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Effects of Chlorofluorocarbons (CFC) on ozone and its role in deplication of ozone layer

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ABSTRACT

Earth enjoys many advantages among the planets in the solar system, from its moderate temperatures and the existence of water and oxygen to its layer of ozone molecules that protect its inhabitants from the sun's harmful energy. The advent of chlorofluorocarbons, or CFCs, threatened the ozone layer and the survival of Earth dwellers. Manufacturers thought the chemicals were the panacea to their manufacturing headaches because CFCs emitted no odors, were stable, were not flammable or toxic and could be manufactured cheaply. Little did these manufacturers know that their hopes would be dashed only decades later.

A layer of ozone envelops the Earth and keeps damaging ultraviolet, or UV, radiation from reaching living things on the planet's surface. The ozone layer exists mainly in the stratosphere, a layer of the atmosphere that reaches from 10 to 50 kilometers (about 6 to 30 miles) above the Earth's surface. UV radiation causes various harmful effects in humans, including skin cancer and cataracts, a clouding of the lens of the eye. Ozone comprises three atoms of oxygen bonded together chemically, while oxygen in its usual form is diatomic, meaning that it contains two chemically bonded atoms of oxygen. Ozone molecules absorb UV rays, using this energy to separate an oxygen atom from the ozone molecule. This uses up the energy of the UV ray and renders it harmless to living things. Of the three types of UV radiation, UVB is the most harmful because it reaches the furthest, even beneath the ocean's surface

Keywords- CFCs, chlorine, fluorine and carbon; aerosols, refrigerants

I.INTRODUCTION

Chlorofluorocarbons, or CFCs, are compounds made up of combinations of the elements chlorine, fluorine and carbon; aerosols, refrigerants and foams contain CFCs. When these CFCs enter the air, they rise up into the atmosphere to meet up with and destroy ozone molecules. First used in 1928, CFCs have since become more common as various other CFC compounds were created. Some of the better-known CFCs are the Freon compounds, which were used as cooling ingredients in refrigerators and air conditioners but have since been phased out of production in the United States. The U.S. government still permits the use of Freon in appliances and vehicles as long as supplies are available. Environmentally friendly compounds have mostly replaced Freon as refrigerants

How do CFCs Destroy the Ozone Layer?

Emissions of CFCs to date have accounted for roughly 80% of total stratospheric depletion. Whilst chlorine is a natural threat to ozone, CFCs which contain chlorine are a man-made problem. Although CFC molecules are several times heavier than air, winds mix the atmosphere to altitudes far above the top of the stratosphere much faster than molecules can settle according to their weight. CFCs are insoluble in water and relatively unreactive in the lower atmosphere but are quickly mixed and reach the stratosphere regardless of their weight. When UV radiation hits a CFC molecule it causes one chlorine atom to break away. The chlorine atom then hits an ozone molecule consisting of three oxygen atoms and takes one of the oxygen molecules, destroying the ozone molecule and turning it into oxygen. When an oxygen molecule hits the molecule of chlorine monoxide, the two oxygen atoms join and form an oxygen molecule. When this happens, the chlorine atom is free and can continue to destroy ozone. Naturally occurring chlorine has the same effect in the ozone layer, but has a shorter life span

II.DESTRUCTIVE POWER OF CHLOROFLUOROCARBONS

When the sun's UV rays come in contact with CFCs, the chlorine atoms come loose. These chlorine atoms wander around the atmosphere until they meet up with ozone molecules. The chlorine atom and one of the oxygen atoms of ozone combine, leaving behind diatomic, or molecular, oxygen. When a free oxygen atom contacts this chlorine-oxygen compound, the two oxygen atoms combine to form molecular oxygen, and the chlorine goes off to devastate more ozone molecules. Molecular oxygen, unlike ozone molecules, cannot keep UV rays from reaching the Earth's surface. The U.S. Environmental Protection Agency estimates that one atom of chlorine can destroy as many as 100,000 molecules of ozone. In 1974, M. J. Molina and F. S. Rowland published a paper outlining how CFCs broke down ozone molecules in the atmosphere.

Ozone depletion

Man-made compounds such as chlorofluorocarbons (CFCs), hydrofluorocarbons (HCFCs) and halons destroy ozone in the upper atmosphere (stratosphere). The stratospheric ozone layer makes life possible by shielding the earth from harmful ultraviolet (UV-B) rays generated from the sun. Decreased concentration of stratospheric ozone allows increased amounts of UV-B to reach the earth's surface.

Stratospheric ozone loss can result in potential harm to human health and the environment, including:

- increased incidence of skin cancer and cataracts
- immune system system damage
- damage to terrestrial and aquatic plant life
- increased formation of ground-level ozone (smog)

Most stratospheric ozone depletion is caused when chlorine or bromine reacts with ozone. Most of the chlorine entering the stratosphere is from man-made sources (84%), such as CFCs and HCFCs with the remaining 16% from natural sources, such as the ocean and volcanoes. About half of bromine entering the stratosphere is from man-made sources, mostly Halons.

Climate change

While acting to destroy ozone, CFCs and HCFCs also act to trap heat in the lower atmosphere, causing the earth to warm and climate and weather to change. HFCs, which originally were developed to replace CFCs and HCFCs, also absorb and trap infrared radiation or heat in the lower atmosphere of the earth. HFCs, CFCs and HFCs are a subset of a larger group of climate changing gases called greenhouse gases (GHGs). Taken together greenhouse gases are expected to warm the planet by 2.5 to 8 degrees Fahrenheit by the end of century.

HFCs, CFCs and HFCs contribute an estimated 11.5% to present-day effect of GHGs on climate and climate change. Some effects of global climate change include:

- Rising sea levels
- Local natural species extinctions and habitat loss
- More frequent heavy rainfall and flooding
- High heat stress in summer
- Increasing health risk from insect and water-borne diseases

The production of CFCs in the United Stated or their import was prohibited as of January 1, 1996. Use of CFCs is restricted to equipment placed into use prior to 1996. The production or import of HCFC-22 and HCFC-142b for use in new units or applications was banned in the US as of January 1, 2010, although production and import for use in existing equipment is allowed through 2019. The production or import of HCFC-141b for any purpose were prohibited as of January 1, 2004.

Most HFC uses in new units or applications are being phased out under USEPA Rules over a staggered schedule that begins in 2016 and stretches through 2024. Under these Rules, most HFC uses in polyurethane and other foams and in new retail food refrigerated cases will be phased out between January 1, 2016 and January 1 2020. Use of HFCs in mobile air conditioning will end with Model Year 2020, while prohibitions on HFC use in new fire suppression systems, cold storage, residential refrigeration, and building chillers go into place on January 1 of 2018, 2021, 2023 and 2024, respectively.

Use of HFCs in existing equipment is unaffected by EPA regulations. Minnesota has an estimated 12 million residential appliances and car air conditioners that contain a total of about 13,000 tons of CFCs, HCFCs and HFCs.

Consequences of ozone layer depletion

Since the ozone layer absorbs UVB ultraviolet light from the sun, ozone layer depletion increases surface UVB levels (all else equal), which could lead to damage, including increase in skin cancer. This was the reason for the Montreal Protocol. Although decreases in stratospheric ozone are well-tied to CFCs and to increases in surface UVB, there is no direct observational evidence linking ozone depletion to higher incidence of skin cancer and eye damage in human beings. This is partly because UVA, which has also been implicated in some forms of skin cancer, is not absorbed by ozone, and because it is nearly impossible to control statistics for lifestyle changes over time.

III.INCREASED UV

Ozone, while a minority constituent in Earth's atmosphere, is responsible for most of the absorption of UVB radiation. The amount of UVB radiation that penetrates through the ozone layer decreases exponentially with the slant-path thickness and density of the layer. When stratospheric ozone levels decrease, higher levels of UVB reach the Earth’s surface.[1][40] UV-driven phenolic formation in tree rings has dated the start of ozone depletion in northern latitudes to the late 1700s.[41]

In October 2008, the Ecuadorian Space Agency published a report called HIPERION. The study used ground instruments in Ecuador and the last 28 years' data from 12 satellites of several countries, and found that the UV radiation reaching equatorial latitudes was far greater than expected, with the UV Index climbing as high as 24 in Quito; the WHO considers 11 as an extreme index and a great risk to health. The report concluded that depleted ozone levels around the mid-latitudes of the planet are already endangering large populations in these areas.[42] Later, the CONIDA, the Peruvian Space Agency, published its own study, which yielded almost the same findings as the Ecuadorian study.

Biological effects

The main public concern regarding the ozone hole has been the effects of increased surface UV radiation on human health. So far, ozone depletion in most locations has been typically a few percent and, as noted above, no direct evidence of health damage is available in most latitudes. If the high levels of depletion seen in the ozone hole were to be common across the globe, the effects could be substantially more dramatic. Ozone depletion would magnify all of the effects of UV on human health, both positive (including production of Vitamin D) and negative (including sunburn, skin cancer, and cataracts). In addition, increased surface UV leads to increased tropospheric ozone, which is a health risk to humans.

Basal and squamous cell carcinomas

The most common forms of skin cancer in humans, basal and squamous cell carcinomas, have been strongly linked to UVB exposure. The mechanism by which UVB induces these cancers is well understood—absorption of UVB radiation causes the pyrimidine bases in the DNA molecule to form dimers, resulting in transcription errors when the DNA replicates. These cancers are relatively mild and rarely fatal, although the treatment of squamous cell carcinoma sometimes requires extensive reconstructive surgery. By combining epidemiological data with results of animal studies, scientists have estimated that every one percent decrease in long-term stratospheric ozone would increase the incidence of these cancers by two percent.

Malignant melanoma

Another form of skin cancer, malignant melanoma, is much less common but far more dangerous, being lethal in about 15–20 percent of the cases diagnosed. The relationship between malignant melanoma and ultraviolet exposure is not yet fully understood, but it appears that both UVB and UVA are involved. Because of this uncertainty, it is difficult to estimate the effect of ozone depletion on melanoma incidence. One study showed that a 10 percent increase in UVB radiation was associated with a 19 percent increase in melanomas for men and 16 percent for women.[1] A study of people in Punta Arenas, at the southern tip of Chile, showed a 56 percent increase in melanoma and a 46 percent increase in nonmelanoma skin cancer over a period of seven years, along with decreased ozone and increased UVB levels.

Cortical cataracts

Epidemiological studies suggest an association between ocular cortical cataracts and UVB exposure, using crude approximations of exposure and various cataract assessment techniques. A detailed assessment of ocular exposure to UVB was carried out in a study on Chesapeake Bay Watermen, where increases in average annual ocular exposure were associated with increasing risk of cortical opacity. In this highly exposed group of predominantly white males, the evidence linking cortical opacities to sunlight exposure was the strongest to date. Based on these results, ozone depletion is predicted to cause hundreds of thousands of additional cataracts by 2050.

Increased tropospheric ozone

Increased surface UV leads to increased tropospheric ozone. Ground-level ozone is generally recognized to be a health risk, as ozone is toxic due to its strong oxidant properties. The risks are particularly high for young children, the elderly, and those with asthma or other respiratory difficulties. At this time, ozone at ground level is produced mainly by the action of UV radiation on combustion gases from vehicle exhausts.

Increased production of vitamin D

Vitamin D is produced in the skin by ultraviolet light. Thus, higher UVB exposure raises human vitamin D in those deficient in it. Recent research (primarily since the Montreal Protocol) shows that many humans have less than optimal vitamin D levels. In particular, in the U.S. population, the lowest quarter of vitamin D (<17.8 ng/ml) were found using information from the National Health and Nutrition Examination Survey to be associated with an increase in all-cause mortality in the general population.[] While blood level of Vitamin D in excess of 100 ng/ml appear to raise blood calcium excessively and to be associated with higher mortality, the body has mechanisms that prevent sunlight from producing Vitamin D in excess of the body's requirements.

IV.EFFECTS ON NON-HUMAN ANIMALS

A November 2010 report by scientists at the Institute of Zoology in London found that whales off the coast of California have shown a sharp rise in sun damage, and these scientists "fear that the thinning ozone layer is to blame".] The study photographed and took skin biopsies from over 150 whales in the Gulf of California and found "widespread evidence of epidermal damage commonly associated with acute and severe sunburn", having cells that form when the DNA is damaged by UV radiation. The findings suggest "rising UV levels as a result of ozone depletion are to blame for the observed skin damage, in the same way that human skin cancer rates have been on the increase in recent decades."

V.EFFECTS ON CROPS

An increase of UV radiation would be expected to affect crops. A number of economically important species of plants, such as rice, depend on cyanobacteria residing on their roots for the retention of nitrogen. Cyanobacteria are sensitive to UV radiation and would be affected by its increase. "Despite mechanisms to reduce or repair the effects of increased ultraviolet radiation, plants have a limited ability to adapt to increased levels of UVB, therefore plant growth can be directly affected by UVB radiation.