GREENHOUSE EFFECT

Greenhouse means a building made mainly of glass, with heat and humidity regulated for growing plants. The atmosphere acts like a glass in a greenhouse.

Atmosphere, like glass absorbs some of the long wave radiation emitted by earth and radiates the energy back to the earth. In this way temperature of the earth is maintained.

The atmosphere surrounding the earth in this manner plays a vital and important role in maintaining an even temperature on the earth's surface.

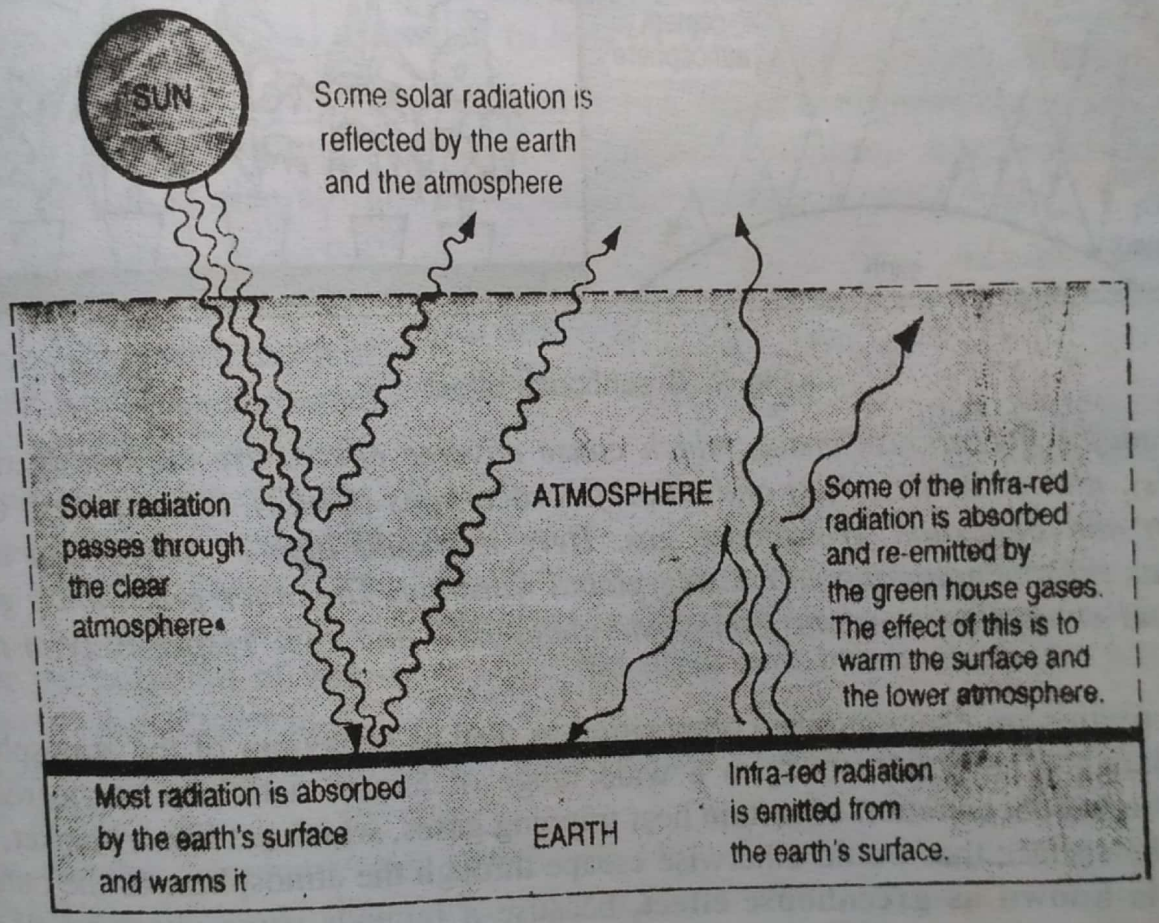

Fig. 1. Simplified representation of global warming.

In a greenhouse, visible light passes through the glass and heats up the soil warming the plants. The warm soil emits radiation in longer wavelengths, particularly in the infrared. Because glass is opaque to longer wavelength of infrared radiation, it partly reflects and partly absorbs infrared radiation. This mechanism keeps the greenhouse warmer than the outer atmosphere.

Thus a ***greenhouse*** *is that body which allows the short wavelength incoming solar radiation to come in, but does not allow the long wave outgoing terrestrial infrared radiation to escape.*

In a similar way, the earth's atmosphere bottles up the energy of the sun, and is said to act like a **greenhouse,** where CO_2 acts like glass windows. CO_2 and water vapours in the atmosphere transmit short wavelength solar radiation but reflect the longer wavelength heat radiation from warmed surface of the earth. CO_2 molecules are transparent to sunlight but not to the heat radiation. So they trap and re-enforce the solar heat stimulating an effect which is popularly known as **greenhouse effect.**

The ***Greenhouse effect*** *may therefore be defined as the progressive warming up of the earth's surface due to blanketing effect of manmade CO_2 in the atmosphere.*

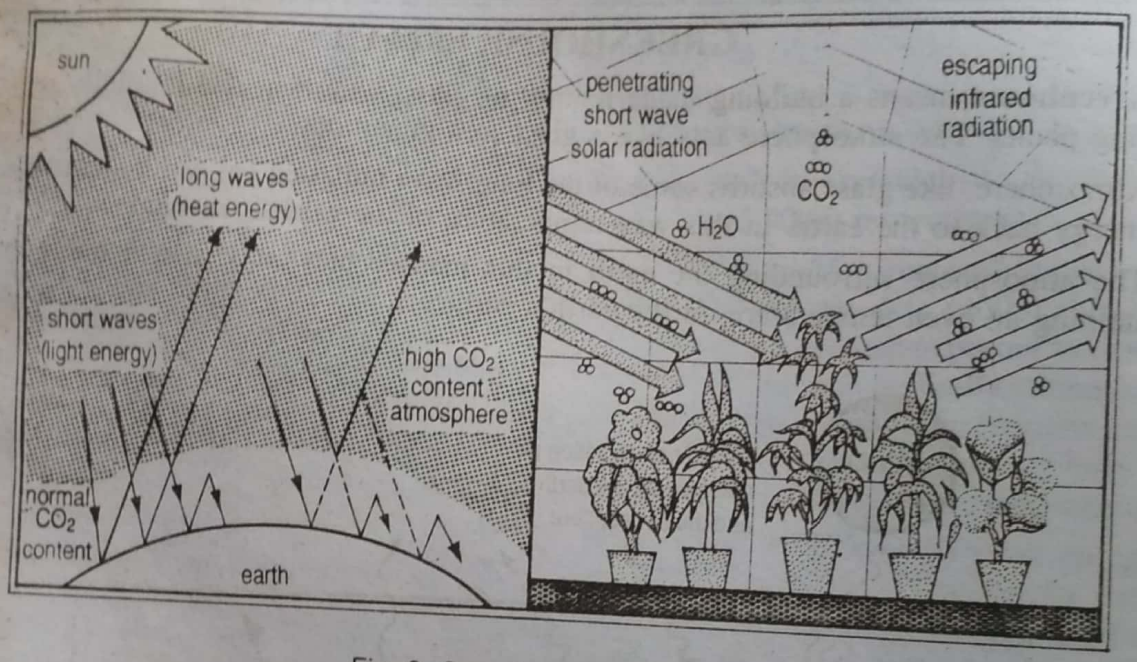

Fig. 2. Greenhouse effect.

The four major greenhouse gases, which cause adverse effects are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs). Among these CO_2 is the most common and important greenhouse gas. Here it should also be noted that ozone and SO_2 also act as serious pollutants in causing global warming. The other greenhouse gases such as methane and chlorofluorocarbons contribute about 18% and 14% respectively to the global warming.

Human activities are changing the composition as well as behaviour of the atmosphere at an unprecedented rate. The pollutants from a wide range of human activities are increasing the global atmospheric concentration of certain heat trapping gases, which act like a blanket, trapping heat close to the surface that would otherwise escape through the atmosphere to the outer space. **This process is known as greenhouse effect,** because it reminds some observers of the heat trapping effect of the glass walls in a horticultural greenhouse.

HOW THE GREENHOUSE EFFECT IS PRODUCED

Under normal concentrations of CO_2, the temperature of the earth's surface is maintained by the energy balance of the sun rays that strike the planet and the heat that is radiated back into the outer space. However, when concentration of CO_2 in the atmosphere increases, the thick envelop of this gas prevents the heat from being re-radiated out. The heated earth can re-radiate this absorbed energy as the radiation of longer wavelength.

...ck CO_2 layer acts like the glass panels of a greenhouse or the window glass of ... allowing the sun rays to filter through but preventing the heat from being escaping ... space, thereby warming the troposphere of the atmosphere. This phenomenon can ... experienced when one returns to the car after a while whose window glasses are closed ... to expect the heat inside on a warm day. This is what happens in a greenhouse. Thus ... effect is a phenomenon which is based on the principle of infrared absorption char... of gases. Higher the concentration of CO_2, greater will be the absorption of thermal ... which means that more infrared radiation is trapped and re-emitted back to earth's ... leading to a **heat trap** increasing **mean global temperature**. (Fig. 3).

GREENHOUSE GASES

...ually for the Earth, **water vapour** is the most important of all greenhouse gases. Water ...or absorbs IR in the region 2.5 to 3.5 μm, 5 to 7 μm, as well as over a broad range above ... The mixing ratio of water vapour is highly variable in time and space, but the global ...e-humidity is constant at about 1% and there are no anthropogenic activities that directly ...ase it to increase. Nevertheless gaseous water is involved in feedback processes : positive in ...r a raised global warming means increased evaporation from ocean and land surfaces leading ...ger rates of atmospheric water, thereby enhancing warming; negative in that the troposphere ...omes more cloudy leading to increased reflection and absorption in the atmosphere so that ...e solar flux at the solid/liquid surface of the Earth is reduced. In 1985, greenhouse warming ...ociated with water vapour was estimated to be 110 Wm^{-2}.

It is now well established that **carbon dioxide** is a major contributor to greenhouse effect. ...rbon dioxide absorbs in the range of 14 to 19 μm, and completely blocks the radiative flux ...tween 13 and 16 μm. It also absorbs at wavelengths between 4 and 4.5 μm.

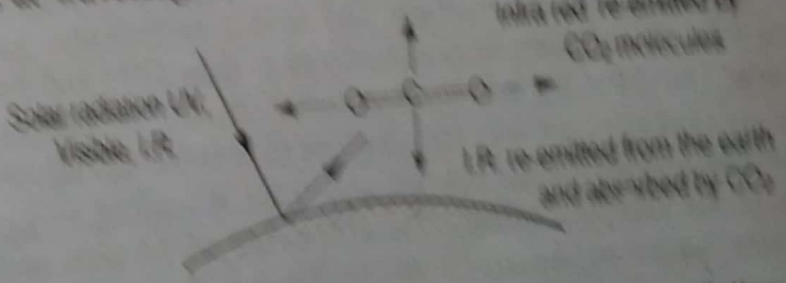

Fig. 3. An illustration of greenhouse effect. IR radiation absorbed by CO_2 molecules is re-emitted in all directions deflecting some back to the earth's surface.

Water and carbon dioxide are the ...o most important greenhouse ...ses. Together, they absorb much of ...e radiation in the thermal infrared ...gion below 7.5 μm and above 13 ...m. Between these two wavelengths, ...y little IR radiation is absorbed by ...ese gases, and this part of the ...ectrum is regarded as **window** ...gion to the radiation of inter... ...se. Other gases which absorb in that ...gion, however, partially close the window and can have a major effect on heat retention in the ...gion of the earth.

Methane, another greenhouse gas, absorbs radiation in the wavelength ranges from 3 to 4 ...m and 7 to 8.4 μm (in the window region). According to 1985 estimates, methane contributes ...7 Wm^{-2} to greenhouse warming.

Ozone absorbs at between 9 and 10 μm in the IR region and it therefore acts as a highly ...efficient greenhouse gas. In the troposphere, ozone concentrations are highly variable, partially ...ecause it has a short lifetime. Greater production of NOx by fossil fuels burning and forest and ...grassland fires has resulted in net lower troposphere concentration of ozone by about 1.6%. ...the northern hemisphere. The decrease in concentration of ozone in the stratosphere allowing ...more UV radiation to reach the earth also contributes to greenhouse warming. The overall ef... ...has been estimated to be 1.3 Wm^{-2} in 1985.

Nitrous oxide absorbs IR radiation in the ranges 3 to 5 μm and 7.5 to 9 μm (infrared window). According to 1995 estimates its concentration was about 312 ppbv and it is increasing at a rate of 0.3% per year. It has approximately the same effect on warming as does ozone. There are no important tropospheric sinks for nitrous oxide gas, so it is lost only by slow leakage into the stratosphere where it undergoes photolytic degradation. It, therefore, has a substantial tropospheric residence time estimated to be about 120 years.

In addition to their role as agents for the catalytic decomposition of stratospheric ozone, **chlorofluorocarbons (CFCs)** are also important greenhouse gases. They absorb in the range 8 to 12 μm with each CFC having specific absorption bands in this region. Thus CFC–11 absorbs at 9.5 μm and 11.5 μm, and CFC-12 at 9.5 and 11.0 μm.

The **hydrochlorofluorocarbons (HCFCs)** also attenuate radiation within the same range, but their residence time in the troposphere is much shorter than that of the CFCs. The rate of increase of the CFCs has declined by a factor greater than two in the past decade, but HCFC concentrations are increasing at a much higher rate.

Three fully fluorinated gases of industrial origin have recently been recognised as potential contributors to global warming. They are present in trace amounts, but have life time of thousands or tens of thousands of years. **Tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6)** both are produced during electrolysis of alumina (Al_2O_3) in cryolite (Na_3AlF_6) at carbon electrodes. The release of the gases has been estimated to be at about 0.77 and 0.1 kg respectively per tonne of aluminium produced. The other gas is **sulphur hexafluoride (SF_6)** which is formed during magnesium production.

Researchers in the US and Europe have made an alarming discovery that the

The greenhouse effect will bring about the following important changes in the climate of the Earth.

(a) *As a result of rise in temperature of the earth due to greenhouse effect the oceans get warm up and sea level would rise flooding low lying regions. A slight increase in sea level could have profound effects on habitation patterns causing many people to move and many of the world's most important cities and ports to come under the threat of floods. In this way, many poor or developing nations may lose large areas of precious coastal land to the rising levels of sea.*

(b) *In temperate regions, the winter will be shorter and warmer and the summer will be longer and hotter. A warmer climate is likely to make some cities extremely hot.*

(c) *There will be enormous increase in rainfall but the problems of desertification, drought and soil erosion will further worsen.*

(d) *The tropics may become wetter and the subtropics, which are already dry, are expected to be drier.*

(e) *The rapid increase in industrialisation and urbanisation, coupled with drastic decrease in forest cover, will create a layer of impenetrable gases on the surface of the earth atmosphere converting the planet Earth into a hot blast furnace.*

(f) *The plants and animals will also be affected resulting in the disruption of the whole ecosystem.*

(g) *The most obvious effect of climate changes will be on agriculture. Because CO_2 is a natural fertilizer, the plants will grow larger and faster with increasing CO_2 in the atmosphere. At first sight, the abnormally fast growth of plants might be expected to be beneficial because the yields of major crops might increase, but with the increase in the yield, the soils may become impoverished or poor more rapidly. The bigger plants with larger yield may cause many complicated problems such as : (1) Disruption of natural eco-system. (2) Increase in yield means lower prices to farmers. (3) Plants will be less rich in nitrogen and hence they are likely to be susceptible to pests. (4) Soil will become poor or impoverished rapidly. As a result, it will become incapable for yielding good plant growth.*