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Topic:- Depletion of the ozone layer: causes, status, recovery, Health and Environmental Effects,

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Content

Ozone depletion and its causes

The atmosphere extends a few hundred kilometres above the Earth. It is made of layers that surround the Earth like rings. However, 99% of its total mass lies in two regions within the first 50 kilometres above the Earth's surface. These two regions are called the troposphere and the stratosphere. The troposphere is closest to the Earth. It extends to about 6 to 17 kilometres above the Earth's surface and is thickest at the equator. The stratosphere extends out, beyond the troposphere, to about 50 kilometres above the Earth. The furthest layer, the mesosphere, is found roughly 50 km to 80 km above sea level.

Ozone depletion is the term commonly used to describe the thinning of the ozone layer in the stratosphere. Ozone depletion occurs when the natural balance between the production and destruction of ozone in the stratosphere is tipped in favor of destruction. Human activity is the major factor in tipping that natural balance, mostly from releasing artificial chemicals, known as ozone-depleting substances (ODS), to the atmosphere. These are stable substances that do not break down in the lower atmosphere and contain either/both chlorine and/or bromine.

The theory about ozone depletion was first put forward in 1974 by American scientists Mario Molina and F. Sherwood Rowland. They were concerned about the impact of CFCs on the ozone layer. Their hypothesis was met with a great deal of skepticism, but scientific work over the next 20 years proved them correct and prompted almost every country in the world to action. In 1995, Drs. Molina and Rowland were given a Nobel Prize in Chemistry, along with a third ozone researcher, Paul Crutzen from the Netherlands.

Ozone-depleting substances containing chlorine include chlorofluorocarbons (CFCs), carbon tetrachloride, methyl chloroform and hydrochlorofluorocarbons (HCFCs). Halons, methyl bromide and hydrobromofluorocarbons (HBFCs) are ODSs that contain bromine.

The best-known and most abundant of the ODS are the CFCs. A single atom of chlorine from a CFC can destroy 100,000 or more molecules of ozone. Ozone depletion only stops when the chlorine randomly reacts with another molecule to form a long-lived, stable substance. At that point, it is no longer free to react with ozone.

Find Out About...

- Ozone-depleting substances

While it is true that volcanoes and oceans release large amounts of chlorine, the chlorine from these sources dissolves in water so it washes out of the lower atmosphere in rain. Volcanoes may, in worst-case scenarios, cause temporary ozone loss.

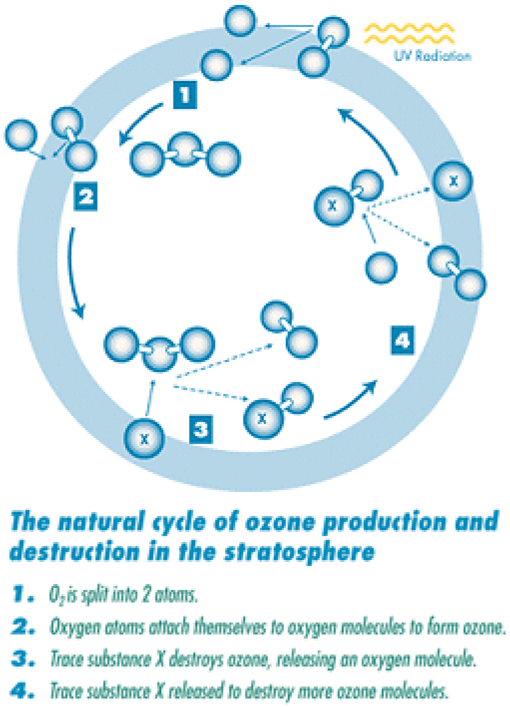

Figure-1

Status of ozone depletion

Ozone measurements fluctuate from day to day, season to season and one year to the next. Ozone concentrations are normally higher in the spring and lowest in the fall. In spite of these fluctuations, scientists have determined, based on data collected since the 1950's, that ozone levels were relatively stable until the late 1970's. Observations of an Antarctic ozone "hole"[1] and atmospheric records indicating seasonal declines in global ozone levels provide strong evidence that global ozone depletion is occurring.

Severe depletion over the Antarctic has been occurring since 1979 and a general downturn in global ozone levels has been observed since the early 1980's. The ozone hole over the Antarctic reached record proportions in the spring of 2000 at 28.3 million square kilometres and vertical profiles from stations near the South Pole showed complete ozone destruction in the lower stratosphere. Ozone decreases of as much as 70% have been observed on a few days.

Severe ozone depletion was also measured over the Arctic. Lowest values over the Arctic occurred in 2000 north of Sweden, with about 60% depletion in some layers of the atmosphere. In addition to the Earth's poles, ozone depletion now affects almost all of North America, Europe, Russia, Australia, New Zealand, and a sizable part of South America. However, smaller decreases in stratospheric ozone have been observed in mid-latitude regions of the world.

The ozone layer over southern Canada has thinned by an average of about 7% since the 1980s. In the late 1990s, average ozone depletion in the summer over Canada was between 3% and 7%. Ozone depletion in Canada is usually greatest in the late winter and early spring. In 1993, for example, average ozone values over Canada were 14% below normal from January to April.

In their assessment of ozone depletion in 2006, the Scientific Assessment Panel, a group of experts established under the Montreal Protocol, made the following key findings:

1. The total abundances of human-made ozone-depleting gases in the troposphere continue to decline from the peak values reached in the 1992-1994 time period.
2. The total abundances of human-made ozone-depleting gases in the stratosphere show a downward trend from their peak values of the late 1990s.
3. Large Antarctic ozone holes continue to occur. The severity of Antarctic ozone depletion has not continued to increase since the late 1990s and, since 2000, ozone levels have been higher than in some preceding years.
4. Arctic ozone depletion shows large year-to-year variability, driven by meteorological conditions. Over the past four decades, these conditions contributed to severe ozone depletion.
5. The decline in stratospheric ozone over mid-latitude (between 60°S and 60°N) seen in the 1990s has not continued.

Recovery of the ozone layer

No one knows for certain how much more ozone depletion will occur. There is a substantial time lag between the time when ODS emissions begin to decline and the point at which the ozone layer begins to recover. It takes years for CFCs and other ozone-depleting compounds to reach the stratosphere. Many of them can persist in the stratosphere for centuries; some have life spans of 25 to 400 years. Almost all of the CFCs and halons ever released are still in the atmosphere and will continue to destroy ozone for many years to come.

In spite of these uncertainties and substantial time lag, the natural balance between ozone creation and destruction can be restored if concentrations of ozone-destroying chemicals are reduced. However, this might require the complete elimination of ozone-destroying chemicals. In addition, there is some concern that the increase in greenhouse gas concentrations may result in delayed ozone layer recovery. Scientists estimate that they will not be able to measure any recovery until 2030.

It is important to note that scientific knowledge of the atmosphere and the processes that deplete the ozone layer is not complete. The sudden and unexpected appearance of the Antarctic ozone hole reveals that the ozone layer does not respond predictably to the quantities of industrial chemicals we are dumping into it.

[1] The term ozone "hole" refers to a large and rapid decrease in the abundance of ozone molecules, not the complete absence of them. The Antarctic ozone "hole" occurs during the southern spring between September and November.

Health and Environmental Effects of Ozone Layer Depletion

Effects on Human Health

Ozone layer depletion increases the amount of UVB that reaches the Earth's surface. Laboratory and epidemiological studies demonstrate that UVB causes non-melanoma skin cancer and plays a major role in malignant melanoma development. In addition, UVB has been linked to the development of cataracts, a clouding of the eye's lens.

Because all sunlight contains some UVB, even with normal stratospheric ozone levels, it is always important to protect your skin and eyes from the sun. See a more detailed explanation of health effects linked to UVB exposure.

EPA uses the Atmospheric and Health Effects Framework model to estimate the health benefits of stronger ozone layer protection under the Montreal Protocol. Updated information on the benefits of EPA's efforts to address ozone layer depletion is available in a 2015 report, Updating Ozone Calculations and Emissions Profiles for Use in the Atmospheric and Health Effects Framework Model.

Effects on Plants

UVB radiation affects the physiological and developmental processes of plants. Despite mechanisms to reduce or repair these effects and an ability to adapt to increased levels of UVB, plant growth can be directly affected by UVB radiation.

Indirect changes caused by UVB (such as changes in plant form, how nutrients are distributed within the plant, timing of developmental phases and secondary metabolism) may be equally or sometimes more important than damaging effects of UVB. These changes can have important implications for plant competitive balance, herbivory, plant diseases, and biogeochemical cycles.

Effects on Marine Ecosystems

Phytoplankton form the foundation of aquatic food webs. Phytoplankton productivity is limited to the euphotic zone, the upper layer of the water column in which there is sufficient sunlight to support net productivity. Exposure to solar UVB radiation has been shown to affect both orientation and motility in phytoplankton, resulting in reduced survival rates for these organisms. Scientists have demonstrated a direct reduction in phytoplankton production due to ozone depletion-related increases in UVB.

UVB radiation has been found to cause damage to early developmental stages of fish, shrimp, crab, amphibians, and other marine animals. The most severe effects are decreased reproductive capacity and impaired larval development. Small increases in UVB exposure could result in population reductions for small marine organisms with implications for the whole marine food chain.

Effects on Biogeochemical Cycles

Increases in UVB radiation could affect terrestrial and aquatic biogeochemical cycles, thus altering both sources and sinks of greenhouse and chemically important trace gases (e.g., carbon dioxide, carbon monoxide, carbonyl sulfide, ozone, and possibly other gases). These potential changes would contribute to biosphere-atmosphere feedbacks that mitigate or amplify the atmospheric concentrations of these gases.

Effects on Materials

Synthetic polymers, naturally occurring biopolymers, as well as some other materials of commercial interest are adversely affected by UVB radiation. Today's materials are somewhat protected from UVB by special additives. Yet, increases in UVB levels will accelerate their breakdown, limiting the length of time for which they are useful outdoors.

The sun emits three different types of UV radiation: UVA, UVB, and UVC.

All types of UV radiation have the potential to damage your skin, but each type affects your skin differently. UVA rays, which account for 95 percent of radiation that reaches the earth's surface, cause wrinkles, "sun spots," and other types of premature aging. They are also strongly linked to skin cancer. UVB rays, which affect skin's top layer, cause skin cancer and most sunburns.

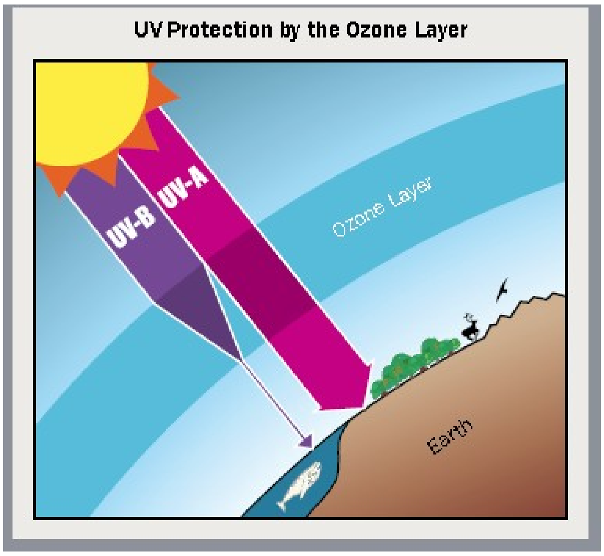

Figure-2

Figure -2. UV protection by the ozone layer.

The ozone layer resides in the stratosphere and surrounds the entire Earth. UV-B radiation (280- to 315-nanometer (nm) wavelength) from the Sun is strongly absorbed in this layer. As a result, the amount of UV-B reaching Earth's surface is greatly reduced. UV-A (315-to 400-nm wavelength), visible light, and other solar radiation are not strongly absorbed by the ozone layer. Human exposure to UV-B radiation inoreases the risks of skin cancer, cataracts, and a suppressed immune system. UV-B radiation exposure can also damage terrestrial plant life, single- cell organisms, and aquatic ecosystems.

Although UVA and UVB rays pose the greatest risk for sun damage, people who work with welding torches or mercury lamps may be exposed to UVC rays, the most dangerous type of UV radiation.

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