© 2018 IJSRSET | Volume 2 | Issue 3 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section : Engineering and Technology

The impact of Ozone layer depletion on environmental - A Review

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ABSTRACT

The Ozone layer is a deep blanket in the stratosphere made up of comparatively high concentration of the ozone. As a result of its chemical composition, ozone is regarded as a special type of oxygen as it contains three oxygen molecules (O3) as opposed to the usual two oxygen molecules (O2).The ozone layer encircles the earth and occurs naturally. It is mainly found in the lower part of the stratosphere, approximately 15 to 30 kilometers (9 to 18 miles) above the earth. The ozone is an extremely reactive layer and it acts as a shield from the harmful ultraviolet B rays discharged from the sun. The ozone layer is continually being generated and broken down owing to several atmospheric processes and chemical reactions. This makes the thickness of the ozone layer to vary geographically and seasonally.

Keywords : Oxygen Molecules, Stratosphere, Troposphere, Ultraviolet, Meteorologist

I. INTRODUCTION

The ozone layer is a layer in Earth's atmosphere which contains relatively high concentrations of ozone (O_3). This layer absorbs 93-99% of the sun's high frequency ultraviolet light, which is potentially damaging to life on earth. Over 91% of the ozone in Earth's atmosphere is present here. It is mainly located in the lower portion of the stratosphere from approximately 10 km to 50 km above Earth, though the thickness varies seasonally and geographically. The ozone layer was discovered in 1913 by the French physicists Charles Fabry and Henri Buisson. Its properties were explored in detail by the British meteorologist G. M. B. Dobson, who developed a simple spectrophotometer (the Dobson meter) that could be used to measure stratospheric ozone from the ground. Between 1928 and 1958 Dobson established a worldwide network of ozone monitoring stations which continues to operate today. The "Dobson unit", a convenient measure of the total amount of ozone in a column overhead, is named in his honor. In the 1970's it was discovered that every spring, a "hole" was formed in the stratospheric ozone layer in particular over Antarctica, and that some chemicals made by humans were responsible of the destruction of ozone. The very low winter temperatures in the Antarctic stratosphere cause polar stratospheric clouds which temporarily prevent "fresh ozone" produced in the tropical region to replace the destroyed ozone. The reduction of the ozone layer changes the UV-radiation reaching the earth surface and this has various impacts on the environment, on health. In 1987, the governments of the world decided, with the Montreal Protocol, to progressively ban the use of ozone-depleting chemicals (or ODCs), a ban made possible by the progressive availability of "ozone-friendly" substitutes. Since then, the seasonal ozone hole has slowly begin to be reduced.

What is Ozone Layer?

To understand ozone layer, it would be helpful to know the different layers of the atmosphere. The earth's atmosphere is composed of many layers, each playing a significant role. The first layer stretching approximately 10 kilometers upwards from the earth's surface is known as the troposphere. A lot of human activities such as gas balloons, mountain climbing, and small aircraft flights take place within this region. The stratosphere is the next layer above the troposphere stretching approximately 15 to 60 kilometers. The ozone layer sits in the lower region of the stratosphere from about 20-30 kilometers above the surface of the earth. The thickness of the ozone layer is about 3 to 5 mm, but it pretty much fluctuates depending on the season and geography. The concentration of ozone in the ozone layer is usually under 10 parts per million while the average concentration of ozone in the atmosphere is about 0.3ppm. The thickness of the ozone layer differs as per season and geography. The highest concentrations of ozone occur at altitudes from 26 to 28 km in the tropics and from 12 to 20 km towards the poles. The ozone layer forms a thick layer in stratosphere, encircling the earth that has large amount of ozone in it. The ozone layer protects life on earth from strong ultraviolet radiation that comes from the sun. Ultraviolet rays are harmful rays that can drive up the risk of deadly disorders like skin cancer, cataracts and damage the immune system. Ultraviolet rays are also capable of destroying single cell organism, terrestrial plant life, and aquatic ecosystems. The ozone layer was discovered in 1913 by the French physicists Charles Fabry and Henri Buisson. The ozone layer has the capability to absorb almost 97-99% of the harmful ultraviolet radiations that sun emit and which can produce long term devastating effects on humans beings as well as plants and animals.

Advantages of the Ozone Layer:

Protection against cancer and cataracts:

Ozone is very efficient at absorbing the sun's ultraviolet (UV) radiation even in very small amounts. For this reason, the ozone layer protects the earth by blocking the harmful ultraviolet (UV) radiation that can cause skin cancer and cataracts in humans.

Protection of the environment and ecosystems:

The ultraviolet (UV) radiation from the sun is very harmful and can be destructive to our natural ecosystems and the environment. UV radiation has an effect upon the fertility of some animals and affects the survival of their offspring. Plants are as well affected by UV radiation as it negatively impacts their ability to develop and grow properly.

Furthermore,

Exposure Category	Colour	UVI Range
Low		< 2
Moderate		3 - 5
High		6 - 7
Very High		8 – 10
Extreme		11+

UV radiation determines chemical reaction and breakdown of various atmospheric processes which can contribute to disastrous changes in the aquatic environments and other earth's ecosystems in general. For instance, changes in UV levels affect the growth and development of phytoplankton. The ozone layer thus plays an important role by preventing the harmful UV radiations from penetrating into the earth's lower atmosphere (the troposphere).

Causes of Ozone Layer Depletion:

There have been several concerns about ozone depletion. The problems and causes associated with ozone depletion arise from human activities. Unlike pollution which has several causes, there is one specific chemical compound that is responsible for the breakdown of the ozone layer. These chemical compounds are present in many industrial manufactured products and aerosols.

Chlorofluorocarbons (CFCs):

Chlorofluorocarbons (CFCs) are the primary cause for the ozone layer depletion. Industrial products including solvents, soaps, spray aerosols, insulating foams, 'take-away' containers and cooling utilities such as refrigerators and air conditioners use chlorofluorocarbons (CFCs). Over time, these substances accumulate in the atmosphere are carried by wind action into the stratosphere. Once the chlorofluorocarbons (CFCs) are in the stratosphere, their molecules are broken up by the ultraviolet radiation from the sun which releases Chlorine atoms. The Chlorine atoms react with the Ozone, setting out a chemical cycle that destroys the good ozone.

The ODS:

There are also other chemical substances that are generally grouped as Ozone Depleting Substances (ODS). Examples are methyl bromide use in pesticides, methyl chloroform used on making industrial solvents, and halons used in fire extinguishers. Just like the chlorofluorocarbons (CFCs), these substances also chemically react with the ozone which starts a chemical cycle that break up the good ozone.

Environmental Effect of ozone layer depletion:

Effects on Human and Animal Health:

With depletion in ozone's layer, we humans are more prone to UV a ray that reaches the Earth's surface. Studies suggest that a high level of UV Rays cause non-melanoma skin cancer and plays a major role in malignant melanoma development. Direct exposure to UV rays can lead to development of cataracts which clouds the eye's lens. Permanent exposure to UV rays can also lead to weakening of the response of immune system and even permanent damage to immune system in some cases. Aging of skin is yet another problem that will make you look older than what you really are. Extensive exposure to UV rays can lead to acceleration of the aging process of your skin. In light skinned human populations, it is likely to develop no melanoma skin cancer Experiments on animals show that UV exposure decreases the immune response to skin cancers, infectious agents and other antigens

Effects on Terrestrial Plants:

Plants become another casualty by radiation effects of UV rays. The physiological and developmental processes of plants are also severely affected apart from the growth. Some other changes that are caused by UV include the way plants form, timing of development and growth, how nutrients are distributed within the plant and metabolism, etc. Scientists believe that an increase in UV levels would necessitate using more UV tolerant cultivar and breeding new tolerant ones in agriculture. In forests and grasslands increased UV radiation is likely to result in changes in species composition (mutation) thus altering the bio-diversity in different ecosystems. These changes can have important implications for plant competitive balance, plant pathogens and bio-geochemical cycles.

Effects on Aquatic Ecosystems:

Effect on marine ecosystems:

UV rays also have adverse effect on the marine ecosystems. It badly affects the planktons that form the foundation of aquatic food webs. Phytoplankton grow close to the surface of the water and plays vital role in the food chain and oceanic carbon cycle. Changes in UV levels are known to affect both orientation and motility in phytoplankton. This reduces the survival and growth rate of these organisms. UV rays are also known to affect the development stages of fish, shrimp, crab, amphibians, and other marine animals. When this happens it affects whole marine food chain. While more than 30 percent of the world's animal protein for human consumption comes from the sea alone, it is feared that increased levels of UV exposure can have adverse impacts on the productivity of aquatic systems.

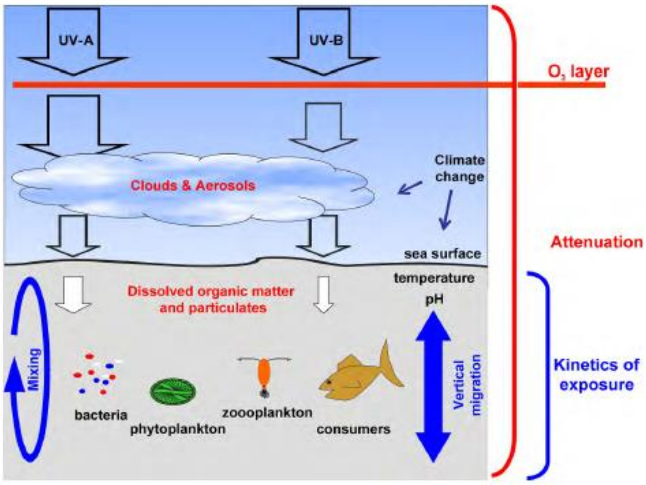

Fig: UV radiation affecting aquatic organisms

Effects on Bio-geo-chemical Cycles:

Increased solar UV radiation could affect terrestrial and aquatic bio-geo-chemical cycles thus altering both sources and sinks of greenhouse and important trace gases, e.g. carbon dioxide (CO_2), carbon monoxide (CO), carbonyl sulphide (COS), etc. These changes would contribute to biosphere-atmosphere feedbacks responsible for the atmosphere build-up of these gases. Other effects of increased UV radiation include: changes in the production and decomposition of plant matter; reduction of primary production changes in the uptake and release of important atmospheric gases; reduction of bacterioplankton growth in the upper ocean; increased degradation of aquatic dissolved organic matter etc. Aquatic nitrogen cycling can be affected by enhanced UV through inhibition of nitrifying bacteria and photodecomposition of simple inorganic species such as nitrate. The marine sulphur cycle may also be affected resulting in possible changes in the sea-to-air emissions.

Effects on Air Quality:

Reduction of stratospheric ozone and increased penetration of UV radiation result in higher photo dissociation rates of key trace gases that control the chemical reactivity of the troposphere. This can increase both production and destruction of ozone and related oxidants such as hydrogen peroxide which are known to have adverse effects on human health, terrestrial plants and outdoor materials. Changes in the atmospheric concentrations of the hydroxyl radical (OH) may change the atmospheric lifetimes of important gases such as methane and substitutes of chlorofluoro carbons (CFCs). Increased troposphere reactivity could also lead to increased production of particulates such as cloud condensation nuclei from the oxidation and subsequent nucleation of sulphur of both anthropogenic and natural origin

Effects on Climate Change:

Ozone depletion and climate change are linked in a number of ways, but ozone depletion is not a major cause of climate change. Atmospheric ozone has two effects on the temperature balance of the Earth. It absorbs solar ultraviolet radiation, which heats the stratosphere. It also absorbs infrared radiation emitted by the Earth's surface, effectively trapping heat in the troposphere. Therefore, the climate impact of changes in ozone concentrations varies with the altitude at which these ozone changes occur. The major ozone losses that have been observed in the lower stratosphere due to the human-produced chlorine- and bromine-containing gases have a cooling effect on the Earth's surface. On the other hand, the ozone increases that are estimated to have occurred in the troposphere because of surface-pollution gases have a warming effect on the Earth's surface, thereby contributing to the "greenhouse" effect. In comparison to the effects of changes in other atmospheric gases, the effects of both of these ozone changes are difficult to calculate accurately. In the figure below, the upper ranges of possible effects for the ozone changes are indicated by the open bars, and the lower ranges are indicated by the solid bars.

Effects on Ultraviolet Radiation:

The depletion of the ozone layer leads, on the average, to an increase in ground-level ultraviolet radiation, because ozone is an effective absorber of ultra-violet radiation. The Sun emits radiation over a wide range of energies, with about 2% in the form of high-energy, ultraviolet (UV) radiation. Some of this UV radiation is especially effective in causing damage to living beings, the largest decreases in ozone during the past 15 years have been observed over Antarctica, especially during each September and October when the ozone hole forms. During the last several years, simultaneous measurements of UV radiation and total ozone have been made at several Antarctic stations. In the late spring, the biologically damaging ultraviolet radiation in parts of the Antarctic continent can exceed that in San Diego, California, where the Sun is much higher above the horizon. In areas where smaller ozone depletion has been observed, increases are more difficult to detect. In particular, detection of trends in UV-radiation associated with ozone decreases can be further complicated by changes in cloudiness, by local pollution, and by difficulties in keeping the detection instrument in precisely the same condition over many years. Prior to the late 1980s, instruments with the necessary accuracy and stability for measurement of small long-term trends in ground-level UV were not available. Therefore, the data from urban locations with older, less-specialized instruments provide much less reliable information, especially since simultaneous measurements of changes in cloudiness or local pollution are not available. When high-quality measurements have been made in other areas far from major cities and their associated air pollution, decreases in ozone have regularly been accompanied by increases in UV. This is shown in the figure below, where clear-sky measurements performed at six different stations demonstrate that ozone decreases lead to increased UV radiation at the surface in amounts that are in good agreement with that expected from calculations (the "model" curve).

II. Conclusion

Under the auspices of United Nations Environment Programme (UNEP), Governments of the world, including the United States have cooperatively taken action to stop ozone depletion with the "The Montreal Protocol on Substances that Deplete the Ozone Layer", signed in 1987. Scientists are concerned that continued global warming will accelerate ozone destruction and increase stratospheric ozone depletion. Ozone depletion gets worse when the stratosphere (where the ozone layer is), becomes colder. Because global warming traps heat in the troposphere, less heat reaches the stratosphere which will make it colder. Greenhouse gases act like a blanket for the troposphere and make the stratosphere colder. In other words, global warming can make ozone depletion much worse right when it is supposed to begin its

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