

Ozone

What Is Ozone?

Ozone is a colorless gas made of three atoms of oxygen (O_3). Most of the oxygen in the atmosphere, the oxygen that supports life, is made of only two atoms of oxygen (O_2).

Ozone can be beneficial or harmful depending on where it is found in the atmosphere. Ozone in the troposphere, the lower atmosphere that we breathe, is considered a pollutant and is harmful to human health and vegetation.

Automobiles, power plants and factories send gaseous pollutants into the troposphere that can react in the presence of strong sunlight to form ozone. Weather conditions and geography can then cause buildups in ozone levels that greatly increase its harmful effects.

Upper-level ozone is located in the stratosphere, a layer of the atmosphere nine to 31 miles above the Earth. Ozone gas in the stratosphere forms an important and very effective protective barrier against harmful radiation from the sun by absorbing ultraviolet radiation.

From Where Does Ozone Come?

Ozone gas in the stratosphere forms when oxygen molecules interact with ultraviolet rays from the sun. Amounts of ozone in the stratosphere are changing all the time. Under normal circumstances, ozone is continuously being destroyed and regenerated by the sun's ultraviolet rays. The seasons of the year, changing wind, and even sunspots affect ozone levels.

What Is the Problem?

In 1985, British scientists discovered a "hole" about the size of the U.S. in the ozone layer over Antarctica. The holes are not completely devoid of ozone, but the ozone concentrations in these areas are lower than under normal conditions, allowing more ultraviolet radiation to reach the Earth's surface. The hole over

Antarctica has reappeared each year during the Antarctic winter (our summer).

More recently, ozone thinning has been found in the stratosphere above the northern half of the U.S. This hole extends over Canada and up into the Arctic. The hole was first found only in winter and spring, but more recently has continued into summer. Between 1978 and 1991, there was a 4-5% loss of ozone in the stratosphere above the U.S.

Ozone holes also have been found over northern Europe. It has become clear that the ozone layer is thinning even more quickly than first predicted.

What Causes the Ozone Holes?

Ozone can be converted into the regular, atmospheric oxygen (O_2) by reacting with chlorine atoms in the stratosphere. The most common ozone-destroying pollutants are in a class of chemical compounds called chlorofluorocarbons (CFCs), which have a diversity of uses ranging from air conditioner coolants to aerosol spray propellants. CFCs are very stable compounds that do not react easily with other materials. These properties make them ideal for many industrial applications.

However, in 1974, scientists discovered that their stable properties enable CFCs to survive in the atmosphere long enough (up to 100 years) to reach the stratosphere where they can break down and destroy ozone. Other common industrial chemicals that destroy ozone include halons, carbon tetrachloride and hydro-CFCs (HCFCs).

When CFCs that are released into the troposphere rise into the stratosphere, ultraviolet light breaks them down into other chemicals. Eventually, chlorine is produced. Free chlorine atoms (Cl) are very unstable and immediately react with the first ozone (O_3) molecules they find to form atmospheric

oxygen (O₂) and chlorine monoxide (ClO). Chlorine monoxide also is unstable and reacts with free oxygen atoms to form atmospheric oxygen and another free chlorine atom. The reaction is then repeated again and again. One chlorine atom has the potential to destroy 10,000 ozone molecules before it sinks into the troposphere.

What Are the Effects of Depleted Ozone?

The ozone layer is an important protective screen for life on Earth, filtering out more than 99% of the ultraviolet rays before they reach the ground. Some scientists forecast that the increasing ultraviolet radiation will tremendously increase such hazards to human health as skin cancer, immune deficiencies, and cataracts. In 1987, the U.S. Environmental Protection Agency (EPA) estimated that with a 5% increase in CFCs per year, 40 million Americans will get skin cancer over the next 88 years and of those, 800,000 will die. Even more serious is the fact that, since 1987, monitoring data indicate that the rate of ozone depletion for certain latitudes is now at levels predicted for the year 2050.

Damage to the ozone layer can reduce crop yields. Terrestrial and aquatic ecosystems also will be harmed, and plant life may be seriously affected to the point of threatening world food supplies.

How Do We Reduce Its Effects?

Scientists have been measuring the ozone layer since the mid-1970s when concerns were first raised about the potentially harmful effects of CFCs on the ozone layer. The only practical approach to stopping the destruction of the ozone layer is reducing human-created pollutants that contribute to its depletion. Efforts to protect the ozone layer now involve many different nations and industries. An international agreement, called the Montreal Protocol, was established in 1987 requiring countries to cut CFC use in half by 1999. Over 90 countries have now signed the protocol. In addition, manufacturers of ozone-destroying chemicals have made major advances in CFC-alternative technologies. But even if all CFC use was halted today, the CFCs already released will continue to break down in the stratosphere and destroy ozone for decades.

Source: Project A.I.R.E., U.S. Environmental Protection Agency, <http://www.epa.gov/region01/students/teacher/airqual.html>