies of man , wild and domestic animals, birds, etc. in water bodies . They degrade the quality of water.

11. By run-off from urban areas : Effluents from urban areas containing substance like oils, grease detergents, nutrients, heavy metals , etc . Cause water pollution.

12. Natural rocks and soil from which arsenic leaks into water .

Effects of water pollution

1. Water is the carrier of pathogenic microorganisms and can cause immense harm to public health. The water borne diseases are typhoid , dysentery , cholera , infectious hepatitis, etc.

2. Domestic wastes and untreated sewage create foul smell in water as well as in air.

3. Air pollutants like oxides of nitrogen and sulphur cause acid rain that changes the P^H of water.

4. Oil spill and leakage covers the water surface and prevents atmospheric oxygen from mixing with water . It adversely affects the fish fauna and aquatic organism .

Effects of water pollution contd….

5. Excessive addition of fertilizers (nitrates and phosphates) from agricultural waste water into aquatic system causes eutrophication , which leads to the depletion of oxygen in water due to excessive growth of algae, thereby BOD of water is increased. This leads to death of fish and other aquatic life.

6. Heated water discharged into water bodies results in an increase in the temperature of water which depletes the dissolved oxygen. It is injurious to aquatic flora and fauna.

Effects of water pollution contd….

7. Heavy metal like mercury causes numbness of limbs, lips, and tongue. It also produces blurred vision , deafness, mental disorders. Mercury poisoning was first discovered in Japan and was called minamata disease. In lethal dose (0.5-1.0 gm), it damages kidney.

8. Compounds of lead , arsenic and cadmium are slow poisons which cause skin disease, anaemia , headache, vomiting , liver and kidney damage , gastrointestinal damage and nerve disorders, etc.

9. Water polluted with radioactive substances and toxic materials may cause poisoning , reproductive disorder , birth defect , genetic defect and cancer in human beings and animals .

Effects of water pollution contd…

10. Nuclear weapons testing in air , leakage from underground nuclear detonations, etc. give to radioactive fallout. The latter shows far reaching effects on the environment and mankind. ^{90}Sr , a long lived component of radioactive fallout is chemically similar to Ca and accompanies Ca in soil. Plants and animals and finally in bones and teeth. The presence of ^{90}Sr in bones leads to disorders in blood cell formation and causes anaemia or more serious disorders.

Water pollution control methods

The problem of water pollution can be reduced by using following techniques :

1.Stabilization of ecosystem by reduction of wastes , trapping of nutrients , fish management , aeration, etc.

2.Recycling of the waste water by suitable treatment, before its discharge into water bodies. Methods like aeration and use of trickling filter can be employed for treating sewage waste.

3.Waste-water reclamation : for example sewage water can be directly used for irrigation and fish-farm raising purposes, since it contains all essential nutrients such as N, P and K to make it a good manure.

Water pollution control methods contd…

4.Use of chemicals : Effective filtration, followed by chlorination of waste water can provide safe water for drinking and domestic use.

5. Dilution of waste water before their discharge into water bodies : Dissolved oxygen of the diluting water causes putrification of waste water due to biodegradation of organic compounds (aerobic) by bacteria (present in waste water), thereby effective concentration of organic matter in the diluted waste water decreases considerably. Evidently, the greater the pollution load in waste water , greater is the dilution required.

Water pollution control methods contd…

6.Removal of pollutants like phosphorus compounds , mercury, ammonia, sodium salts , phenolic compounds , etc. using special techniques such as adsorption , ion-exchangers, electrodialysis , reverse osmosis, etc.

7. Different types of settlement techniques like formation of precipitates can be applied.

8. Industrial and household waste water should not be discharged directly into water bodies.

Soil pollution

- Soil is the thin layer of organic and inorganic materials that covers the earth's rocky surface.
- Soil pollution is the addition of some chemical substances in an indefinite proportion to the soil system , whereby the fertility of soil changes.
- Any substance capable of changing the productive capacity of the soil is termed as soil pollutant.
- The polluted soil produces inferior quality of crop.

Sources of soil pollution

- Improperly disposed human and animal excreta , solid and liquid waste .
- Domestic refuge and industrial wastes dumped on land .
- Dumping of wastes from mineral and coal mining and metal smelting on land.
- Chemicals like fertilizers, pesticides , insecticides, etc. applied to plants and soil.
- Radioactive wastes discharged from industrial and research centers and hospitals.

Sources of soil pollution contd…

- Soil gets polluted by the removal of upper fertile layer.
- Soil erosion due to deforestation, over-grazing, unplanned irrigation and defective agricultural practice.
- Pollutants present in air and fall out from smoke stacks of chemical works.

Sources of soil pollution contd…

- Environment consists of gases like SO_2 , NO_2 , etc. SO_2 present in air undergoes oxidation to form SO_3 and may further react with rain water or moisture to form H_2SO_4.

$$SO_2 + O_2 \longrightarrow SO_3 \xrightarrow{H_2O} H_2SO_4$$

Similarly , NO_2 reacts with rain water or moisture in the presence of O_2 and produces HNO_3.

$$4NO_2 + 2H_2O + O_2 \longrightarrow 4HNO_3$$

(Nitric acid)

So formed H_2SO_4 and HNO_3 come down the earth as acid rain through the atmosphere.

Effects of soil pollution

a) Effect on environment

- Agrochemicals when sprayed on plants , affects all organisms directly or indirectly through food chain , thus have adverse effect on soil and water ecosystems including birds, fishes , etc.
- Metallic contaminants (Hg, Pb, Zn , As , Cr , K) destroy the beneficial microorganisms in soil.

Effects of soil pollution

- Industrial wastes containing various chemicals are extremely toxic to living beings.
- Solid wastes dumped in soil decreases the quality of soil. Hence it affects its fertility reducing plant productivity.
- Overgrazing and deforestation leads to partial or complete loss of soil fertility.

Effects of soil pollution contd….

b) Effect on human health

- Agrochemicals especially organic pesticides that enter human body by biomagnifications cause cirrhosis of liver , nervous disorder , and sexually defects.
- Excessive use of fertilizers contaminate water , when consumed such water affects digestive system and also reduces oxygen carrying capacity of haemoglobin.

Soil pollution control methods

1) Using sanitary landfills i.e. where untreated waste is buried in layers and covered with earth.
2) Soil pollution from agricultural waste can be reduced by

- Controlling the use of chemical pesticides and fertilizers and giving priority to bio-pesticides and bio-fertilizers.
- Utilizing the agricultural wastes in various ways such as production of biogas from animal refuge , compost from discarded vegetables and fruits .
- Applying proper drainage system while irrigating the crop fields so that water logging can be prevented.

Soil pollution control methods contd….

3) Industrial garbage should be treated before dumping .

4) Soil pollution from domestic garbage can be controlled by

- Establishment of dumping site far from urban areas .
- Recycling of garbage like paper, glass , tin , iron , etc.
- Producing compost from biodegradable wastes .

Soil pollution control methods contd….

5) An important aspect is to create public awareness about pollution hazards.

6) Afforestation should be encouraged . Forestation also helps to check the spread of desert.

7) Chemicals which have relatively high immediate as well as persistent toxicity (aldrin , dieldrin , arsenic compounds , etc.) may be used in special situations only and not for general use.

Soil pollution control methods contd…

8) High concentration of lead and cadmium can be controlled by growing a special type of grass .

9) Crop rotation should be adapted to revive the depleted nutrients in the soil .