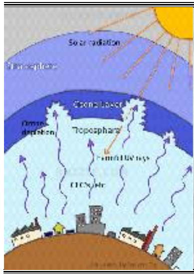
Ozone Depletion | RASHTRIYA KRISHI | Volume 9 | Issue 1 | June, 2014 | 10-12

e ISSN–2321–7987 | ●●● Article ●●● |Visit us : *www.researchjournal.co.in*|



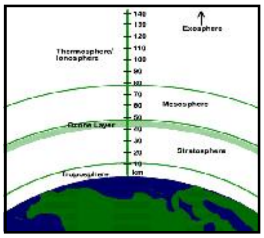
Ozone depletion leading to increased ionising radiation and its implication on crop growth

Sarika D. Patil and Rajendra M. Handore[1]

Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, AKOLA (M.S.) INDIA

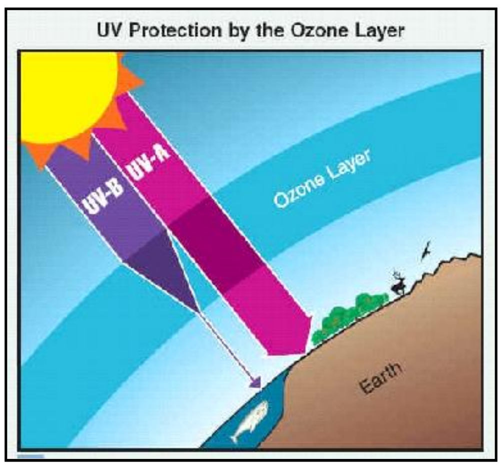
[1]Sahyadri Biotech, Innovating Agro Solutions, NASHIK (M.S.) INDIA

The Earth's atmosphere is divided into several layers. The lowest region, the troposphere, extends from the Earth's surface up to about 10 kilometres (km) in altitude.



Virtually all human activities occur in the troposphere. Mt. Everest, the tallest mountain on the planet, is only about 9 km high. The next layer, the stratosphere, continues from 10 km to about 50 km. Most commercial airline traffic occurs in the lower part of the stratosphere. For nearly a billion years, ozone molecules in the atmosphere have protected life on Earth from the effects of ultraviolet rays. It is a form of oxygen (O_2). We all know that, oxygen we need to live and breathe. Normal oxygen consists of two oxygen atoms. Ozone, however, consists of three oxygen atoms and has the chemical formula O_3. Ozone is formed when an electric spark is passed through oxygen.

"The ozone layer" refers to the ozone within stratosphere, where over 90% of the earth's ozone resides. Ozone is an irritating, corrosive, colourless gas with a smell something like burning electrical wiring. In fact, ozone is easily produced by any high-voltage electrical arc (spark plugs, Van de Graaff generators, Tesla coils, arc welders).



The earths / atmosphere system balances absorption of solar radiation with emission of long wave radiation (infrared) radiation to space. The earth surface primarily absorbs most of the short wave solar radiation from the Sun, but it also reradiate some of the radiation as long wave radiation. Energy is lost before reaching surface of the earth through reflection from clouds and aerosols in the atmosphere, which is relatively transparent to short wave radiation. Also, an average of about 30% is reflected off the earth's surface.

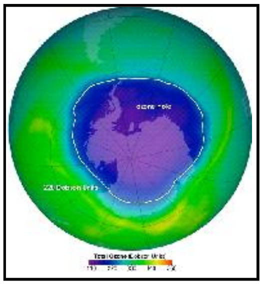
The atmosphere is more efficient at absorbing long wave radiation, which is then both emitted upward toward space and then downward toward earth. This downward emission serves to heat the earth further. This further warming by reradiated long wave radiation from the atmosphere is known as Greenhouse effect. Over millions of years the action of sunlight and specifically the action of ultra violet light or UV on oxygen has created a layer of ozone high up in the atmosphere. This ozone layer resides in the stratosphere and surrounds the entire Earth.

Ionizing and UV radiation act on oxygen to produce ozone. In the troposphere, ozone is a toxic constituent of photochemical smog, created by interaction of UV radiation with automobile and other exhaust fumes; ozone also occurs in some industrial emissions. In the stratospheric, ozone shields the biosphere from what otherwise would be lethal amounts of UV radiation. The stratospheric ozone layer is situated at an altitude of 12-45 km; the ozone moiety would be only a few millimeters thick at surface pressure and temperature, but of course expands greatly at high altitudes.

Ultraviolet radiation comprises UV-A, with a wavelength of 320-400 nm; UV-B, which is 290-320 nm; and UV-C, which is 200-290 nm. The most dangerous, UV-C, is prevented from reaching the earth's surface by stratospheric ozone. The least harmful UV-A passes through the stratosphere; it contributes to tanning of fair-skinned persons. Biologically harmful UV-B reaches the earth's surface in amounts inversely proportional to the concentration of atmospheric ozone, UV-B is impeded by urban air pollution, suspended particulates, aerosols, and ozone in the troposphere, as well as by stratospheric ozone.

The stratospheric ozone layer is a fragile shield. Among the chemicals that destroy ozone are chlorine monoxide, which began to accumulate in the atmosphere following the development and widespread use of refrigerants, and volatile solvents containing chlorofluorocarbons (CFCs). Chlorofluorocarbons are stable, lighter-than-air chemicals, but break down to release chlorine monoxide when exposed to UV radiation.

Ozone acts as a shield to protect the Earth's surface by absorbing harmful ultraviolet radiation. If this ozone becomes depleted, then more UV rays will reach the earth. Exposure to higher amounts of UV radiation could have serious impacts on human beings, animals and plants.

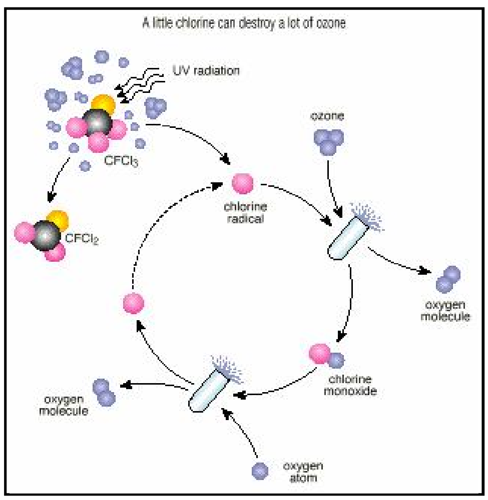


Depletion of stratospheric ozone (O_3), as commonly known as 'the hole in the ozone layer', is an issue of international concern. Most ozone is found in the stratosphere (upper part of the atmosphere), more than 10 to 16 kms from the surface of the Earth. The natural distribution of ozone around the Earth is not uniform, as seasonal winds and formation patterns contribute to lower concentrations at the equator and higher concentrations at the poles. Ozone in the stratosphere protects life on Earth as it limits penetration of ultraviolet radiation through the atmosphere, but it is considered a pollutant in the troposphere (close to the ground). The amount of ozone in the atmosphere is measured in Dobson units (DU). One DU is about twenty-seven million molecules per square centimeter. The average thickness of the atmospheric ozone layer at any place varies from month to month, but is generally between 260 and 330 DU.

The depletion of stratospheric ozone has been a problem because it has allowed increased ultraviolet radiation to reach the earth surface. However, the increase in tropospheric ozone is also problematic since tropospheric ozone acts as a greenhouse gas and is also a pollutant that affects human plants and animals. Tropospheric ozone contributed more than N_2O to the positive forcing of the climate system during the 20th century.

Effects of ozone layer depletion: Ozone is an unstable molecule. High-energy radiation from the Sun not only creates it, but also breaks it down again, recreating molecular oxygen and free oxygen atoms. The concentration of ozone in the atmosphere depends on a dynamic balance between how fast it is created and how fast it is destroyed. Today, there is widespread concern that the ozone layer is deteriorating due to the release of pollution containing the chemicals chlorine and bromine. Such deterioration allows large amounts of ultraviolet B rays to reach Earth, which can cause skin cancer and cataracts in humans and harm animals as well.

Human activities are mostly responsible for ozone depletion : Human activity is by far the most prevalent and destructive source of ozone depletion, while threatening volcanic eruptions are less common. Human activity, such as the release of various compounds containing chlorine or bromine, accounts for approximately 75 to 85% of ozone damage. Perhaps the most evident and destructive molecule of this description is chloroflourocarbon (CFC). CFCs were first used to clean electronic circuit boards, and as time progressed, were used in aerosols and coolants, such as refrigerators and air conditioners. When CFCs from these products are released into the atmosphere, the destruction begins. As CFCs are emitted, the molecules float toward the ozone rich stratosphere. Then, when UV radiation contacts the CFC molecule, this causes one chlorine atom to liberate. This free chlorine then reacts with an ozone (O_3) molecule to form chlorine monoxide (ClO) and a single oxygen molecule (O_2).



$$Cl + O_3 \longrightarrow O_2 + ClO.$$

Then, a single oxygen atom reacts with a chlorine monoxide molecule, causing the formation of an oxygen molecule (O_2) and a single chlorine atom ($O + ClO \longrightarrow Cl + O_2$). This threatening chlorine atom then continues the cycle and results in further destruction of the ozone layer.

Increased ultraviolet radiation reaching the Earth's surface can have significant detrimental impacts on animal and plant life. The radiation damages cells, causing damage to DNA and can lead to cell death or mutation and cancers. Radiation can also cause photochemical reactions in freshwater and marine waters, forming radicals (such as peroxide and hydroxide) that can cause further biological damage. On land, increased ultraviolet light can cause significant damage to native vegetation and agricultural crops, such as reduced plant height, reduction in foliage area and changes to tissue composition.

– Physiological and developmental processes of plants are affected by UVB radiation, even by the amount of UVB in present-day sunlight. Despite mechanisms to reduce or repair these effects and a limited ability to adapt to increased levels of UVB, plant growth can be directly affected by UVB radiation. Indirect changes caused by

UVB (such as changes in plant form, how nutrients are distributed within the plant, timing of developmental phases and secondary metabolism) may be equally, or sometimes more, important than damaging effects of UVB. These changes can have important implications for plant competitive balance, herbivory, plant diseases, and biogeochemical cycles.

– As far as effect on plant is concerned, an increase of UV radiation would be expected to affect crops. A number of economically important species of plants, such as rice, depend on cyanobacteria residing on their roots for the retention of nitrogen. Cyanobacteria are sensitive to UV light and they would be affected by its increase. Thinning of the ozone layer also interfere with the photosynthetic process of plants.

– Several of the world's major crop species are particularly vulnerable to increased UV, resulting in reduced growth, photosynthesis and flowering. Many agricultural crops are sensitive to the burning rays of the sun, including the world's main food crops, rice, wheat, corn and soybean.

– Many species of crops like sweet corn, soybean, barley, oats, cow peas, carrots, cauliflower, tomato, cucumber, peas and broccoli are highly sensitive to UV-B radiation. As a result, food production could be reduced by 10% for every 1% increase of UV-B radiation.

– The effect of ozone depletion on the Indian agricultural sector could be significant.

– Only a few commercially important trees have been tested for UV (UV-B) sensitivity, but early results suggest that plant growth, especially in seedlings, is harmed by more intense UV radiation.

– Based on studies of higher plant response to UV-B, several possible consequences for ecosystems include decreased primary production, altered plant species composition, and altered secondary chemistry with implications for herbivores, litter decomposition and biogeochemical cycles. However, like the assessment of increased atmospheric CO_2, extrapolation from studies with isolated plants to ecosystem function is very tenuous at best.

Received : *05.03.2014* *Revised :* *14.04.2014* *Accepted :* *05.05.2014*