The Effect of Atmospheric Ozone Depletion on Environment: A Review

Dipak Kumar Saha

Department of Chemistry, Dinabandhu Mahavidyalaya, Bongaon, 24PGS (N)

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Abstract

There are many situations where human activities have significant effects on our environment. Stratospheric ozone layer depletion is one of them. Ozone is depleted in many ways. The human released chlorofluorocarbons are the main and primary causes to destroy ozone layer. As a result more solar UV-B radiation (290-320 nm) reaches to the surface. This UV radiation destroys DNA and proteins in all living organisms. This review presents a brief discussion of the effect of ozone depletion on solar UV-radiation, sunburn and skin cancer, eyes, aquatic ecosystems, atmospheric concentrations of HOx, CH_4, CO, H_2O_2 and also on the Antarctic and Arctic aquatic ecosystems.

Key words: Chlorofluorocarbons, UV-radiation

1. Introduction

O_3 is a minor constituent of the atmosphere. It is mainly distributed in the stratosphere. It is not distributed equally in the atmosphere. The concentration of ozone gradually increases from upper troposphere of about 10 km altitude and attains maximum at an altitude of about 25 km and then decreases gradually. Farman *et al*,[1] first reported the dramatic decrease of ozone concentration at Antarctica. Later, it is proved that O_3 concentration gradually decreases with smaller amount in the other parts of the world also. In very brief emission of gases containing chlorine and bromine like CFCs, halons, CH_3Cl, CH_3Br, and CCl_4 etc are transported around the globe and into the stratosphere. Then reactive halogen atoms (Cl., Br.) are produced by sunlight. These react with O_3 and destroy it[2]. Severe polar spring time depletion due to formation of polar stratospheric clouds and subsequent chemical reactions. This ozone depletion causes many effects on the environment which are presented here.

2. Discussion

Effect on solar UV- radiation: Ultra violet radiation (UVR) is high energy electromagnetic wave emitted from the sun. It is made up of wavelengths ranging from 100nm-400nm. There are three types of UV-region and these are UV-A, UV-B and UV-C. UV-A is the least dangerous form of UV radiation with wavelength range between 315nm-400nm and is weakly absorbed by O_3. UV-B with a wavelength range between 280-315nm are partially absorbed by ozone but not completely. UV-C which is the most dangerous, ranges between 100-400nm. UV-C is unable to reach earth's surface due to stratospheric ozone's ability to absorb it. At the equator about 30% of UV-B radiations are transmitted to the Earth's surface under clear sky[3]. Solar UV-B radiation reaching to the ground increases as ozone depletion takes place. High levels of UV-B radiation have been observed directly in association with the Antarctic ozone hole.

Effect on sunburn and skin cancer: Direct exposure to UV radiation has acute undesirable effects including sunburn and skin pigmentation consisting immediate pigment darkening, neomelanogenesis and the chronic effects. Sunburn is a burn that occurs when skin cells are damaged. This damage to the skin is caused by the absorption of energy from UB rays. Extra blood flows to the damaged skin in an attempt to repair it, as result skin turns red during sunburn. Sunburn reaches its maximum redness eight to twelve hours after exposure and fades within one to two days. The production emission of ozone depleting substances (ODS) through O_3 depletion increases the carcinogenic UV-radiation, which increases the skin cancer. Slaper *et al*,[4] evaluated three types of skin cancer. Squamous cell carcinoma (SCC) and basal cell carcinoma (BCC) are the most frequent but least aggressive[5]. The cutaneous malignant melanoma (CMM) is the least frequent but most aggressive. Scotto and Fears[6] reported that the present skin cancer incidence in the USA is about 2000 per million per year and North-West Europe an incidence of about 11000 per million per year for the Netherlands as representative[7]. Squamous cell carcinoma (SCC) associated with ambient solar exposure has been reported in cattle, horses, cats, sheep, goats and dogs.

Effect on tropospheric ozone and lung function: Pollutants like oxides of nitrogen, hydrocarbon in urban and industrialized zone produce tropospheric ozone by the photochemical reactions. This O_3 is an absorber of UV-B radiation. But increase in tropospheric ozone causes climate change through global warming, environmental pollution and also affect human health. Whitefield *et al*,[8] reported the qualitative and quantitative judgments regarding the risk of chronic lung injury to children aged between 8 to 16 years and adult outdoor workers due to long term ozone exposure in areas with patters of exposure similar to those in Southern California and the northest. Ozkaynak *et al*,[9] reported that ozone exposure was associated with increased pneumonia and influenza in adults after a 24 hour lag period. High tropospheric ozone concentration can also causes asthma, bronchitis even heart attack. Manning *et al*,[10] showed that the ozone injury to native plants in class 1 wilderness areas in Vermont and New Hampshire. Symptoms of O_3 injury were confirmed for black cherry, milkweed whiteash and white pine.

Effect on eyes: UV-rays can damage the eyes as more than 99% of UV radiation is absorbed by the front of the eyes. The ocular effect due to environmental exposures to UVR is photo keratitis11 or snow blindness. It is characterized by reddening of the eye ball, gritty feeling of severe pain, photophobia and blepherospasm or twitching. Additional ocular effects are climate droplet keratopathy (CDK), pingueclue, pterygium and squamous cell carcinoma (SCC) of the cornea and conjunctiva. Of all the ocular diseases associated with solar exposure which affects the lens, cataract is characterized by a gradual loss in the transparency of the lens due to accumulation of oxidized lens proteins[11]. The ultimate result is blindness. A type of skin cancer known as Melanoma can also develop within the eye. The journal of the American Medical Association reported in 1998 that even low amounts of sunlight can increase the risk of creating eye damage such as cataracts. UV exposure damage to the eye is cumulative. So it is very essential to protect the eyes in the early stages.

Damage to aquatic life: UV radiation can hamper the aquatic life also. Phytoplankton is the most important biomass producers in aquatic ecosystem populating at the top layers of the oceans and fresh water. They receive solar radiation for photosynthesis processes. Solar UV radiation affects growth, reproduction and other cellular proteins, as well as photo synthetic pigment contents[12,13]. The radiation has been found to cause DNA damage and DNA synthesis delay in many organisms. The zooplankton concentrations depend on phytoplankton availability, grazing pressure as well as solar UV and temperature. UV-B induced DNA damage also occurs in zooplankton. UB-B severely affects survival fertility and sex ratio in several intertidal copepods[14]. The eggs and larvae of many fish are sensitive to UV-B exposure. Worrest and Kimeldorf[15] showed several adverse effects of increased exposure to UV-B on the systematic development of boreal toad tadpoles in the laboratory. In addition loss of biodiversity in oceans, rivers and lakes can reduce fish yields for commercial and sport fisheries.

Effect on atmospheric concentrations of HOx, CH_4, CO and H_2O_2: HOx radicals play a significant role in tropospheric chemistry. Increased UV-B actinic fluxes yield higher tropospheric concentrations of the HOx radicals. Fuglestvdet *et al*,[16] clearly reported that the increases in UV-B radiation over 1979-1993 have led to an increase of OH concentration on the global scale of about 8%. A carbon monoxide concentration measurement indicates an increase in the CO abundance of 1% per year over the past 40 years in the Northern Hemisphere[17] and no significant change in the Southern Hemisphere[18]. Model calculations suggest that tropospheric H_2O_2 concentrations should increase in response to enhanced tropospheric UV-B actinic fluxes. Photochemical model calculations for Summit[19] suggest that ozone depletion over 1980-1990 produces H_2O_2 increase of about 7% for summer. The concentration of atmospheric methane started to increase about 100 years ago. The rate of increase was nearly 16 ppb per year in late 1970s.

Damage to immune system: Over exposure to UV radiation has a harmful suppressing effect on the immune system. Repeated over exposure to radiations can cause even more damage to the body's immune system. Grossman and Leffel has shown that the immunosuppressive effects of UV may be as important as the carcinogenic effects of UV radiation in the establishment and progressive growth of UB induced skin tumors.

Effect on the Antarctic and arctic aquatic ecosystem: Productivity in the southern ocean is characterized by large scale spatial and temporal variability which is reported by Sullivan *et al,*[20]. This makes it difficult to filter out UV-b specific effects from other variable environmental effects (Neale *et al,*) or to estimate the impact on single species or whole phytoplankton. Neale *et al,*[21] showed that an abrupt 50% reduction in ozone cloud, as a worst case, lower daily integrated water column photosynthesis by as much as 8.5%. They noted that inhibition associated with realistic environmental variability can have a strong influence on integrated water column photosynthesis than UV-B effects. They also note that regardless of natural interactions, UV is a significant environmental stressor, and its effects are enhanced by O_3 depletion

There are some differences between the Arctic and Antarctic aquatic ecosystem. Productivity in the Arctic Ocean has been reported to be higher and more heterogeneous than the Antarctic Ocean[22]. Both endemic and migratory species breed and reproduce in this ocean in spring time and early summer at a time of maximum UV-B radiations. The nitrogen cycle controls the primary productivity of marine ecosystems. Nitrogen and phosphorous uptake capacity are UV-B sensitive[23], which may increase the UV-B sensitivity of Arctic phytoplankton.

3. Conclusion

The consequences of UV-B exposure include loss of biomass, food sources for human, changes in species composition, decreases in availability of nitrogen compounds. The uptake capacity for atmospheric CO_2 is reduced that results global warming. In addition of the above effects a lot of hazards can occur on the environment, so preventive measures should be taken immediately to protect ozone layer. The Montreal Protocol agreement which is related to ozone depleting substances (ODS) should be strictly followed to ban ODS. We can protect ourselves from UV radiation by sitting in shade, avoiding prolonged exposure when the sun is high between 10 a.m and 4p.m, wearing protective clothing and broad-brimmed sunhat. Sunglasses with 100% UV protection and a good sunscreen with a sun protection factor (SPF) of 30 or above are also useful. A vast research works is going on to find out more critical effects of UV radiation and ozone depletion.

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