A LITERATURE REVIEW ON OZONE LAYER EFFECTS

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ABSTRACT

This paper summarize a literature review on ozone layer effects. The data regarding effect of ozone layer on human was reviewed and compiled as a review paper from various papers, published articles of international reputed journals, e- books, annual/environmental reports of recognized organization. The ozone layer is the common term for the high concentration of ozone that is found in the stratosphere around 15–30km above the earth's surface. It covers the entire planet and protects life on earth by absorbing harmful ultraviolet-B (UV-B) radiation from the sun. Ozone is a naturally occurring molecule. An ozone molecule is made up of three oxygen atoms. It has the chemical formula $O_{3.}$ Chemicals containing chlorine and bromine atoms are released to the atmosphere through human activities. These chemicals combine with certain weather conditions to cause reactions in the ozone layer, leading to ozone molecules being destroyed. Depletion of the ozone layer occurs globally, however, the severe depletion of the ozone layer over the Antarctic is often referred to as the 'ozone hole'. Increased depletion has recently started occurring over the Arctic as well.

Keyword: - *Ozone, ozone layer, ozone depletion, ozone hole, UV radiation*

1. INTRODUCTION

Ozone is a naturally occurring molecule. An ozone molecule is made up of three oxygen atoms. It has the chemical formula O3. The ozone layer is the common term for the high concentration of ozone that is found in the stratosphere around 15–30km above the earth's surface[1]. It covers the entire planet and protects life on earth by absorbing harmful ultraviolet-B (UV-B) radiation from the sun. The stratospheric ozone layer effectively serves as a protective shield that reduces the harmful ultraviolet radiation (UV) reaching the earths surface. As a consequence, the depletion of stratospheric ozone observed over the last two decades, probably caused by emission of man-made halocarbons (CFCs), has probably led to higher ambient UV-levels. An increase in UV at ground-level may induce a wide range of harmful effects like an increase in skin cancer, cataracts, a decrease in bio-mass production and crop yields, and suppression of the human immune system [United Nations Environmental Program (UNEP), 19981. The Vienna Convention in 1985 was the starting point for international policy agreements to reduce the production and emission of ozone depleting substances, and provided the framework for the restrictive protocols that were agreed upon later. The Montreal protocol in 1987 provided the first restrictive countermeasures and in view of the compelling evidence that ozone depletion occurred, this protocol was subsequently strengthened in several more restrictive Amendments. In the latest Amendments the production of the most potent ozone depleting substances is completely phased out in 1996. A longer phase out period is allowed for the developing countries. These countermeasures are expected to lead to a slow recovery of the ozone layer over the next century. The effects of the agreed countermeasures in terms of a recovery of the ozone layer, the (future) UV-radiation levels and their effect on the excess skin cancer risks associated with ozone depletion were previously analysed for the USA and Europe [Slaper et al., 1996][2]. In line with other studies (UNEP, 199$) it was expected that a slow recovery of the ozone layer will occur with a return to 'normal' (1980) levels around 2050. Excess skin cancer risks, caused by ozone depletion, are in those scenarios expected to rise until 2050-2070. Slaper *et al* [1996][2] clearly showed the potential success of the countermeasures in reducing the future excess skin cancer risks associated with the chemical depletion of ozone. A limitation of these analyses is that they assume ozone depletion to be purely chemically driven, and that no interaction with climate change is included in the analysis. Growing insight in the radiative balance of the atmosphere and its disturbance by the continued increased emission of greenhouse gases, indicates cooling of the stratosphere and a change in dynamical processes. These changes can have implications for the ozone levels on itself and furthermore they can interact with the chemical break down processes. Until recently, risk assessments did not account for this link between ozone layer morphology and dynamical processes initiated by climate change.

2. OZONE

Sivasakthivel.T *et al* says that Without ozone, life on Earth would not have evolved in the way it has. The first stage of single cell organism development requires an oxygen-free environment. This type of environment existed on earth over 3000 million years ago. As the primitive forms of plant life multiplied and evolved, they began to release minute amounts of oxygen through the photosynthesis reaction (which converts carbon dioxide into oxygen) [3]. The buildup of oxygen in the atmosphere led to the formation of the ozone layer in the upper atmosphere or stratosphere. This layer filters out incoming radiation in the "cell-damaging" ultraviolet (UV) part of the spectrum. Thus with the development of the ozone layer came the formation of more advanced life forms. Ozone is a form of oxygen. The oxygen we breathe is in the form of oxygen molecules (O2) - two atoms of oxygen bound together. Normal oxygen which we breathe is colourless and odourless. Ozone, on the other hand, consists of three atoms of oxygen bound together (O3). Most of the atmosphere's ozone occurs in the region called the stratosphere. Ozone is colourless and has a very harsh odour. Ozone is much less common than normal oxygen. Out of 10 million air molecules, about 2 million are normal oxygen, but only 3 are ozone. Most ozone is produced naturally in the upper atmosphere or stratosphere. While ozone can be found through the entire atmosphere, the greatest concentration occurs at altitudes between 19 and 30 km above the Earth's surface. This band of ozone-rich air is known as the "ozone layer". [9] Ozone also occurs in very small amounts in the lowest few kilometres of the atmosphere, a region known as the troposphere. It is produced at ground level through a reaction between sunlight and volatile organic compounds (VOCs) and nitrogen oxides (NOx), some of which are produced by human activities such as driving cars. Ground-level ozone is a component of urban smog and can be harmful to human health. Even though both types of ozone contain the same molecules, their presence in different parts of the atmosphere has very different consequences. Stratospheric ozone blocks harmful solar radiation - all life on Earth has adapted to this filtered solar radiation. Ground-level ozone, in contrast, is simply a pollutant. It will absorb some incoming solar radiation, but it cannot make up for ozone losses in the stratosphere.

3. OZONE HOLE

Fakhra Anwar *et al* says that Ozone hole is created in the region where ozone layer has been depleted. The term “Ozone hole” is applied when the depletion level is below 200 Dobson Unit (D.U). Ozone holes are first discovered in Antarctica in 1970. Few years ago ozone holes are also discovered in arctic region. Since 2000 rate of ozone depletion is increasing 0.5 percent per year [10]. Due to depletion of Ozone UV rays are penetrating in troposphere and leading to more ozone formation in troposphere which is causing injurious effects on our health as ozone is toxic for our body [11]. Sivasakthivel.T *et al* says that In some of the popular news media, as well as in many books, the term "ozone hole" has and often still is used far too loosely. Frequently, the term is employed to describe any episode of ozone depletion, no matter how minor. Unfortunately, this sloppy language trivializes the problem and blurs the important scientific distinction between the massive ozone losses in Polar Regions and the much smaller, but nonetheless significant, ozone losses in other parts of the world. Technically, the term "ozone hole" should be applied to regions where stratospheric ozone depletion is so severe that levels fall below 200 Dobson Units (D.U.), the traditional measure of stratospheric ozone. Normal ozone concentration is about 300 to 350 D.U [12]. Such ozone loss now occurs every springtime above Antarctica, and to a lesser extent the Arctic, where special meteorological conditions and very low air temperatures accelerate and enhance the destruction of ozone loss by man-made ozone depleting chemicals (ODCs).

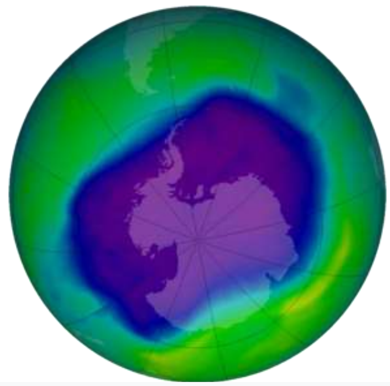

Fig -1: Image of the largest Antarctic ozone hole ever recorded over the South Pole

4. OZONE DEPLETION

Ozone depletion, gradual thinning of Earth's ozone layer in the upper atmosphere caused by the release of chemical compounds containing gaseous chlorine or bromine from industry and other human activities. The thinning is most pronounced in the polar regions, especially over Antarctica. Ozone depletion is a major environmental problem because it increases the amount of ultraviolet (UV) radiation that reaches Earth's surface, which increases the rate of skin cancer, eye cataracts, and genetic and immune system damage. The Montreal Protocol, ratified in 1987, was the first of several comprehensive international agreements enacted to halt the production and use of ozone-depleting chemicals. As a result of continued international cooperation on this issue, the ozone layer is expected to recover over time. Ozone depletion consists of two related events observed since the late 1970s: a steady lowering of about four percent in the total amount of ozone in Earth's atmosphere (the ozone layer), and a much larger springtime decrease in stratospheric ozone around Earth's polar regions[3].

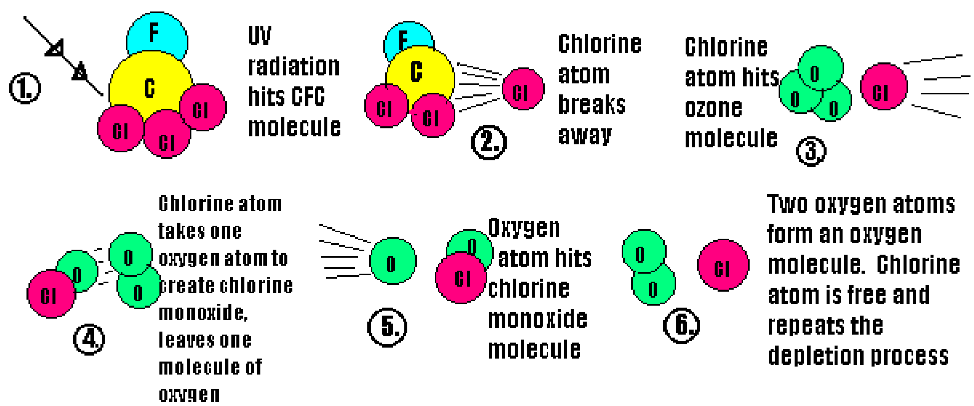

Fig -2: ozone depletion reaction

The latter phenomenon is referred to as the ozone hole. There are also springtime polar tropospheric ozone depletion events in addition to these stratospheric events. In 2019, NASA announced the "ozone hole" was the smallest ever since it was first discovered in 1982[4][5]. The main cause of ozone depletion and the ozone hole is manufactured chemicals, especially manufactured halocarbon refrigerants, solvents, propellants and foam-blowing agents (chlorofluorocarbons (CFCs), HCFCs, halons), referred to as ozone-depleting substances (ODS). These compounds are transported into the stratosphere by turbulent mixing after being emitted from the surface, mixing much faster than the molecules can settle. Once in the stratosphere, they release halogen atoms through photodissociation, which catalyze the breakdown of ozone (O_3) into oxygen (O_2)[6]. Both types of ozone depletion were observed to increase as emissions of halocarbons increased. Ozone depletion and the ozone hole have generated worldwide concern over increased cancer risks and other negative effects. The ozone layer prevents most harmful UV wavelengths of ultraviolet light (UV light) from passing through the Earth's atmosphere. These wavelengths cause skin cancer, sunburn and cataracts, which were projected to increase dramatically as a result of thinning ozone, as well as harming plants and animals. These concerns led to the adoption of the Montreal Protocol in 1987, which bans the production of CFCs, halons and other ozone-depleting chemicals. The ban came into effect in 1989. Ozone levels stabilized by the mid-1990s and began to recover in the 2000s[7][8]. Recovery is projected to continue over the next century, and the ozone hole is expected to reach pre-1980 levels by around 2075. The Montreal Protocol is considered the most successful international environmental agreement to date.

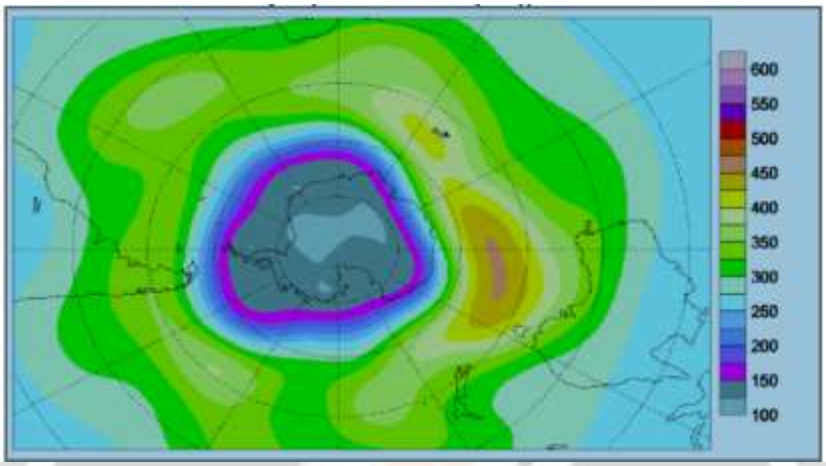

Fig -3: Total ozone depletion layer

5. OZONE LAYER EFFECTS

Peter M. *et al* & Sivasakthivel.T *et al* says that Increased penetration of solar UV-B radiation is likely to have profound impact on human health with potential risks of eye diseases, skin cancer and infectious diseases [13]. UV radiation is known to damage the cornea and lens of the eye. Chronic exposure to UV-B could lead to cataract of the cortical and posterior subcapsular forms. UV-B radiation can adversely affect the immune system causing a number of infectious diseases. In light skinned human populations, it is likely to develop nonmelanoma skin cancer (NMSC). Experiments on animals show that UV exposure decreases the immune response to skin cancers, infectious agents and other antigens.

D. H. Stedman *et al* defines that it is a known fact that the physiological and developmental processes of plants are affected by UV-B radiation. Scientists believe that an increase in UV-B levels would necessitate using more UV-B tolerant cultivar and breeding new tolerant ones in agriculture. In forests and grasslands increased UV-B radiation is likely to result in changes in species composition (mutation) thus altering the bio-diversity in different ecosystems [14]. UV-B could also affect the plant community indirectly resulting in changes in plant form, secondary metabolism, etc. These changes can have important implications for plant competitive balance, plant pathogens and bio-geochemical cycles.

Sivasakthivel.T *et al* defines reduction of stratospheric ozone and increased penetration of UV-B 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 (e.g. COS and DMS).

Fakhra Anwar *et al* defines the effects on eyes & skin of humans, the major cause of blindness in this world is cataracts. There would be 0.3% - 0.6% increase in risk of cataract if there will be 1% decrease in Ozone level [15]. Eye lens can be damaged by oxidative agents. Oxidative oxygen produced by UV radiation can severely damage eye lens and cornea of eye is also badly damaged by UV radiation [16]-[17]. Photokeratitis, cataract, blindness all are caused due to UV rays [18]. Exposure to UV radiations can cause skin cancer. UV radiations alter the structure of biomolecules and thus lead to different diseases [19] Skin is the most often exposed part of body to UV radiations There are two types of skin cancer, Melanoma and Non-melanoma. Melanoma is most serious form of cancer and is often fatal, while non-melanoma is most common type and less fatal. Depletion of ozone layer leads to both Sun burn and skin cancer [20].

6. CONCLUSIONS

Under the auspices of United Nations Environment Programme (UNEP), 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. Scientist's 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. Ozone layer is continuously depleting which is highly alarming situation of today. Chloroflourocarbons are major cause of ozone depletion. These substances should be banned or we should use their alternatives so that in future we can protect ourselves from the harmful effects of UV radiation. Human eye and skin are the most exposed part of the body to these radiations. So there is high degree of incidence of blindness and skin cancer disease increasing day by day with the depletion of ozone layer so we should use sunglasses and full body clothes especially in summer when there is high intensity of sunlight so that we can protect our body from harmful UV radiations. We should also use sun block creams to protect our skin.

7. REFERENCES

1) https://www.environment.gov.au/protection/ozone/publications/ozone-layer-factsheet
2) Slaper, H., Daniel, J.S., de Gruiji, F.R., and van der Leun, J.C., 1996. Estimates of ozone depletion and skin cancer incidence to examine the Vienna convention achievements. NATURE, 384, 256-25 8.
3) *"Twenty Questions and Answers About the Ozone Layer" (PDF). Scientific Assessment of Ozone Depletion: 2010. World Meteorological Organization. 2011. Retrieved March 13, 2015.*
4) https://www.wsj.com/articles/ozone-hole-above-antarctica-shrinks-to-smallest-size-on-record-11571847944
5) https://nypost.com/2019/10/22/antarctic-ozone-hole-shrinks-to-smallest-size-on-record-due-to-rare-event/
6) Andino, Jean M. (October 21, 1999). "Chlorofluorocarbons (CFCs) are heavier than air, so how do scientists suppose that these chemicals reach the altitude of the ozone layer to adversely affect it ?". *Scientific American*. **264**: 68.
7) *"Part III. The Science of the Ozone Hole". Retrieved March 5, 2007.*
8) "The Antarctic Ozone Hole Will Recover". NASA. June 4, 2015. Retrieved August 5, 2017.
9) “Production, Sales, and Atmospheric Release of Fluorocarbons,” Alternative Fluorocarbons Environmental Acceptability Study(AFEAS), Washington, DC 1996.
10) Rozema, J., Boelen, P. and Blokker, P. (2005) Depletion of Stratospheric Ozone over the Antarctic and Arctic: Responses of Plants of Polar Terrestrial Ecosystems to Enhanced UV-B, an Overview. *Environmental Pollution*, **137**,428-442. http://dx.doi.org/10.1016/j.envpol.2005.01.048
11) Fears, T.R., Bird, C.C., Guerry, D., Sagebiel, R.W., Gail, M.H., Elder, D.E., Halpern, A., Holly, E.A., Hartge, P. and Tucker, M.A. (2002) Average Midrange Ultraviolet Radiation Flux and Time Outdoors Predict Melanoma Risk. *Cancer Research*, **62**, 3992-3996.
12) Alternative Fluorocarbons Environmental Acceptability Study (AFEAS), Washington, DC, 1995.
13) Morrisette, Peter M. "The Evolution of Policy Responses to Stratospheric Ozone Depletion". *Natural Resources Journal*, vol. 29, 1995.
14) D. H. Stedman, “Atomic Chlorine and the Chlorine Monoxide Radicalin the Stratosphere: Three in Situ Observations.” *Science*, vol.198,1981.
15) United Nations Environment Programme (1994) Environmental Effects of Ozone Depletion: 1994 Assessment. UNEP,Nairobi.
16) Christenson, L.J., Borrowman, T.A., Vachon, C.M., *et al.* (2005) Incidence of Basal Cell and Squamous Cell Carcinomas in a Population Younger Than 40 Years. *JAMA*, **294**, 681-690. http://dx.doi.org/10.1001/jama.294.6.681

17) Lee, K.W., Meyer, N. and Ortwerth, B.J. (1999) Chromatographic Comparison of the UVA Sensitizers Present in Brunescent Cataracts and in Calf Lens Proteins Ascorbylated *in Vitro*. *Experimental Eye Research*, **69**, 375-384. http://dx.doi.org/10.1006/exer.1999.0709.
18) Wargent, J.J. and Jordan, B.R. (2013) From Ozone Depletion to Agriculture: Understanding the Role of UV Radiation in Sustainable Crop Production. *New Phytologist*, **197**, 1058-1076. http://dx.doi.org/10.1111/nph.12132
19) Tian, J. and Juan, Y. (2009) Changes in Ultrastructure and Responses of Antioxidant Systems of Algae (*Dunaliella salina*) during Acclimation to Enhanced Ultraviolet-B Radiation. *Journal of Photochemistry and Photobiology B*: *Biology*,**97**, 152-160. http://dx.doi.org/10.1016/j.jphotobiol.2009.09.003
20) Pearce, M.S., Parker, L., Cotterill, S.J., Gordon, P.M. and Craft, A.W. (2003) Skin Cancer in Children and Young Adults: 28 Years' Experience from the Northern Region Young Person's Malignant Disease Registry, UK. *Melanoma Research*, **13**, 421-426. http://dx.doi.org/10.1097/00008390-200308000-00013.