The Negative Effects of UVB (Ultraviolet B) Radiation as a Result of Ozone Depletion

Written by Rachael Hogeveen

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Although many people are unaware of its significance, the ozone layer plays a significant role in the protection of life on earth [2]. This layer acts as a protective boundary, made up of ozone (O3) particles, which surrounds the earth at the stratospheric level and prevents the exposure of harmful UV radiation produced by the sun [2]. Unfortunately, ozone particles can be easily destroyed by chemicals called ozone depleting substances (ODSs) which are used in various refrigerants and solvents [3]. Despite being beneficial in the world of air conditioning and refrigeration, these substances have had a great and negative impact on the ozone layer - the most significant being the ozone holes at both poles - and continue to deplete this protective barrier [3]. According to current studies, UVB radiation levels can as much as double at times due to the lack of ozone in Antarctica [2]. As a result, there are numerous negative effects that come with the depletion of the ozone layer - of which I will be covering in this paper, along with various short and long term solutions regarding UV radiation and the matter of ozone depletion. Since the effects of UVB radiation have the most urgency, I will be focusing on this specific type of radiation [8, 5].

Starting at the bottom of the food chain and the foundation for life itself, the physiological and developmental processes involved in plant growth can be easily disrupted by UVB radiation directly or indirectly through alterations in plant form, distribution of nutrients, and temporal patterns for developmental phases and secondary metabolism [2]. These alterations ultimately affect the plant's ability to compete with other plants, defend itself against herbivory and disease, and take part in the necessary biogeochemical cycles [2]. Due to these effects, several concerns arise such as the loss of plant species and the global food supply, soil erosion, water loss, and reduction in oxygen production and carbon dioxide storage [5]. Regarding plants dwelling in marine ecosystems, the reduction in phytoplankton survival has been linked to increases in UVB radiation due to ozone depletion [2]. As with the terrestrial environment, the reduction in marine plant life can have catastrophic implications regarding the survival of other organisms and the ecosystem as a whole.

Along with plant life, animals are also greatly affected by UVB radiation [2]. Referring back to marine ecosystems, it has been found that UVB radiation disturbs the early development of many fish, shrimp, crab, amphibians, etc. - leading to decreased reproductively and impaired larval development [2]. On land, several diseases in animals are the result of UVB exposure and raise the concern of the reduction in fertility and growth as well as a greater vulnerability to other diseases - ultimately leading to a reduction in the populations themselves [7]. Of the most

prominent effects associated with UVB exposure, cancerous diseases such as squamous cell carcinoma can affect the non-pigmented skin of cats, cattle, sheep, horses, and other domestic animals [5, 4]. Other diseases such as Uberreiter's syndrome in dogs are expected to increase with UVB radiation, along with infectious keratoconjunctivitis (New Forest eye) in cattle [4]. UVB radiation is also found to damage the immune systems of animals - stripping their protection from other diseases (as mentioned above) [7]. In addition to these consequences, the decrease in plant health due to UVB radiation (as mentioned previously) also doubles as an indirect effect on animal health in regards to food shortage and food-related illnesses.

Along with the indirect health effects of UVB radiation caused by its effects on plants and animals - such as food and oxygen shortage among other things -, humans are also directly impacted by UVB exposure. Based on epidemiological studies, exposure to UVB radiation directly results in and contributes to various cancerous health effects on humans such as non-melanoma skin cancer and malignant melanoma development [2, 1]. Based on data taken from Brazil and Italy, occupation-related sun exposure was associated with an increase in developing Cutaneous Malignant Melanoma (CCM) [1]. Other studies show a correlation with Keratinocyte cancers (KCs) such as basal and squamous cell carcinomas (BCC and SCC) instead of CCM [1]. Eye-related damage due to UVB radiation includes snow blindness at higher altitudes as well as cataracts - which is the world's leading cause of permanent blindness [5]. According to the government of Canada, if a 10% depletion of the ozone layer is continually sustained, scientists believe that it "would lead to a 26% percent increase in non-melanoma skin cancer. This could mean an additional 300,000." as well as "nearly two million new cases of cataracts per year globally." (Government of Canada, 2013) [5]. It has also been found that UVB radiation affects your immune system, can activate certain viruses, and causes other skin-related problems such as sunburn and premature aging [5]. Exposure to UVB radiation has also been linked to DNA damage [1]. In order to properly analyze the negative health effects on humans due to UVB radiation and work on a solution, it is important that more research is conducted.

In the abiotic environment, UVB radiation has the potential to interfere with terrestrial and aquatic biogeochemical cycles (referring back to its effect on plants) - therefore altering the current levels of trace gases in the world and further contributing to ozone depletion and global warming [2]. UVB radiation also negatively affects commercial materials such as synthetic polymers and natural biopolymers by accelerating breakdown and decreasing their lifespan [2].

Although the negative effects of UVB radiation seem daunting, several short and long term solutions have been developed to combat UVB and restore the ozone layer [9]. Regarding short term solutions, it is important to reduce your exposure to the sun between 10:00 a.m. and 3:00 p.m. when UV radiation is the most intense and to stay indoors [5]. If being outdoors is unavoidable, make sure to wear a wide-brimmed hat, sunglasses with UVB protection, and a long shirt and pants or sunscreen with a Sun Protection Factor (SPF) of at least 15 on bare skin [5]. It has been found that applying sunscreen regularly can prevent DNA damage and sunburns [1]. Several studies have also shown potential for cancer prevention when using sunscreen containing an SPF of at least 15; however more research must be done [1].

Due to the recognition of the negative effects of chlorine and bromine within ODSs on the ozone layer, international long term solutions have already been placed in order to reduce and restrict the production and consumption of CFCs and other halocarbons [9]. In 1987, the Montreal Protocol was put into effect and "began the phase-out of CFCs in 1993 and sought to achieve a 50 percent reduction in global consumption from 1986 levels by 1998" (Wuebbles) [9]. As a result of the Montreal Protocol along with several other international agreements, it is predicted that the ozone layer will recover in time [9]. According to a United Nations report in 2018, an estimation was made stating that the Antarctic ozone hole is on a slow path to recovery and the concentrations of stratospheric ozone will return to 1980 concentrations by the 2060s [9]. In 2019, it was predicted that certain regions of the ozone layer will be completely healed by the 2030s, according to the UNEP [6].

In conclusion, there are numerous harmful effects caused by UVB radiation on the biotic and abiotic environment as a result of ozone depletion. However, there is hope in the short and long term solutions developed to fight against exposure to UVB radiation. With increased awareness of the negative effects of UVB radiation as well as programs working to restore the ozone layer and reduce ODS production; the planet can heal itself and continue to protect life from harmful UV radiation.

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