FACT SHEET

Community Development

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The Ozone Layer

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Much attention is given by the media to an issue called ozone depletion and the impacts of this depletion on human health. But what is ozone and how is this depletion occurring?

Ozone is a form of oxygen. The oxygen we breathe is composed of molecules of two atoms of oxygen (O_2). Ozone is three atoms of oxygen bonded together. Ozone is found between 6 and 30 miles above the earth in the stratosphere and is more unstable and uncommon than the oxygen we breathe. Although ozone is found in only about one molecule out of every 100,000 air molecules, it provides a valuable protective screen for the earth. This fact sheet will explain how ozone interacts with ultraviolet rays and chlorine molecules, discuss causes and effects of ozone depletion, and offer suggestions for citizen action.

How Ozone Works

Ozone, which is found in the stratosphere, filters the ultraviolet (UV) rays of the sun. The physical reaction is represented by:

$$O_3 + UV = O_2 + O$$

The UV radiation (energy) is absorbed by O_3, and the radiation breaks the molecule into two parts, one being a single atom of oxygen and the other being a molecule of O_2. This exchange releases the "energy" from the UV, which means it can no longer reach the lower atmosphere. The oxygen molecules (O_2 and O) are highly reactive, so these free molecules continually rejoin, rejuvenating the ozone layer.

Although ozone is vital to the balance of the earth, ozone occurring in the lower atmosphere is harmful to breathe and can damage plant life. This "tropospheric ozone" is formed when the radiation from the sun reacts with reactive hydrocarbons and oxides of nitrogen from automobiles and industrial sources. This is called photochemical smog.

How Oxygen and Chlorine Interact

When released, chlorofluorocarbons, methylchloroforms, and carbontetrachlorides can drift into the stratosphere, break apart, and release the chlorine atoms. These chlorine atoms react with ozone molecules to form a molecule of O_2 and a molecule of chlorine monoxide (ClO). The chlorine monoxide then reacts with an atom of oxygen found in the stratosphere and separates the molecule to form a molecule of O_2 and an atom of chlorine.

$$Cl + O_3 = ClO \text{ and } O_2; ClO + O = Cl + O_2$$

The chlorine reacts with the ozone and makes a single molecule of chlorine monoxide and releases a molecule of O_2. The chlorine monoxide molecule reacts to free oxygen found in the stratosphere and separates the molecule into chlorine and O_2. The chlorine atom is now available to react with another ozone molecule. One atom of chlorine can destroy up to 100,000 ozone molecules before reacting with a molecule that can stop the cycle. This destruction of ozone molecules weakens the ozone layer and its ability to block UV.

Chlorine Molecules

The chlorine that is released into the stratosphere comes primarily from two sources: chlorofluorocarbons (CFCs) and bromofluorocarbons or halons. These molecules have stable chemical structures and so do not break down in the lower atmosphere. It takes several years (some estimates say 5 to 10 years) for these molecules to reach the stratosphere. In the stratosphere, the UV radiation causes the molecule to break apart and release the chlorine.

Chlorofluorocarbons are used as propellant gases in some products and manufacturing processes. CFCs are also used as refrigerant in many appliances and air conditioners. Halons are used as propellants in such items as fire extinguishers and are also used in the dry-cleaning process. These chemicals

have been useful in society, but as more is known about ozone depletion, alternatives for these chemicals are being developed. Non-essential uses of these substances are being banned.

Effects of Ozone Depletion

Measurements taken from satellites and research stations and aircraft in the Antarctic region indicate an increase of ozone depletion in the area. Although a natural fluctuation in the ozone layer occurs throughout the year, until 1975 these fluctuations evened out over the course of the year. However, after 1975 the amount of ozone in the atmosphere above Antarctica dropped dramatically. For example, the ozone layer in October 1994 was half that measured in the month of October during the 1990s.

The harmful effects of UV radiation are well understood and include both health and economic aspects. Most notably, the more humans are exposed to UV radiation, the greater the likelihood of skin cancer. The U.S. Environmental Protection Agency suggests that a 1 percent thinning of the ozone layer can produce as much as a 5 to 7 percent increase in skin cancer. Other health effects include potential increased instances of cataracts and a weakening of the immune system.

Soybeans and loblolly pines are particularly sensitive to UV radiation. Soybeans are the third largest food crop in the United States. Loblolly pines are the source of more than two-thirds of the wood pulp formed for paper manufacturing. A decrease in ozone would have more immediate effects on plants like these that are sensitive to UV radiation.

In the marine food chain, fish larvae and phytoplankton near the ocean surface are destroyed by exposure to increased levels of UV radiation. Phytoplankton are the basis of the marine food chain and are also important in the production of oxygen.

Ozone Regeneration

The creation and destruction of ozone molecules in the stratosphere are natural cycles. The average life of an ozone molecule is relatively short in nature, but until recently, ozone was being created at least as quickly as it was destroyed since the oxygen molecule continually rejoins to rejuvenate the ozone layer.

The increase of chlorines and bromines into the atmosphere has interfered with the natural cycle. Ozone is now being destroyed more quickly than it can be created. When the emissions of these chemicals cease, the ozone layer will eventually repair itself. The repair will not be instantaneous. Even if all CFC emissions were immediately stopped, depletion of the ozone would continue to worsen for 15 to 20 years before any repair would begin. The natural rejuvenation of the ozone will be a very slow process. Estimates are that the Antarctic ozone hole will not be fully repaired until the late 21st century.

Individual Action That Can Help

The adverse effects of the use of CFCs, halons, and other ozone-depleting substances were not well documented until the 1970s. As the time required for chlorines to rise to the stratosphere is as long as 10 years, the benefit of actions taken recently as part of the Clean Air Act Amendments of 1990 and citizen action will not be realized for several years.

Individuals can act to have an impact on ozone depletion in several ways. Avoid using gas propellants of any sort, as the long-term effects of many propellants are unknown. Twenty years ago, there was little thought given to the effects of CFCs from aerosols (as in hair sprays or deodorants). Today, "pump" products can be used just as effectively for many purposes and have far less potential to harm the environment.

Individuals can act to minimize the impact on the ozone layer in other ways. They can comply with the disposal requirements for old refrigerators as identified in the Clean Air Act, have automobile air conditioners serviced in a station that recycles the fluid and have air-conditioner coolant removed from auto air conditioners before disposal. Labeling requirements of the Clean Air Act will allow consumers to choose or not choose those products containing, produced with, or packaged in ozone-depleting compounds. Legislation has put an end to the production and ultimate use of CFCs and other compounds. All remaining production will be used and reused, not released.

Individual action drives industrial action and the political process. Although 59 countries have agreed to end the production of many of these damaging substances by the year 2005, it is individuals who will end the use of these substances through choices as consumers.

Updated in 2007 by E. Elaine T. Horr. Series edited by Joe E. Heimlich and Jacqueline LaMuth, OSU Extension.