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GLOBAL WARMING

BY

Prof. Dr. Javed A. Aziz

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ABSTRACT

Global Warming poses one of the most serious threats to humankind. The phenomenon may bring climatic change during the next century. The present climate models indicate a rise in sea level, changes in precipitation pattern, death of forests, extinction of animals and plants and problems for agriculture. Global warming could result in displacement of millions of people from coastal areas. The challenge can be met by reducing reliance on fossil fuel, shifting to solar energy and hydropower, banning production of CFCs, undertaking extensive plantation and limiting the family size.

INTRODUCTION

Life on earth planet is possible due to the energy continuously supplied by the sun. The earth intercepts only a small proportion of the total energy given out by the sun; perhaps as little as one-five-billionth (Kemp., 1994). The average temperature of the sun's surface is about 6000°C. It radiates its energy to the earth in three regions i.e. ultraviolet (0.1 - 0.4μ), visible waveband (0.4 - 0.7μ) and infrared (0.7 - 4.0μ). Ultraviolet rays are highly penetrative and constitute about 9% of the total solar input. Visible light constitutes 45% whereas infrared (heat) rays make up the rest 46% of the incoming solar energy (Money, 1994).

Of every 100 units of solar energy arriving at the outer edge of atmosphere, 30 units are bounced back unaltered into space due to the earths reflection from the land, sea and clouds and scattering by atmospheric aerosols. The remaining 70 units are absorbed into the earth's atmospheric system i.e. 20 units by oxygen, ozone and clouds (water vapours) in the atmosphere and 50 units reaching the earth surface to warm it.

Most of the 50 units absorbed by the earth surface are reradiated back as long wave terrestrial radiation (4.0 - 50.0μ) at a peak of about 10μ. Around 5 units with wavelength between 8μ - 11μ escape directly to the space. The remaining 45 units of terrestrial radiation are trapped by clouds and some gases usually referred to as greenhouse gases in the atmosphere. Some of the terrestrial radiation absorbed by the atmosphere is emitted to space also, but sufficient accumulates to allow 95 units to be re-radiated back to the earth surface. This exchange of energy between the atmosphere and the earth surface involves amounts apparently in excess of that provided by solar radiations (i.e. 145 units Vs 100 units). The phenomenon is known as `greenhouse effect' and enables the earth to retain energy in the lower atmosphere (Kemp., 1994). Eventually all of the long wave radiation passes into space but not before it has provided the energy necessary to allow atmospheric and terrestrial processes to function.

[1] Director, Institute of Environmental Engineering and Research, University of Engineering and Technology, Lahore.

The term greenhouse effect' as employed in the above stated context is a misnomer but still widely used. Greenhouses are usually established in areas with very low temperatures. In a greenhouse, the sensitive and precious plants are grown in a place which is enclosed by glass or plastic sheets. The glass lets in the short wave radiations from the sun that heat the ground but absorbs long wave radiations (>5) emitted from the ground surface. Thus the inside temperature of the greenhouses is elevated to the benefit of the plants. In contrast to atmosphere, there is no wind movement in a greenhouse for convective cooling of the plants by the outside air and this is the dominant difference (Money, 1994).

Had there been no atmosphere around the earth, the whole incoming radiation would have been immediately reradiated to space. Thus, without a greenhouse effect, the average temperature of the surface of the earth would be around 33°C cooler and life would be impossible (Tickell, 1993). Therefore greenhouse effect is essential for the survival of life form.

The sun's heat supply to the earth remains constant. If the composition of earth atmosphere also remains constant, then the heat balance of the atmosphere and the earth surface would be constant. But this is not the case. Infact the concentration of greenhouse gases in the atmosphere is increasing due to human activities and this leads to `global warming'. The term `global warming' refers to rising the earth's average temperature. As a result global temperatures are expected to rise in the future and this may have detrimental impact on human environment. The issue needs consideration as the average earth temperature has risen from 14.86°C in 1950 to 15.39°C in 1995 (Brown et al., 1996).

ATMOSPHERIC CONSTITUENTS CAUSING GREENHOUSE EFFECTS

The principal constituents that absorb long wave energy and reradiate it include water vapours, carbon dioxide, methane, nitrous oxide and chlorofluorocarbons. Water vapours make prime contribution to atmospheric warming. These infact account for some 97% of global warming. Since their concentration is little affected by human activities, water vapours have received little attention in global warming debate (Kemp., 1994). The remaining constituents responsible are gases and referred to as greenhouse gases.

Various greenhouse gases and their trends are discussed here briefly.

Carbon Dioxide (CO_2)

Carbon dioxide accounts for the largest proportion (55%) of warming by greenhouse gases. (Taylor et al., 1994). 80% of all CO_2 is emitted from burning fossil fuels i.e., coal, oil and gas and the rest comes from cutting down tropical forests. It is estimated that burning of fossil fuel releases about 6.1 billion tonnes of carbon per annum to atmosphere (Brown et al., 1996) whereas deforestation releases around 1-3 billion tonnes of carbon per annum (Cornwell, 1993). Other sources of CO_2 emissions include respiration. If policies are not changed and dependence on fossil fuels not reduced, global carbon emission from fossil fuel burning could reach 7 billion tonnes by 2000. Oceans which comprise 70% of the global

surface are the biggest sink of CO_2. These along with forests absorb 3 billion tonnes of carbon, in the form of CO_2, from the atmosphere. As a net result, CO_2 levels in the atmosphere are rising. Since the first systematic measurements were made at Mauna Loa in Hawaii in 1958, CO_2 levels have risen from 315 ppm to 361 ppm in 1995 (Brown et al., 1996). The data gathered from global network of background air pollution stations established by UNEP and WMO indicate a steady increase in CO_2 levels of about 0.5% per year and its concentration may rise to 450 ppm by the year 2050 (Botkin and Keller, 1995).

The Intergovernment panel on Climate Change (IPCC) suggests that doubling of atmospheric CO_2 is likely to increase the global temperature by 1.5 - 4.5°C. On average, CO_2 stays in the atmosphere for a century (Begley, 1997).

Methane (CH_4)

Methane contributes to about 15% of the global warming by greenhouse gases. Major sources of its release include anaerobic decomposition of organic matter, marshes, rice peddies, termites, ruminants and gas leaks. Total annual emissions of methane are estimated to be 515 million tonnes per year (Middleton, 1995).

Methane concentrations in the atmosphere were recorded as 1.7 ppm in 1990 (Taylor et al., 1995) and are increasing at a rate of 1.4% pr annum (Money, 1994) Methane is more effective greenhouse gas than CO_2 as a molecule of methane is equivalent to 20 molecules of CO_2. It has a life span of 10 years in the atmosphere.

Nitrous Oxide (N_2O)

Nitrous oxides account for 6% of the global warming through greenhouse gases. With respect to warming, one molecule of N_2O is equivalent to 200 molecules of CO_2. N_2O is generated by denitrifying bacteria in soil, burning of fossil fuel and from oceans. Half of the atmospheric N_2O is released from tropical rain forests, 25% from oceans, 20% through farming and 5% by fossil fuel burning (Money, 1994). N_2O emissions through fossil fuel burning in 1993 were estimated to be 70 million tons (Brown et al., 1996). In 1991, N_2O levels were recorded as 0.3 ppm (Cornwell, 1993) and these are increasing at a rate of 0.3% per year. The current increase is due to the use of nitrogen fertilizers in agriculture. N_2O has a life span of 150 years.

Chlorofluorocarbons (CFCs)

CFCs are widely employed in the manufacture of foam, as insulation materials and aerosols and used in refrigerators and air conditioners. Annually 0.9 million tonnes of CFCs are being released in the atmosphere. They constitute around 24% of the global warming through greenhouse gases. One molecule of CFCs is equivalent to 10,000 molecules of CO_2 with respect to its warming effect. The lifetime of various CFCs varies from 60 - 170 years.

CONSEQUENCES OF GLOBAL WARMING

Attempts to understand the consequences of global warming are based on mathematical models of the global circulation of atmosphere and oceans. Unfortunately the models are not completely refined as the interactions between atmosphere and biosphere are extremely complex. Nevertheless, most climate modellers agree that if present emission trends for greenhouse gases continue, global temperature may rise by 1.5 to 5.5°C by the year 2050 (Miller, 1994).

Such a rise may cause drastic impacts on the human environment. In fact nothing can be said with confidence about the extent and consequences of global warming as the behaviour of climate system is unpredictable in principle. For example, if global warming causes more low-lying clouds to form, they will block some sunlight and decrease the warming trends. On the other hand, global warming may cause more high level, thin cirrus clouds to form, which would actually intensify the greenhouse effect (Raven et al., 1993). More important impacts to which many environmentalists agree are briefly discussed here.

Climate Change

The current models predict that the earth mean surface temperature would rise 1.5 to 5.5°C by 2050. The Northern Hemisphere will warm more and faster than the Southern Hemisphere, mostly because the later has more oceans which can absorb more heat than land can. Temperatures at middle and high altitudes will be two to three times the global average whereas the temperatures near the equator would rise less than the global average (Miller, 1994). In temperate zones, winter would tend to be shorter and warmer; summer hotter and longer. Due to increased temperature, evaporation from sea would be more and over all rainfall would rise (Money, 1994). The release of more energy from warmer oceans will also lead to more intense and violent storms. Changes in global and local temperatures and rainfall could expand the geographical distribution of parasites and vectors, increasing the risk of infectious diseases. In a warm world, prolonged heat waves and draughts will become norms in many areas and hurricanes and typhoons would occur more frequently. The melting of arctic ice would affect global climate through realignment of warm and cool currents.

Temperature changes are always more pronounced on land than over oceans. Temperature differences on the global surface would result in changes in wind direction and speed and precipitation patterns (Money, 1994). More areas will have extreme heat waves and more forest and bush fires to intensify global warming. If these large scale climatic changes occurred, the social, political and economic impacts would be significant. Increased temperatures will result in reduced heating requirements in buildings. Similarly, a 3°C increase in global temperature could double the incidence of diseases carried by mosquitoes. At present malaria causes 1 to 2 million deaths annually. Climate change could amplify the existing problem and even areas that are now malaria free, such as Nairobi, Kenya, Zimbabwe, could be at risk. High temperatures may also help spread dengue fever.

Ocean may act as thermostat to global warming. At increased temperature, it will release dissolved CO_2 creating more global warming. Nevertheless, more evaporation to form clouds will offer shield against temperature.

Volcanic activity may also play its role. Currently about 600 volcanoes are considered active above sea level and on average 30 volcanic eruptions are being experienced per day. Sulphur dioxide molecules released through eruptions act as nuclei for water condensation to form mostly low level clouds which reflect the incoming solar energy to space, thus making an overall effect of atmospheric cooling.

Impact on Crop Yields

Crop yields will be affected due to increased atmospheric concentrations of CO_2 and higher temperatures. It would be possible to grow rice, wheat and other crops in areas towards the poles. However, if soils in such areas are poorer, the crop yield will fall. The plants will grow faster and have broad leaves with higher stomata density to reduce evapotranspiration. Excessive evapotranspiration will result in shorter growing season in dry areas. Warming contributes to pest out breaks that can kill the plant. Due to lack of adequate nitrogen, the plants will therefore be prone to pest attack. To cope with the situation, more fertilizers and insecticides will be required. In areas with sufficient rainfall, grasslands will expand. Similarly in drier areas, the excessive loss of water from soil will leave the land barren and thus deserts will expand. It is envisaged that while some regional variations may prove favourable to crop growth, many food producing regions may be affected adversely. Climate change is therefore likely to sharpen agricultural inequities between the rich and the poor. It is expected that global production of wheat, rice and other grains will decrease 1.2 to 7.6% by 2060 (O'Meara, 1997). A warmer world would disrupt supplies of food and fresh water displacing millions of people in unpredictable ways. At greatest risk of famine are those living in sub-saharan Africa, South and South-east Asia and tropical areas of Latin America.

Impact on Forests and Biodiversity

Most plants are adapted to particular regimes of moisture and temperature. Entire ecosystems could unravel if changes in climate force plants out of their current ranges. The warming could cause the range of high elevation trees, including pine to decrease to such an extent that the trees will not be able to survive. Thus entire forests of oak, beech and other deciduous trees could die. During the next century, boreal forests will be diminished to such an extent that the supply of industrial roundwood will cease to meet demand (O,Meara, 1997).

Drying from global warming could cause massive fires in the forests destroying wildlife habitat and releasing huge amounts of CO_2 in the atmosphere to amplify global warming. Large scale forest diebacks would cause massive extinction of species. (Miller, 1994).

Animals, too, are vulnerable to change in climate. Recent findings have indicated a

rise of 2.5°C in antarctic average temperature over the past 50 years and this has resulted in 40% drop in the population of penguines in the area. Penguines feed on krill and the krill population is diminishing due to less availability of marine plankton as a result of sea ice melts (O,Meara, 1997).

Warming is expected to reduce the vertical mixing of lake water, impeding nutrient distribution. This would harm fresh water fisheries. Coral reefs which are rich in biological diversity will also be affected by warming as 1° to 2°C rise can cause corals to `bleach' as they expel the algae that provide them with food and colour. Sustained increases of 3° to 4°C can cause significant coral death (O,Meara, 1997).

Rise in Sea Level

Due to thermal expansion of sea and melting of polar ice and mountain glaciers, the sea level will rise. Various models predict a sea level rise of 2 - 4 cm per decade (Miller, 1994) and 0.2 to 2.2 m by the year 2050 (Raven et al., 1993). This will flood low lying coastal areas, causing erosion and lead to salt water intrusion into the groundwater. As more than 70% of the world's population lives within 60 km of a coast (O,Meara, 1997), the impacts of sea level rise are particularly critical. Areas at the greatest risk of inundation from sea level rise are Maldives, and Netherlands which may be completely washed out. Other countries vulnerable to rise in sea level include Bangladesh, Egypt, Vietnam and Mozambique. Around 13 - 15 million Bangladeshi will have to flee their homes by the year 2050. Cities like Bombay and Bangkok will be badly affected (Dhyani, 1994). A sea level rise of about half a meter would create a significant impact on habitation patterns and pose threat to ports.

STRATEGIES TO CONTROL GLOBAL WARMING

To stop the global warming would require major reduction in the emission of greenhouse gases. For example, a 60% reduction is needed in CO_2 emissions to achieve atmospheric stabilization (Dowdeswell, 1997). Such reductions can only be achieved by reducing reliance on fossil fuels and by a decline in the global demand of energy. Shifting from fossil fuels to renewable energy resources such as solar energy and hydropower, that do not emit CO_2 will help stem global warming. The use of natural gas would also be beneficial as when burnt, it emits only half as much CO_2 per unit of energy as coal. Halting deforestation would reduce CO_2 emissions and help preserve biodiversity.

Deforestation accounts for as much as a third of CO_2 added to the atmosphere from human activities and as such it should be halted. To reduce CO_2 concentration in the atmosphere, extensive tree plantation should be employed. The concentrations of N_2O may be lowered by reducing the use of nitrate fertilizers. Efforts must also be made to restrict the use of CFCs. Since a greater part of greenhouse gases is produced through human activities, therefore population planning should be considered as a long term solution to the global warming problem. Humans must realize that the life on earth can be made comfortable only by limiting the family size and by conservative use of natural resources.

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