Notes

33

AIR POLLUTION

Organisms have a close inter-relationship with their immediate environment. Oxygen from air is taken in during respiration and carbon dioxide released into the atmosphere by majority of organisms. The CO_2 is taken up by plants to manufacture food. This harmonious relationship between various organisms and nature has been disrupted by human activities. Intensive agriculture, industrialisation, urbanisation have degraded our physical resources and as a result soil, water and atmosphere have become highly polluted.

In this lesson we will define atmosphere and mention its constituents, discuss sources of air pollution and damage done to plant and animal life by atmospheric pollutatns. We shall also outline measures that can stop further atmospheric pollution.

Objectives

After reading this lesson you will be able to :

- explain the composition of air;
- define air pollution;
- explain respiration, photosynthesis and decay cycle;
- cite examples of major air pollutants;
- recall sources of major air pollutants;
- identify relationship between carbon cycle and oxygen depletion by fossil fuel burning;
- explain nitrogen cycle;
- define greenhouse effect;
- recognize factors causing greenhouse effect;
- explain global warming;
- define ozone layer;
- explain depletion of ozone layer;

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- explain acid deposition/acid rain;
- recognise ill effects of carbon monoxide on haemoglobin and
- list measures for reducing air pollution.

33.1 Composition of Air

You know that the atmosphere is a thin layer of air surrounding the earth. It is held around the earth due to gravitational pull of the earth. The air become thin (less dense) as we go higher up from the surface.

Most of the air is present within 50 km from the surface of the earth.

The atmosphere is broadly divided into four distinct zones, for example, troposphere, stratosphere, mesosphere and thermosphere.

Troposphere is the zone where all weather events occur.

Stratosphere is the zone of water vapour and ozone whereas in mesophere low concentrations of ozone is present.

Thermosphere is the zone where the gases are present in highly ionized form.

The temperature variation as we go away from earth is not uniform. It increases or decreases as we go higher from the earth.

The increase of temperature with the increase of altitude is known as **positive lapse rate.**

The decrease in temperature with the increase of altitude is known as **negative lapse rate.**

Positive lapse rate occurs in stratosphere and thermosphere. Negative lapse rate occurs in troposphere and mesosphere.

The composition of clean, dry and unpolluted air remains almost constant. The composition of air remains constant due to various natural cycles like carbon cycle, nitrogen cycle, etc. in nature. Any disturbance in the cycles has a harmful effect on organisms. Natural atmospheric air is made up of gaseous and non-gaseous constituents.

(a) Gaseous: Nitrogen and oxygen make up over 98% of volume of air. Other gases are CO_2, water vapour and inert gases such as argon, neon, krypton, helium, xenon radon and ozone are present in traces. These gases based on their available concertrations in the atmosphere are broadly catagorised as major, minor and traces (Table 33.1)

(b) Non-gaseous : Smoke, dust and salt (through evaporation from the sea) are the non-gaseous constituents of air.

Table 33.1 Composition of Atmosphere

Categories	Gas	Formula	Percent by Volume
Major	Nitrogen	N_2	78.09
	Oxygen	O_2	20.94
	Water vapour	H_2O	0.1 to 5
Minor	Carbon dioxide	CO_2	0.035
Trace	Helium	He	0.00052
	Methane	CH_4	0.00015
	Hydrogen	H_2	0.00005
	Sulphur dioxide	SO_2	0.000002
	Ammonia	NH_3	0.00001
	Carbon monoxide	CO	0.00001
	Nitrogen dioxide	NO_2	0.00001
	Ozone	O_3	Trace

33.2 Carbon Transfer Pathways – Respiration, Photosynthesis and Decay Cycle

There is a delicate balance between various constituents of air. Any disturbance in the concentration of the constituents due to pollution will adversely affect the organisms. For example, carbon is actively cycled between inorganic carbon dioxide and various kinds of organic compounds of which organisms are made up of. It moves from inorganic to organic form through the activity of autotrophs (auto; self; trophos : feed). The plants, synthesize food through photosynthesis are the "producers" in the food chain. The process which releases carbon dioxide into thc environment is **respiration.** It is a process indispensible for survival of almost all organisms. Another carbon transfer pathway is decay and decomposition of organic matter brought about by micro organisms.

33.2.1 Respiration

Respiration is a process of exchange of gases between organisms and atmosphere. Atmosphere is a reservoir of oxygen and organisms take in this oxygen for oxdiation of food. Oxidation of food liberates energy. When oxygen reaches the cell of an organism a series of enzyme catalysed reactions take place in which chemical bonds of glucose are broken, energy in the form of ATP (adenosine triphosphate) is liberated and carbon dioxide is released. Carbon dioxide goes back into the atmosphere. (Fig. 32.1) Thus a considerable amount of carbon dioxide is returned to the atmosphere through respiratory activity of organisms.

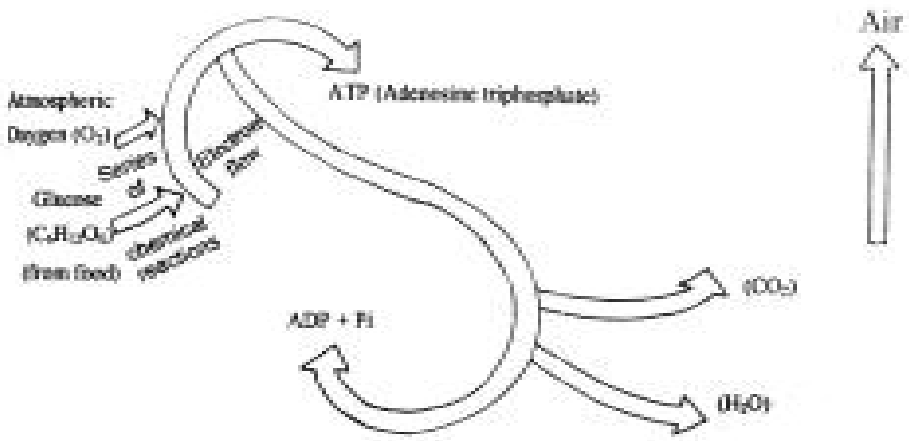

Fig. 33.1 : *Cellular Respiration*

Fig. 33.1 shows cellular respiration in which oxygen oxidises glucose through a series of chemical reactions and an electron transport chain. Energy is released in the form of several molecules of ATP. The CO_2 is given out and goes into the atmosphere. Some ATP molecules are also used up in the process and break up into ADP (adenosine diphosphate) and Pi (inorganic phosphate).

33.2.2 Photosynthesis

Green plants pick up CO_2 from the atmosphere and water from soil. Leaves of green plants contain a green pigment chlorophyll - the photosynthetic pigment. Leaves trap solar energy from sunlight. Light and the pigment interact and through a series of steps, starch is synthesized by plants and oxygen is liberated. Oxygen moves into the atmosphere (Fig. 33.2). Infact for the first two billion years after living organisms evolved on the earth, there was no oxygen. **Oxygen of the atmosphere resulted from photosynthetic organisms (e.g. plants).** So plants are responsible for providing oxygen on the earth which is so valuable to living organisms.

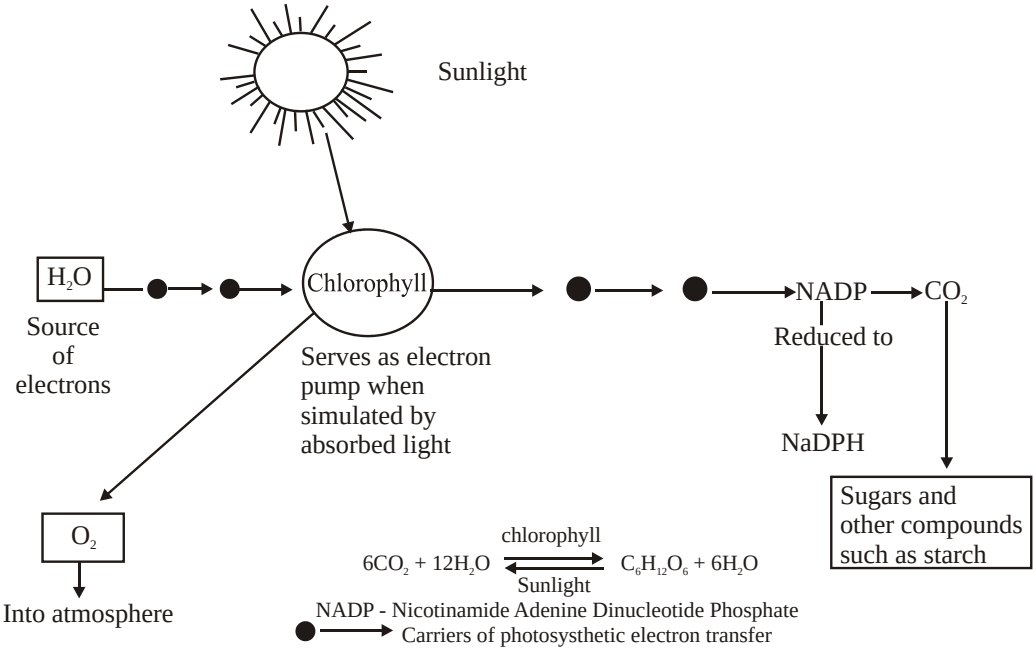

Fig 33.2 : *The Photosynthesis process*

33.2.3 Decay of Organic Matter

Micro organisms like bacteria and fungi bring about decay and decomposition of organic matter left after the death of organisms. Due to microbial (by microorganisms) decomposition of partially digested organic matter and dead organisms, CO_2 is liberated and released into the atmosphere. Thus the decay cycle also adds CO_2 to the atmosphere.

In swamps, paddy (rice) fields and wetlands, anoxic (lack of oxygen) conditions prevail. Methanogenic bacteria convert low molecular weight fatty acids into methane in these areas. These bacteria can also convert CO_2 into CH_4 through a special anaerobic respiratory pathway. An anaerobic pathway is one in which respiration takes place and food is broken down in the absence of O_2 since CO_2 is not available (as in case of aerobic respiration) to autotrophic

Very few organism, such as methanotrophs and nitrifers can oxidise methane and reintroduce carbon into the normal carbon cycle.

33.3 Carbon Cycle in Nature

Carbon cycle is the most important biogeochemical gaseous cycle. Also, carbon is returned to the environment as fast as it is removed.

The richest source of carbon is the ocean where carbon exists as carbonate and bicarbonate ions. Carbon enters the atmosphere mainly as a product of aerobic respiration in the form of CO_2. Volcanic eruptions also release carbon from rocks deep in the earth's crust. CO_2 is taken in by plants for photosynthesis during which they use light energy for reducing CO_2. Plants are, therefore, termed **photoautotrophs.** (photo means light). There are other organisms such as some bacteria which use energy stored in chemical bonds for reducing carbon dioxide to methane. They are termed **Chemoautotrophs.** Photosynthesis, however, is the most important process through which inorganic carbon is converted into organic form.

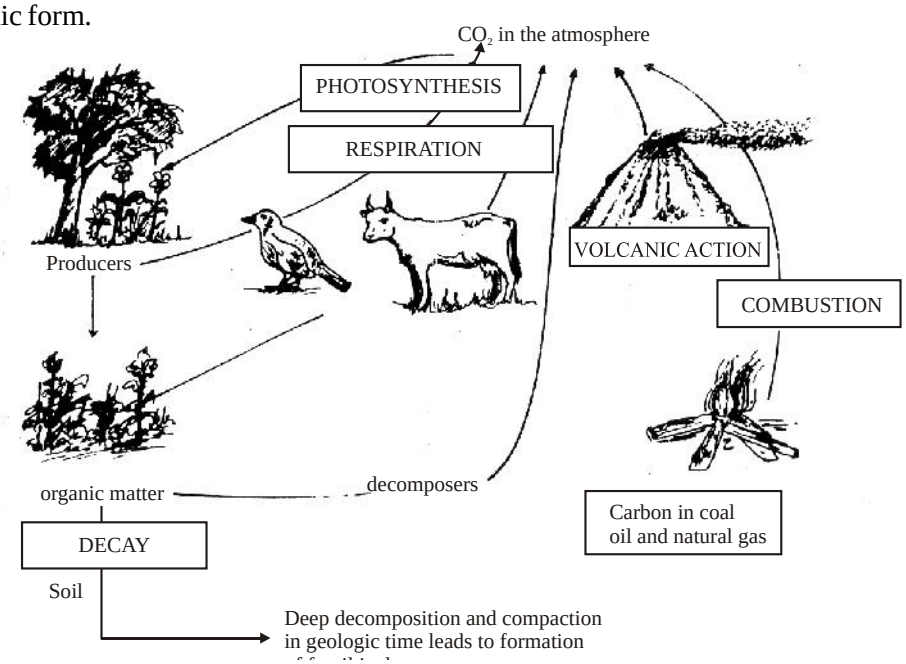

Fig. 33.3 : *The Carbon Cycle in Nature*

When producers and consumers die, decomposers reduce the organic matter of these dead organisms and carbon moves into the soil. Producers, consumers and decomposers add CO_2 to the atmosphere through respiration. Thus a balance in the proportions of O_2 and CO_2 is maintained in nature. (Fig.33.3)

When trees die and fall they get buried in the sediments and over a long geological time they become fossil fuels. Fossil fuels are buried deep in the soil. Carbon in this form remains unavailable till humans deliberately remove it.

33.4 The Nitrogen Cycle

Nitrogen and its compounds are essential for the maintenance of life processes in the biosphere. For example, organisms cannot exist without amino acids, peptides, and proteins, all of which are organic molecules containing nitrogen.

Nitrogen is the most abundant gas (about 78% of the atmosphere), however, plants cannot use free nitrogen (N_2) directly. Plants, algae and bacteria take up inorganic nitrogen either as the nitrate ion (NO_3^-) or the ammonium ion (NH_4^+) from the environment and use it to build their own protein molecules i.e. organic nitrogen . Organic nitrogen is consumed by animals and human beings to build their bodies.

Nitrogen is a relatively inert element and there are few processes that convert the stabilized nitrogen to available nitrogen compounds. Nitrogen gas in the atmosphere is transformed by lightning or bacterial uptake to nitrates or ammonia. In natural process the nitrogen-fixing bacteria (some blue green bacteria) have a highly specialized ability to "**fix**" nitrogen i.e. they change it to less mobile, more useful forms by combining it with hydrogen to . . . . . $_3$). This is called **Nitrogen fixation.** In this form the nitrogen is used up by plants and algae. They convert inorganic nitrogen compounds into organic compounds and nitrogen becomes available. Through ecological food chains organic nitrogen enter into other living organisms including humans and animals.

When organisms die, other bacteria are able to convert the organic compounds containing nitrogen back to nitrates, ammonia and then to molecular nitrogen (gas). In this way molecular nitrogen is returned back to atmosphere. The process of releasing fixed nitrogen back to molecular nitrogen is know as **denitrification**. The nitrogen cycle is shown in Fig 33.4.

Nitrogen fixation : $N_2 \longrightarrow NH_3$ (By bacteria)

Denitrification: NO^-_3 or $NO^-_2 \longrightarrow N_2$ (by bacteria)

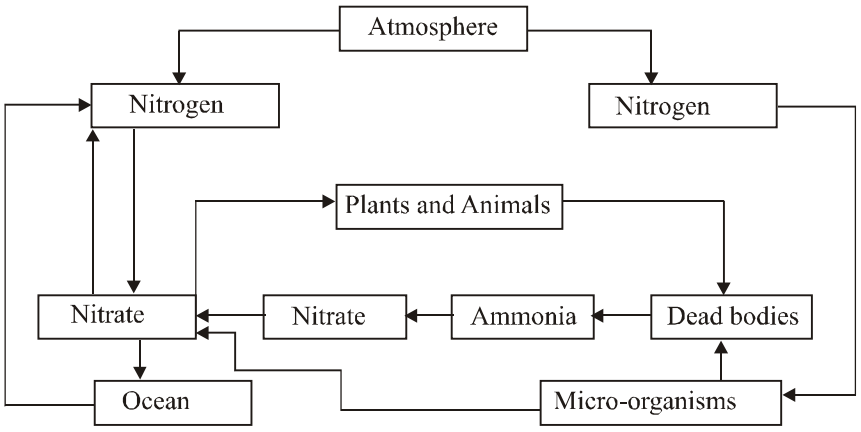

Fig.33.4 : *The Nitrogen Cycle*

Intext Questions 33.1

1. Which gas is present in the maximum amount in the atmosphere?

   .....

2. Name any two major constituents of air.

   .....

3. Which organisms are called autotrophs and why?

   .....

4. Name the food constituent which is broken down during respiration to liberate energy and carbon dioxide.

   .....

5. What is the green photosynthetic pigment present in plants?

   .....

6. How does carbon get into the enviromnent from dead organic matter?

   .....

7. Are humans producers or consumers?

   .....

8. Name two physical phenomena by which carbon is fixed in the nature.

   .....

9. Name the atmospheric layer where ozone is mainly available.

   .....

33.5 Air Pollution

You have just learnt how nature has its own means of using up and getting back its components such as CO_2, O_2 and N_2. If the balance of CO_2, O_2 or N_2 is disturbed by human activity then it will have adverse affect on life on the earth. Now you know why environmentalists are deeply concerned about environmental pollution, tree plantations and afforestation.

Undesirable changes have occurred in the physical and chemical constituents of air due to human activities. Undesirable change in the atmosphere is air pollution. Pollutant gases such as SO_2 oxides of nitrogen, CO and excessive amount of CO_2 have been added to the atmosphere. Air pollutant may be classified as particulate matter, liquid droplets and gaseous pollutants (Fig 33.5) :

Air Pollutants

Particulate pollutants	Liquid droplets	Gaseous pollutants
Soot	Hydrocarbons	SO_2
Fly ash		H_2S
Flourides		$NO_{(x)}$
Lead		NH_3
Dust from cement		CO_2 and CO
and other industries		Photo-chemical
Sodium chloride		oxidants (O_3, PAN)
Agricultural chemicals		Tobacco smoke

Fig. 33.5 : *Classification and Example of Air pollutants*

33.5.1 Particulate Pollutants

Particulate pollutants such as soot and fly ash are released by various industries as by products of industrial processes. They are blown away by wind when they come out of the chimneys and other outlets of industries and mix with air.

Suspended particulate matter is also emitted by exhaust of polluting diesel vehicles and ill managed coal fired power plants. In nature, forest fires, wind erosion and volcanic eruptions add suspended particulate matter into air. Examples of particulate pollutants are soot, flyash from thermal power plants, cement dust, petrocoke from petroleum refineries. Some of the particulate pollutants are discussed in detail below:

Fluoride: Aluminium, steel and electrochemical plants, blast furnaces, brick kilns, coal combustion, tile and glass etching factories add fluoride particles which settle on vegetation. They burn tips of leaves and when cattle eat the vegetation they suffer from fluorosis resulting in loss of teeth, weight and lameness. Humans also suffer from fluorosis. Volcanoes also release fluorides which form gaseous as well as particulate pollutant.

Lead: Lead particles come into air from automobile exhausts. Lead is used as an antiknock agent in automobile gasoline which contains tetraethyl lead. Paint, ceramic and pesticide industries also add lead particles to the atmosphere. Manufacture of lead storage battries and recycling of discarded battries add to lead pollution. Lead interferes with development of red blood corpuscles and causes anaemia (lack of haemoglobin - the oxygen carrying pigment of blood). Lead is a cumulative poison and prolonged exposure even in low concentration may damage kidneys and liver.

Dust: Particulate matter less than 10 microns in size is dust. It reaches lungs, deposits along the respiratory tract and causes asthma or even lung cancer. Dust from stone crushers is another example of particular pollutant.

Sodium chloride: Sodium chloride is used to remove snow in winter and remains in the enviromnent. Some sodium chloride is also added to the environment when waves of the sea spray it. Excess sodium chloride has been found to cause defoliation (leaf falling), suppression of flowering and breaking of terminal shoots of apple.

Agricultural chemicals: Chemical insecticides, herbicides and other pesticides are known to have damaging effects on plants. They are toxic to animals and humans also. Residues of pesticides get suspended as particulate matter in air.

33.5.2 Hydrocarbons

Hydrocarbons which may be in the form of liquid droplets or gas pollute air. As liquid droplets they spill or are added through seepage of oil fields and natural gas leakage. Methane is emitted in the swamps and paddy fields by methanogenic bacteria. Methane (CH_4) is also generated in stomachs of ruminant animals. Incomplete combustion of fuels release 3, 4 benzopyrene which causes lung cancer. Pesticides, paints and solvents also release hydrocarbons. Hydrocarbons are a source of photochemical smog.

33.5.3 Gaseous Pollutants

SO_2, CO_2, nitrogen oxides are commonly added to the air by human activities. Excess of these have very serious damaging effects on the physical environment as well as on humans.

SO_2 and H_2S : These are released into atmosphere through smelting of ores containing sulphur, manufacture of H_2SO_4 petroleum refining, combustion of fossil fuels, paper making, burning of sulphur containing refuse and in nature through volcanic eruptions. Plants exposed to SO_2 and H_2S show defoliation (leaves falling off) and reduced growth.

In humans, SO_2 pollution causes headache, vomiting, irritation of eye and respiratory passages. SO_2 reacts with water to form H_2SO_4 which is washed down as acid rain about \which you shall study later in the chapter.

Nitrogen Oxides: Anaerobic breakdown of nitrogenous compounds by bacteria is the natural source of nitrogen oxides. Burning fossil fuel also releases them. Power generators, automobile exhausts, explosives and nitrogenous fertilizer industries and the other anthropogenic sources produce nitrogen oxides.

NO_2: causes early dropping off of leaves and fruits in plants. Nitrogen oxides are one source of photochemical smog, acid deposition and greenhouse effect. .

CO_2 and CO : Combustion of oil, gas, coal and wood releases CO_2 in the atmosphere. CO is released chiefly from gasoline engines and burning of coal in defective furnaces. Motor vehicles with internal combustion engines emit high levels of CO and hydrocarbons. Excess of CO_2 can cause global warming, CO causes photochemical smog and has a fatal effect when inhaled by humans.

CO poisoning: CO has a high affinity for haemoglobin. It combines with the blood pigment haemoglobin to form carboxyhaemoglobin. The normal function of haemoglobin is to carry O_2. But CO combines with haemoglobin about two hundred times faster than O_2. Tissues do not get oxygen and die due to lack of oxygen. Carboxy haemoglobin is dark red in colour, the victims of CO poisoning have dark red lips. Mild CO poisoning causes lung disorders like bronchitis and emphysema. CO from cigarette smoke makes haemoglobin non functional in smokers.

Photochemical oxidants: Primary pollutants such as nitrogen oxides and hydrocarbons mix in the atmoshpere and form secondary pollutants like peroxyacetyl nitrate (PAN) and ozone, under the influence of UV radiation from the sun. Both PAN and O_3 form photochemical smog. PAN and O_3 are toxic to plants. In humans they cause irritation of eyes coughing, headache, dry throat, respiratory problems and haemorrhage.

Tobacco smoke: Smoke from burning cigarettes or bidis contains nicotine, aromatic hydrocarbons and tar. These cause problems of blood pressure and heart, windpipe and lungs in the smoker as well as those around the smoker. Cigarette smoke is also carcinogenic.

The various human and natural activities which introduce air pollutants into the atmosphere are summarised in Table 33.2

Table 33.2 : Common air pollutants, their sources and contribution of Natural and Anthropogenic pollution

Air Pollutants	Some Sources	Emission (% of total)	
		Natural	Anthropogenic
Sulphur oxide (SO_x)	Fossil fuel burning, industry biomass biomass burning, volcanoes, oceans.	50	50
Carbon monoxide (CO)	Incomplete combustion, methane oxidation, transportation, biomass burning, plant metabolism.	91	9
Nitrogen oxide (NO_x)	Fossil fuel burning, lightening, biomass burning, soil microbes.	40	60
Hydrocarbons (HC)	Fossil fuels, industrial processes, evaporation of organic solvents, agricultural burning, plant isoprenes and other biogenics.	84	16
Suspended Particulate Materials (SPM)	Biomass burning, dust, sea salt, biogenic aerosols, gas to particle conversion.	89	11

Intext Questions 33.2

1. What is atmospheric pollution?

   .....

2. Name two particulate pollutants.

   .....

3. Name two gaseous pollutants?

   .....

4. Name one source which causes pollution due to methane.

   .....

5. Name two air pollutants which form photochemical smog.

   .....

33.6 Effects of Excessive Atmospheric Pollutants on Nature (Outdoor Pollution)

You are now familiar with the various atmospheric pollutants. Most of these are products of fuel combustion. These pollutants have been released into atmosphere ever since human first started burning wood and coal. Later on, pollutants are being released into air due to increased industrial activity. The nature has not been able to remove all these pollutants

because much more pollutants are added than the nature can handle to maintain the balance. Therefore, pollutants have now accumulated in the atmosphere to a proportion whereby atmospheric composition of air has been significantly altered. It is the causes of physical phenomena such as photochemical smog, acid rain, ozone depletion, greenhouse effect and global warming. These are damaging to plants, animals and humans.

The figure Fig. no. 33.6 shows the four major effects of atmospheric pollutants. In the diagram, arrows from the pollutant depicts its involvement in the physical phenomenon. The sources of the pollutants are depicted below the names of the pollutants. The four major phenomena are subsequently discussed one by one. They are temperature inversion, photochemical smog, acid rain, greenhouse effect and ozone layer (shield) depletion.

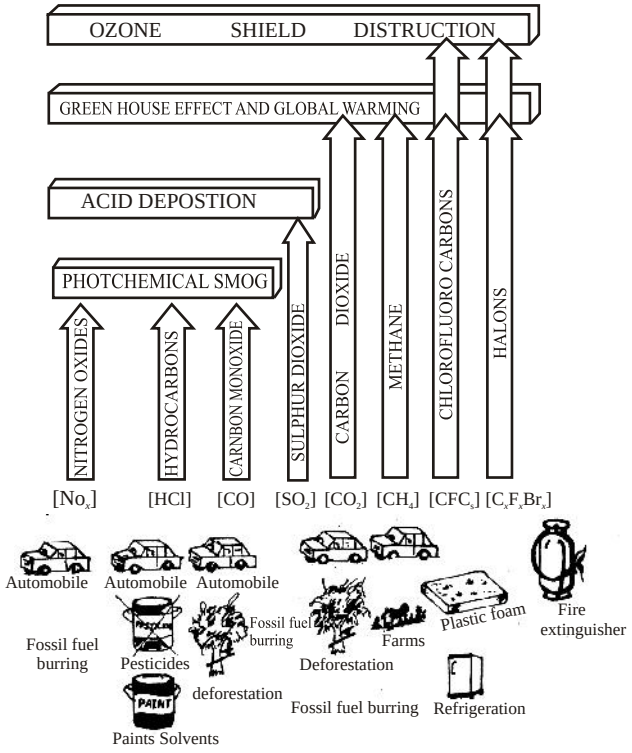

Fig. 33.6 : *Four Major Effects of Atmospheric Pollutants*

33.7 Temperature Inversion and Photochemical Smog

Pollutants like sulphur dioxide which is released while burning sulphur containing fuels (fossil fuels) and particulate matter like soot present in stagnant air masses, get modified in sunlight and form a sheet called photochemical smog.

Smog is a combination of fog, smoke and fumes released by mills and factories, homes and automobiles.

When sunlight falls on stagnant air under low humid conditions in the presence of pollutants such as SO_2 soot, nitrogen oxides and hydrocarbons, photochemical smog is formed (photochemical: chemical reactions in the presence of light). Smog stays close to the ground and reduces visibility and causes irritation.

Photochemical smog is also called *PAN **smog*** due to the formation of peroxyacetyl nitrate or PAN and ozone which are formed from hydrocarbons and nitrogen oxides in the presence

of solar radiation. PAN and ozone are called photochemical oxidants. Both of these are toxic irritants to human lungs.

Smog formation is accompanied by ***Temperature inversion or Thermal inversion,*** Temperature inversion causes smog to settle and remain near the ground till wind sweeps it away. Normally, warm air rises up into atmosphere. When a layer of cool air at the ground level is held there by an overlying layer of warm stagnant air. It is called **temperature** or **thermal inversion** (Fig.33.7).

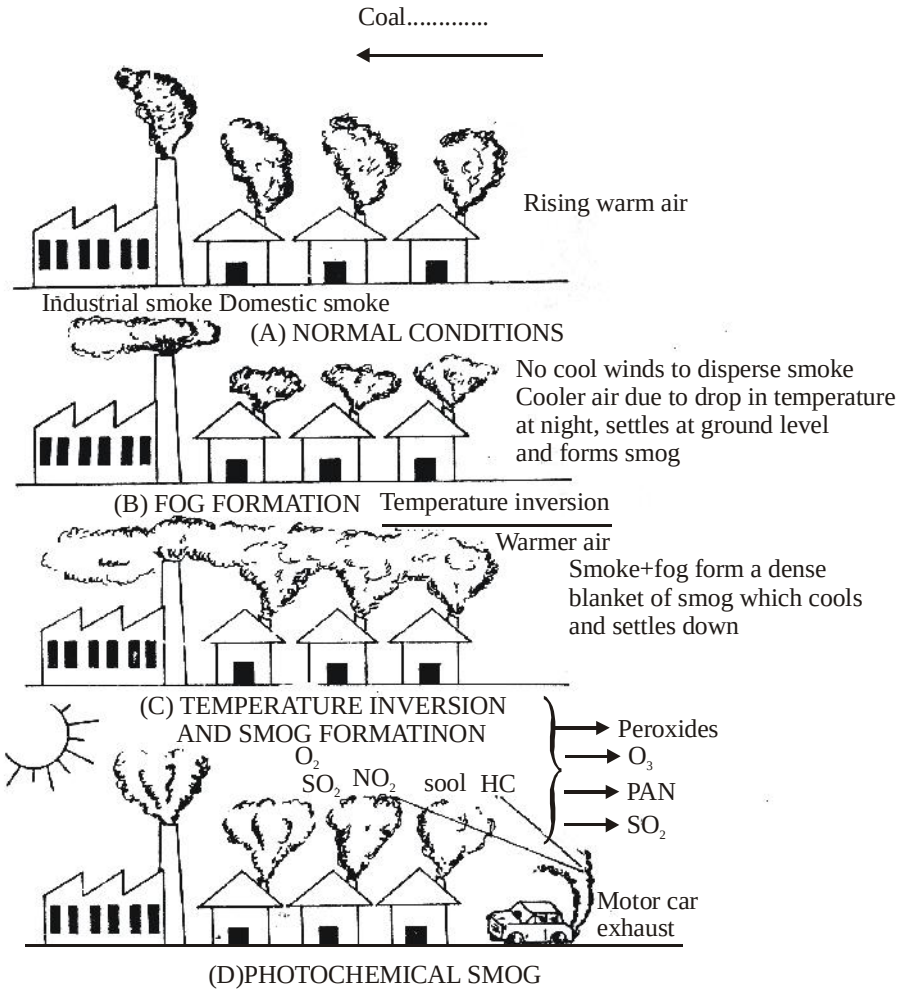

Fig. 33.7 : *Formation of Photochemical Smog and Temperature Inversion*

Exposure to smog causes respiratory problems, bronchitis, sore throat, cold, headache and irritation to eyes (red shot eyes). Smog also damages crops and reduces crop yield.

33.8 Acid Rain

Coal and oil burned by power plants and other industries release SO_2 into air because coal and oil contain small amount of sulphur. Automobile exhausts add SO_2 and nitrogen oxides to the air. Both SO_2 and nitrogen oxides are converted into acids HNO_3 and H_2SO_4 when they combine with oxygen and water vapour in the atmosphere as per the following photo chemical reactions.

$$2SO_2 + O_2 + 2H_2O \rightarrow 2H_2SO_4$$

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

This reaction is promoted by O_3 in smog. The acids, so formed are washed down from air to earth during rain or snow fall. It is called acid rain or acid snow. The acids react with minerals present in soil to form sulphates and nitrates due to acid rain.

Rain water even in its purest form is slighlty acidic with pH 5.6 due to dissolved CO_2. But areas near coal and oil burning industries and where motor vehicles ply in large numbers, pH goes down to 2 and rain becomes strongly acidic. Mountain foot hills are the worst affected. There is moisture laden air rises to higher altitudes it condenses to fall as rain or snow, dropping its load of pollutants. In spring. snow melts and adds pollutants to lakes and other water bodies.

When the dissolved pollutants drop as rain or snow (wet deposition) it is termed acid precipitation. Deposition of dry gases and salts is dry deposition. Acid rain spreads over areas of several hundreds to several thousand kilometers.

33.8.1 Effects of Acid Rain

Some of the effects of acid rain are listed below:

(1) Excessive acid concentrations are phytotoxic (toxic to plants). There have been widespread death of trees in forests due to acid rain.

(2) Sea waters are rich in minerals and have great buffering capacity. But buffering capacity of fresh water bodies is low and acid deposits have a toxic effect on the fresh water ecosystems.

(3) Mature (capable of reproduction) fish survives in acid rain fed water bodies but fails to reproduce. So there are no young fish in such waters.

(4) Exposed surfaces of buildings, statues get corroded. Limestone or marble ($CaCO_3$) structures are specially damaged (Fig. 32.8).

The chemical reaction is like
$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + CO_2 + H_2O$.

The sulphates are leached out by rain water.

(5) Acidic sulphate when present in the atmosphere causes laziness. Acidic mist falling on the ground reduces visibility.

Fig. 33.8 : *A Stone statue showing corrosive effects of Acid Rain*

33.9 Green House Effect and Global Warming

The literal meaning and function of green house is to trap the heat. You must have seen delicate plants being grown in a glass chamber which is comparatively warmer inside than outside. Glass permits solar radiations to come in but restricts the outward movement of heat. The radiations get trapped inside the glass chamber and raises the temperature.

Gases such as CO_2, NO_2, CFCs (chloro fluorocarbons) allow sun rays to pass through them but then absorb and reradiate the heat back towards the earth. These are therefore termed as **green house gases**.

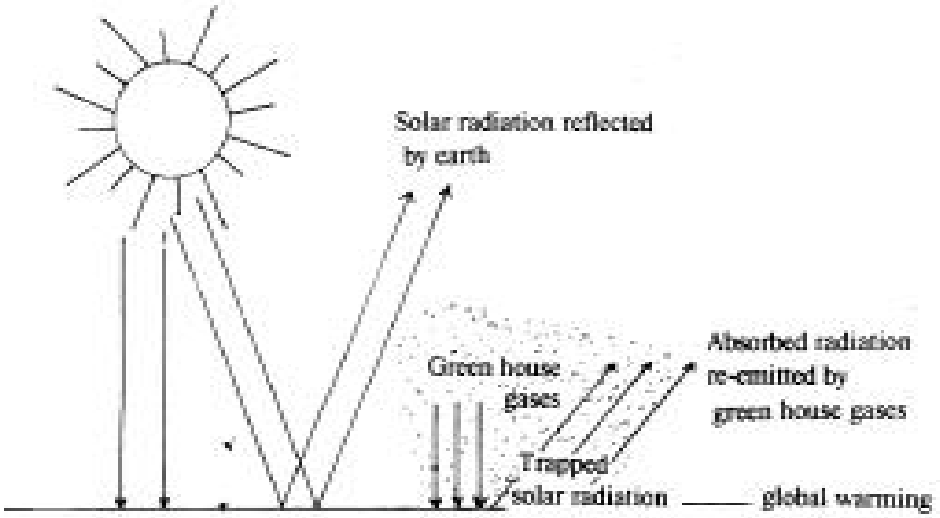

Fig. 33.9 : *Green House Effect*

33.9.1 Greenhouse Gases

The common green house gases and their sources of pollution are listed below:

(1)	CO_2	-	from fossil fuel burning.
(2)	NO_2	-	from fertilizer plants, automobile exhaust use and animal waste.
(3)	CH_4	-	from bacterial decomposition, biogas, flooded rice fields.
(4)	CFCs	-	from freon, (a refrigerant), areosol sprays.
(5)	HALONS (halocarbons)	-	from fire extinguishers.

33.9.2 How Does Earth's Atmosphere Trap Heat?

Radiations (ultra violet) from the sun penetrate the earth's atmosphere and reach earth. The surface of earth partially absorbs the radiations. The rest is re-radiated as infrared radiation from the earth's surface. In polluted air, molecules of CO_2, CH_4, CFCs, N_2O, O_3 and water vapours are present. These gases can absorb infrared radiations but cannot absorb the ultra violet radiations. Energy of these trapped radiations raise the temperature of earth and its atmosphere. Thus if proportion of green house gases increases in the atmosphere heat trapped by them will raise the temperature of the earth and will cause global warming.

Greenhouse effect leading to global warming shall have severe effects on rainfall, sea level, plant and animal growth..

Global warming is defined as the increase in the average global temperature of the atmosphere near earth's surface.

(1) **Rise in sea level:** It is estimated that by the turn of the century a rise of 5°C in global temperature will be due to effect of greenhouse gases if not checked now. Polar ice caps would melt because of rise in temperature and add more water to sea. Moreover water expands when it heats up. This will lead to rise of sea level. It will flood the low lying coastal area and many cities will get submerged in water.

(2) **Drought:** A 3° C warming will result in 10% decrease in precipitation (rain fall) and this will decrease rain fall causing drought conditions.

(3) **Effect on plant growth:** Drought will reduce photosynthesis in plants and lead to reduced growth of plants.

(4) **Effect on animals:** Warmer conditions will encourage growth of pests.

(5) **Water shortage:** Increase in temperature will lead to increased evaporation leading to shortage of water for agricultural, municipal and industrial use.

(6) **Climatic changes :** It has great effect on climate changes. For example, spring now occurs about a week earlier than normal time.

(7) **Increase in CO_2** Warmer conditions accelerate microbial degradation of organic matter and add more CO_2

(8) **Day and Night temperature :** Night temperatures have increased more than day temperature as green house gases prevent heat from escaping at night.

(9) **Formation of ozone hole :**

The atmosphere has two layers, the stratosphere and troposphere. Stratosphere lies 15 km to 50 km above the surface of earth. The energy of the sun splits some molecular O_2 in this layer to give individual (O) atoms which combine with intact molecular oxygen to give O_3. The layer of O_3 forms a shield as it absorbs UV rays and prevent them from striking the earth. If UV rays penetrate our atmosphere the life would not be possible as organisms cannot tolerate heavy doses of UV radiation. Troposphere is the atmospheric layer closest to the earth's surface whose compostion you have already studied. Chloro fluorocarbons and halons released into the atmosphere have destroyed the ozone shield and an ozone hole has been detected at the South Pole of Antartic and North Pole of Arctic.

33.10 Depletion of ozone layer

Ozone shield depletion is primarily caused due to the following reasons:

(a) Chlorofluorocarbons (CFCs) are the heat transfer agents used in refrigerators and air conditioners, and foaming agents in foam cups and cartons.

(b) Halons or halocarbons are anti fire agents used in fire extinguishers.

The ozone in the stratosphere is being depleted by the presence of mainly chlorofluorocarbons (CFCs) and halogen gas, particularly chlorine. The highly energetic ultra violet radiation splits up the CFCs, releasing chlorine. The released chlorine is responsible for convertion

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of the ozone into oxygen molecule consequently depletion of ozone layer occurs as per the following equations.

$$Cl + O_3 \rightarrow ClO + O_2$$

$$ClO + O \rightarrow Cl + O_2$$

It is believed that one molecule of CFC is capable of destroying 1,00,000 ozone molecules in the stratosphere. The area where the ozone is completely destroyed is known as **ozone hole.** The first ozone hole was observed over Antaractic Ocean.

The important function of ozone layer in the stratosphere in to protect us from dangerous ultra violet (UV) radiations from the sun by absorbing it.

33.10.1 Effects of Ozone Depletion

Ozone layer depletion will allow more UV rays to enter the troposphere and will cause a series of harmful effects such as :

(1) Plants and animals living on the surface will start dying.

(2) UV radiation will fasten the formation of smog

(3) Temperature of the earth will increase leading to rise in sea level and flooding of low lying areas.

(4) More UV rays will directly fall on the skin of humans causing skin cancer.

(5) Leaves of plants will show chlorosis (loss of chlorophyll and yellowing),

33.11 Effects of Air Pollution on Humans

Air is mobile and impact of air pollution on ecosystems is reduced as wind blows away pollutants. But when winds are calm, air pollution becomes not only damaging but life threatening.

The damaging effects of atmospheric pollution have been described along with the account on pollutants. Long term exposure to moderate pollution causes more discase and death. Some adverse effects of air pollution on humans are summarised in table 33.3.

Table 33.3 : Effects of air pollutants on humans

Disease / Discomfort	Caused by
Emphysema. Bronchitis	CO, SO_2, PAN, O_3
Eye irritation, headache	SO_2, PAN, O_3
Silicosis. Asbestosis	Suspended particulate matter like silica, asbestos.
Coronary artery disease	Tobacco smoke
Anemia, kidney, liver damage	Pb
Fluorosis, Skin Cancer	Fluorides
Poisoning death	CO

33.12 Control of Air Pollution

The alarming rate at which the atmosphere is being polluted, soon there will be more ailing human beings than healthy. The need of the hour is to put a quick check to atmospheric pollution.

Since most of air pollutants are emitted during combustion of fossil fuels, there are two practical approaches for air pollution control which are discussed below :

(i) One approach is control undesirable changes in the air we breathe by observing the following precaution :

(a) Limiting pollutants into air by using sulphur-free oil and coal, using catalytic convertors in automobiles and avoiding burning of waste material.

(b) Taking stringent measures against release of emissions from industries.

(ii) The other approach is to use sources of energy other than fossil fuels such as wind, water, solar power, etc. Use bicycles and battery powered cars rather than vehicles with internal combustion engines. Service vehicles should use lead free petrol.

Above all, it is necessary to educate the general public. Air pollution should become every human being's concern. Only then will the air become more congenial to healthy living.

Intext Questions 33.3

1. What is smog?

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2. Name two photochemical oxidants.

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3. Name two gases which form acid rain.

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4. Mention any four greenhouse gases.

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5. What are the sources of freons and halons in air?

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6. What effect does acid rain have on marble statues ?

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7. Mention one measure to control air pollution.

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What You Have Learnt

- Nature's balance has beeen upset by human activities releated to urbanisation, industrialisation and intensive agriculture.
- Atmosphere is made up of gases of which nitrogen - 78%, oxygen - 21%, carbondioxide - 0.1 to 0.3%, inert gases 1 %
- Increase of temperature with altitude is known as positive lapse rate where as decrease in temperature with increase of altitude is negative lapse rate of temperature.
- Carbon is actively cycled between its inorganic form to organic form through respiratioin and photothenthesis. Decay cycle converts organic carbon to inorganic carbon.
- During respiration food is oxidised through a series of enzyme controlled steps in which chemical bonds of glucose are broken down to release energy and CO_2 is liberated.

- In photosynthesis green plants trap solar energy and synthesize starch from CO_2 and H_2O. Oxygen is released into air.
- After death of organisms are degraded by microorganisms. The carbon in organisms moves back enviornoment.
- Air pollution is due to

  (i) particulate matter (soot, dust)

  (ii) aerosols composed of hydrocarbons

  (iii) gases like SO_2, NO_2 are mostly released by burning fossil fuels.
- NO_2 and hydrocarbons are modified by sunlight to form photochemical smog. Smog is a combination of smoke and fog. Automobile exhausts give out NO_2 and hydrocarbons. They form PAN (peroxyacetyl nitrate) which along with ozone and SO_2 forms photochemical smog.
- Smog cools and settles down near the earth and forms a blanket, while warmer air covers it. Thus there is a 'temperature inversion' with warm air above and cool air below unlike in the normal conditions.
- SO_2 and NO_2 form acids which drop as H_2SO_4 and HNO_3 on statues and spoil them. This is called acid precipitation. Acid rain kills trees, prevents reproduction in fish and causes poor visibility.
- Greenhouse gases are CO_2, NO_2, CH_4, chlorofluorocarbons and halons. They trap solar radiation and cause global warming.
- Global warming due to greenhouse effect leads to drought, rise in sea level, lack of rain and water shortage.
- There is a layer of ozone in stratosphere, which protects us from UV radiation by absorbing it.
- Chlorofluorocarbons which are used in refrigerators and foam cups as aerosols and halons used in fire extinguishers, when released into the air cause depletion of ozone shield which protects us from harmful effects of solar radiations. It is feared that ozone depletion will have damaging effects on humans such as causing skin cancer.
- Complete destruction of ozone layer over an area is termed as ozone hole.
- Air pollution causes respiratory diseases such as emphysema and bronchitis, eye irritation, fluoroisis, cancer and may even be fatal.
- Control measures include use of sulphur free oil and coal, use of alternative sources of energy such as wind and solar power, use bicycle and battery powered vehicles, stop burining waste indiscriminately, have stringent measures for release of emissions from industries and above all educate general public and caution them against releasing air pollutants.

Terminal Exercise

1. How are fossil fuels formed in nature?
2. What are the damaging effects of SO_2 and NO_2 on plants and animals?

Notes

3. Write a note on carbon monoxide poisoning.
4. What is thermal inversion and how is it caused?
5. Enumerate the various effects of acid rain.
6. What is ozone hole? What are the effects of ozone depletion?
7. Why does sea level rise due to global warming?
8. How do greenhouse gases cause global warming.
9. Mention five disease/discomforts in humans caused by different air pollutants.
10. Enumerate the various measures of control of air pollution.

Answers to Intext Questions

33.1

1. nitrogen
2. nitrogen and oxygen
3. plants; because they synthesize their own food
4. glucose
5. chlorophyll
6. through decay and decomposition
7. consumers
8. (i) volcanic eruption and (ii) combustion
9. Stratosphere

33.2

1. undesirable level of undesirable and harmful substances in the atmosphere
2. soot, fluoride, Pb dust, NaCl (any two)
3. SO_2, CO_2, CO, NH_3, H_2S (any two)
4. methanogenic bacteria, ruminant stomach, fermentation in water logged paddy fields (any one).
5. PAN and O_3

33.3

1. fog and smoke
2. O_3 and PAN
3. SO_2 and NO
4. CO_2, NO_2, CH_4, CFC, Halons
5. refrigerants, fire extinguishers
6. corrode them
7. reducing use of fuel which releases air pollutants and use clean renewable fuels. Educate everyone about dangers of pollution.