

Effects of Stratospheric Ozone Depletion the Environment and Agriculture

Dr.S.M.Ali , Mr.Nutan Ku. Dash, Ms. Arjadhara Pradhan

¹Dr.S.M.Ali, School of Electrical Engineering,KIIT University,Bhubaneswar, Odisha , India; ²Mr.Nutan Kumar Dash , School of Electrical Engineering,KIIT University,Bhubaneswar, Odisha , India, ³Ms Arjadhara Pradhan, School of Electrical Engineering,KIIT University,Bhubaneswar, Odisha , India

Email: drsma786@gmail.com , aryaa.dharaa@yahoo.com

ABSTRACT:

Ozone depletion results in greater amounts of UV-B radiation that had an impact on terrestrial and aquatic biogeochemical systems. Biogeochemical cycles were the complex interactions of physical, chemical, geological and biological processes that control the transport and transformation of substances in the natural environment and therefore the conditions that humans experience in Earth's system. The increased UV-B radiation impinging on terrestrial and aquatic systems, due to ozone depletion, results in changes in the trace gas exchange between the continents, oceans and the atmosphere. This had result in complex alterations to atmospheric chemistry, the global elemental cycles such as the carbon cycle, and had an impact on the survival and health of all organisms on Earth, including humans.

Keywords: vernalisation, photorespiration, DOM, CFC

1. INTRODUCTION:

Stratospheric ozone depletion normally increases the ozone concentration at ground level. In general the impact of stratospheric ozone depletion is smaller than that of local and regional air pollution sources. Increases in the particulates in the atmosphere related to global warming may reduce troposphere ozone production. Climate change can alter air quality in many ways. Changes in temperature, winds and cloudiness can all be important. Some of these changes will also alter the impact of stratospheric ozone depletion. As an example, an increase in atmospheric CO₂ concentration would accelerate photosynthesis, which might enhance the emissions of biological volatile organic compounds from forests and other natural ecological systems. Other sources of tropospheric air pollutants may be affected by global warming. It is known that local and large-scale biomass fires, such as are used for land-cleaning, are fish sources of nitrogen oxides, carbon monoxide, methane, and other non-methane hydrocarbons, that can lead to enhanced tropospheric ozone production. Climate changes resulting from global warming may increase the risk of large-scale forest and brush fires and so affect concentrations of troposphere air pollutants. The resulting particulates in the atmosphere can scatter sunlight, thus improving the efficiency of UV-B absorption of the boundary layer ozone and contributing to global warming. The Earth's climate has always been changing, just as life on Earth constantly changes. What we are concerned about is that human actions have added to natural changes ever since the Industrial Revolution in the 18th century, and during the last few decades this contribution has escalated. Much of this human influence on our climate has to do with economic development and increasing quality of life in many countries. This is reflected in higher demands for energy to heat homes and fuels our cars, and increased consumption of a range of products, most of which have used fossil fuels in their production.

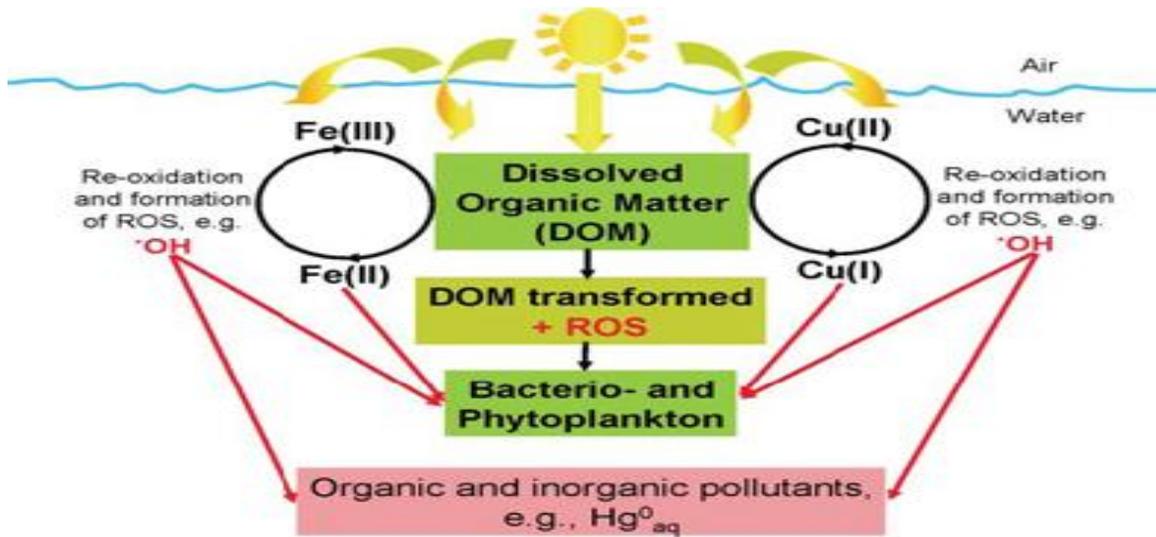
In other words, climate change is not new, not even human-influenced climate change. What *is* new is the rate at which we are now contributing to changes in climate through our actions. Two major consequences of human activity have been the increase in atmospheric CO₂ and the decrease in the stratospheric ozone layer. This declining ozone layer is linked to climate change, because many of the man-made chemicals responsible for the decrease in O₃ are also gases that absorb infrared (heat) radiation and so have contributed to the greenhouse effect. And of course, the 'ozone hole' allows more ultraviolet (UV) radiation to reach the Earth's surface.

2. Stratospheric ozone depletion

The **stratospheric ozone layer** is found 10-40km above the Earth's surface. The concentration of O₃ molecules in this layer has been decreased by man-made chemicals such as the chlorofluorocarbons (CFCs). This effect is most apparent over the Arctic and Antarctic,

where it has resulted in the 'ozone hole'. The stratospheric ozone layer protects life on Earth by absorbing the damaging, high-energy UV-C radiation. However, O₃ itself acts as a greenhouse gas, and this is important for ozone in the layer of the atmosphere called the troposphere, where it forms smog and, as a pollutant, has a harmful effect on animals and plants. Back to the stratospheric ozone layer. When this becomes thinner, more UV-B radiation reaches the Earth's surface - and this can affect the biogeochemical cycles.

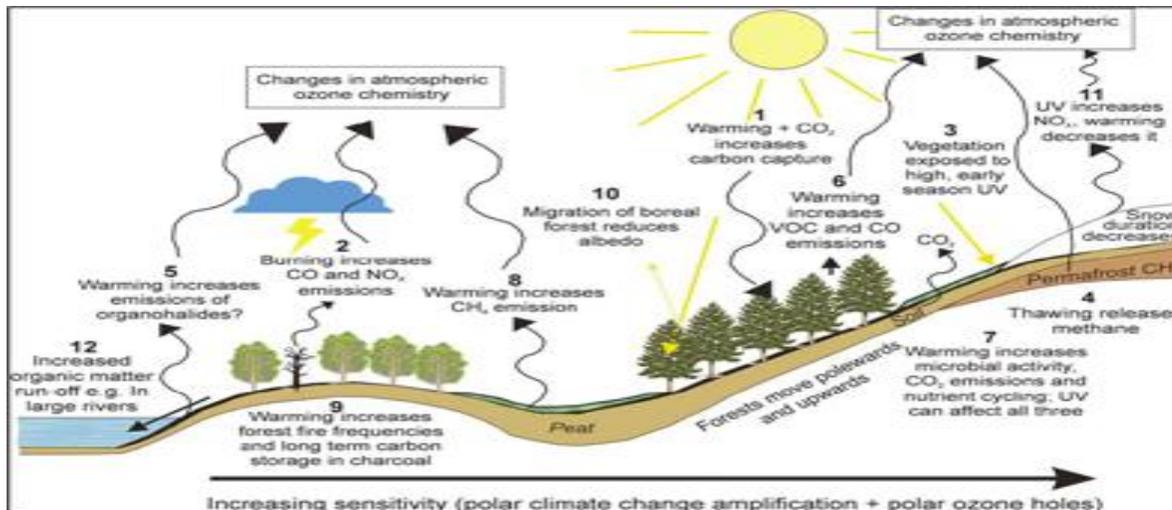
3. Mechanism showing effect of UV radiation on environment



UV radiation is a key factor in the chemistry of iron and copper in aquatic systems, including their interactions with dissolved organic matter (DOM) and microorganisms. This diagram shows the UV-induced reduction-oxidation cycling of iron & copper and the production of free radicals that can adversely affect bacterio- & phytoplankton and react with pollutants such as dissolved gaseous mercury.

An increase in UV-B can promote production of carbon monoxide (CO) from dead plant matter, and release of nitrogen oxides from snow in the Arctic and Antarctic. UV-B can also help break down dead plant material, and thus contributes to the release and cycling of plant nutrients, including nitrogen. Since the efficiency of nitrogen cycling also depends on temperature, any warming of the Earth will also affect the availability of nitrogen for plants. UV (both A and B) can also make metals such as iron and copper more readily available for uptake by plants. For example, copper can form complexes (linkages) with other materials and thus is not available for plants and animals. However, UV radiation can break up these complexes, freeing up the copper.

Many events related to climate change, such as increased drought or snowfall, increased numbers or outbreaks of pests, thawing of snow or ice, will all change the pattern and rate of biogeochemical cycling. At the same time, changes in UV-B radiation will have an effect on the amount of plant material available for recycling, and the growth of aquatic organisms. And the effects of climate change and UV radiation are linked. For example, with the thawing of snow and ice, organisms previously protected from UV-A and -B radiation will be more exposed, and this can have a damaging effect on their productivity. With prolonged periods of drought, the amount of carbon in soils will decrease, especially in peat bogs and wetlands where large stores of carbon are found. At the same time, UV-B radiation often increases the breakdown of dead plant material, returning more nutrients (including C and N) to the soil. A higher frequency of forest fires - due to drought - and increasing temperatures will decrease the carbon stored in the short term, but increase it through the production of charcoal through incomplete combustion, while N will be lost from forests and escape to the atmosphere.



Modelling the potential effects of enhanced UV radiation and climate change on biogeochemical cycles in terrestrial ecosystems. Key: CO = carbon monoxide, NO_x = oxides of nitrogen, CH₄ = methane, CO₂ = carbon dioxide, VOC = volatile organic compounds.

Thus both land and water provide sinks and sources for gases, nutrients, and other compounds. And climate-change factors such as increasing temperatures, increasing UV-B radiation, and changes in rainfall will all contribute to changing the cycling of nutrients in so many ways that it's hard to predict the outcomes. Scientists are becoming more aware that they have to focus their research on the many interactive processes that are occurring, rather than on just one event. This makes the science both exciting, and a challenge for future generations, and opens up many opportunities to apply knowledge from many subject areas to solve a particular problem.

Fortunately most countries have signed an international agreement, the Montreal Protocol, to stop any further decline in the stratospheric ozone layer. The next big challenge is to slow down the warming of the Earth by reducing other greenhouse gas emissions, particularly CO₂. The Kyoto Protocol was written for this purpose, but it has a tough road ahead of it. Through participating in the meetings of the Environmental Effects Assessment Panel of the United Nations Environmental Programme, as well as the Montreal Protocol, Waikato University's Janet Bornman and scientists from around the world are trying to get a better understanding of the complexity behind the interactions and impacts of climate change and a declining ozone layer.

4. Effect of climate change on agriculture:

Despite technological advances, such as improved varieties, genetically modified organisms, and irrigation systems, weather is still a key factor in agricultural productivity, as well as soil properties and natural communities. The effect of climate on agriculture is related to variabilities in local climates rather than in global climate patterns. The Earth's average surface temperature has increased by 1.5°F {0.83°C} since 1880. Consequently, agronomists consider any assessment has to be individually considering each area. On the other hand, agricultural trade has grown in recent years, and now provides significant amounts of food, on a national level to major importing countries, as well as comfortable income to exporting ones. The international aspect of trade and security in terms of food implies the need to also consider the effects of climate change on a global scale.

In the long run, the climatic change could affect agriculture in several ways :

- productivity, in terms of quantity and quality of crops
- agricultural practices, through changes of water use (irrigation) and agricultural inputs such as herbicides, insecticides and fertilizers
- environmental effects, in particular in relation of frequency and intensity of soil drainage (leading to nitrogen leaching), soil erosion, reduction of crop diversity
- Rural space, through the loss and gain of cultivated lands, land speculation, land renunciation, and hydraulic amenities.
- Adaptation, organisms may become more or less competitive, as well as humans may develop urgency to develop more competitive organisms, such as flood resistant or salt resistant varieties of rice.

They are large uncertainties to uncover, particularly because there is lack of information on many specific local regions, and include the uncertainties on magnitude of climate change, the effects of technological changes on productivity, global food demands, and the numerous possibilities of adaptation.

5. Effect of elevated carbon dioxide on crops:

Carbon dioxide is essential to plant growth. Rising CO₂ concentration in the atmosphere can have both positive and negative consequences. Increased CO₂ is expected to have positive physiological effects by increasing the rate of photosynthesis. Currently, the amount of carbon dioxide in the atmosphere is 380 parts per million. In comparison, the amount of oxygen is 210,000 ppm. This means that often plants may be starved of carbon dioxide, due to the enzyme that fixes CO₂, rubisco also fixes oxygen in the process of photorespiration. The effects of an increase in carbon dioxide would be higher on C₃ crops (such as wheat) than on C₄ crops (such as maize), because the former is more susceptible to carbon dioxide shortage. Studies have shown that increased CO₂ leads to fewer stomata developing on plants which lead to reduced water usage.^[31] Under optimum conditions of temperature and humidity, the yield increase could reach 36%, if the levels of carbon dioxide are doubled further; few studies have looked at the impact of elevated carbon dioxide concentrations on whole farming systems. Most models study the relationship between CO₂ and productivity in isolation from other factors associated with climate change, such as an increased frequency of extreme weather events, seasonal shifts, and so on. In 2005, the Royal Society in London concluded that the purported benefits of elevated carbon dioxide concentrations are "likely to be far lower than previously estimated" when factors such as increasing ground-level ozone are taken into account

6. Agricultural surfaces and climate changes:

Climate change may increase the amount of arable land in high-latitude region by reduction of the amount of frozen lands. A 2005 study reports that temperature in Siberia has increased three degree Celsius in average since 1960 (much more than the rest of the world). However, reports about the impact of global warming on Russian agriculture indicate conflicting probable effects: while they expect a northward extension of farmable lands, they also warn of possible productivity losses and increased risk of drought.

Sea levels are expected to get up to one meter higher by 2100, though this projection is disputed. A rise in the sea level would result in an agricultural land loss, in particular in areas such as South East Asia. Erosion, submergence of shorelines, salinity of the water table due to the increased sea levels, could mainly affect agriculture through inundation of low-lying lands. Low lying areas such as Bangladesh, India and Vietnam will experience major loss of rice crop if sea levels are expected to rise by the end of the century. Vietnam for example relies heavily on its southern tip, where the Mekong Delta lies, for rice planting. Any rise in sea level of no more than a meter will drown several km². Of rice paddies, rendering Vietnam incapable of producing its main staple and export of rice.

7. Agricultural Crop development models:

Models for climate behavior are frequently inconclusive. In order to further study effects of global warming on agriculture, other types of models, such as crop development models, yield prediction, quantities of water or fertilizer consumed, can be used. Such models condense the knowledge accumulated of the climate, soil, and effects observed of the results of various agricultural practices. They thus could make it possible to test strategies of adaptation to modifications of the environment. Because these models are necessarily simplifying natural conditions (often based on the assumption that weeds, disease and insect pests are controlled), it is not clear whether the results they give will have an in-field reality. However, some results are partly validated with an increasing number of experimental results.

Other models, such as insect and disease development models based on climate projections are also used (for example simulation of aphid reproduction or septoria (cereal fungal disease) development). Scenarios are used in order to estimate climate changes effects on crop development and yield. Each scenario is defined as a set of meteorological variables, based on generally accepted projections. For example, many models are running simulations based on doubled carbon dioxide projections, temperatures raise ranging from 1 °C up to 5 °C, and with rainfall levels an increase or decrease of 20%. Other parameters may include humidity, wind, and solar activity. Scenarios of crop models are testing farm-level adaptation, such as sowing date shift, climate adapted species (vernalisation need, heat and cold resistance), irrigation and fertilizer adaptation, resistance to disease. Most developed models are about wheat, maize, rice and soybean

Conclusion:

The agricultural sector is a driving force in the gas emissions and land use effects thought to cause climate change. In addition to being a significant user of land and consumer of fossil fuel, agriculture contributes directly to greenhouse gas emissions through practices

such as rice production and the raising of livestock according to the Intergovernmental Panel on Climate Change, the three main causes of the increase in greenhouse gases observed over the past 250 years have been fossil fuels, land use, and agriculture. Climate change induced by increasing greenhouse gases is likely to affect crops differently from region to region. For example, average crop yield is expected to drop down to 50% in Pakistan according to the UKMO scenario whereas corn production in Europe is expected to grow up to 25% in optimum hydrologic conditions. More favorable effects on yield tend to depend to a large extent on realization of the potentially beneficial effects of carbon dioxide on crop growth and increase of efficiency in water use. Decrease in potential yields is likely to be caused by shortening of the growing period, decrease in water availability and poor verbalization.

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