

**T**he chemistry of the atmosphere plays a vital role in determining the surface temperature. Although oxygen and nitrogen are by far the major constituents of the atmosphere, many trace elements play an important part in the way in which energy is transferred through the atmosphere. To permit a ready assessment of the changes that are currently occurring, *air pollution* is defined as a change in the concentration of material (or energy) in the air such that the modified content adversely affects the well-being of living things. Air pollution is neither new nor is it necessarily associated with industrial processes. Gases from fetid marshes and smoke from fires are examples of natural air pollution. Even before factory chimneys and automobiles added their output to the atmosphere, pollution was observed. Juan Rodriguez Cabrillo, sailing into San Pedro Bay in 1542, named the Los Angeles Basin the "Bay of Smokes." Prevailing weather conditions caused the smoke from scattered Indian fires to hang as a pall of pollution over the area. As we now know, this was a harbinger of things to come.

It makes no sense in today's world to consider the atmosphere in its natural form for the reason that human activity is rapidly altering atmospheric chemistry. Technological processes inject into the air a wide variety of solids, liquids, and gases collectively called *pollutants*. It is true that the atmosphere is never completely pure under any circumstances. Gases such as sulfur dioxide, hydrogen dioxide, and carbon monoxide are continually released into the air as by-products of natural occurrences such as volcanic activity, decay of vegetation, and range and forest fires. Thus, some **effluents** introduced into the atmosphere are in fact natural constituents.

These materials become pollutants only when they are placed into the atmosphere in abnormally large amounts. The volume of **effluents** placed in the atmosphere has reached the extent where levels of some constituents are increasing beyond natural limits. The Environmental Protection Agency (EPA) released a report in 1989 indicating the magnitude of the industrial injection of chemicals into the atmosphere.) In the United States, there are at least 1600 industrial facilities in 46 states that release into the air significant amounts of chemicals suspected of being carcinogenic. Some 125 of these plants release more than 400,000 pounds of chemicals each year. There are some 30 industrial facilities that emit more than 1 million pounds a year each. For instance, 2.7 billion pounds of pollutants were placed into the atmosphere in 1987. Of this amount, 360 million pounds are suspected of being **carcinogenic**.



4. **What do you mean by green house gases ? What are the uses of green house gases ?**

5. The gases which play an important role in increasing the average temperature of the earth's atmosphere are called Green House Gases. Some of the Green House Gases are Carbon Dioxide ( $\text{CO}_2$ ), Carbon Monoxide ( $\text{CO}$ ), Methane ( $\text{CH}_4$ ), Chloro fluoro carbon (CFC), Nitrous Oxide ( $\text{N}_2\text{O}$ ), Water vapour, etc.

**Uses** – The Green House Gases are prepared naturally in the environment and are also sometimes the outcome of human activities. These gases are very important for life activities. The sun's energy reaches the earth's surface daily as insolation, and is radiated back daily. The Green House Gases trap the outgoing infrared radiation and send it back towards the earth's surface. This helps to keep the earth's atmosphere warm, which would have otherwise become so chilled due to out-radiation that no life would have been possible on earth.

But the problem is, if the amount of Green House Gases increases drastically, they will hold back so much heat that it will increase the atmospheric temperature at alarming rates. This condition will also be not suitable for existence of life on earth.

## 1. Global Warming

The evidence of global atmospheric warming seems compelling and modern civilization's role in its occurrence appears easily traced. Human kind's massive assault on the atmosphere began with the Industrial Revolution. First coal and then increasing amounts of petroleum and natural gas have been burned to power industry, heat and cool cities, and drive vehicles. Their burning has turned fuels into carbon dioxide and water vapour. At the same time, the world's forestlands have been destroyed by logging and to clear land for agriculture. With more carbon dioxide in the atmosphere and fewer trees to capture the carbon and produce oxygen, carbon dioxide levels have risen steadily. They now total 150% of their levels at the start of the Industrial Revolution, with some 280 billion tonnes of carbon having been added to the atmosphere. Carbon dioxide concentrations in the atmosphere increased by 25% between 1950 and 1990 alone.

Concentrations of extra carbon dioxide make the atmosphere less transparent to the long-wave heat energy radiated back into space from the Earth. Along with three other partially man-made gases (methane, nitrous oxides, and chlorofluorocarbons), the carbon dioxide traps the heat before it can escape and produces 'greenhouse effect'. The retained heat raises the average temperature of the Earth and the process results in new patterns of climates.

During the first century of the Industrial Revolution (1780-1880), mean global temperature rose  $0.3^{\circ}\text{C}$  ( $0.5^{\circ}\text{F}$ ). They rose another  $0.5^{\circ}\text{C}$  in the last half of the 1980s alone. Thereafter, the ten warmest years between 1880 and 1995 occurred in the final 13 years of that period. If temperatures rise by  $1.1^{\circ}\text{C}$  to  $3.9^{\circ}\text{C}$  over the next (21st) century, the effects on world climates could be profound.

The role of humans in global warming has been disputed. Sceptics note that nearly half the observed atmospheric warming occurred before 1940 even though all the increased production of  $\text{CO}_2$  and other greenhouse gases came after that. Doubters note that every millennium since the end of the last Ice Age has had one or two centuries in which temperatures have risen by as much as they have in the last century. They claim that it is reasonable to assume that recent atmospheric temperature increases are part of a natural warming cycle and have nothing to do with carbon dioxide. The Intergovernmental Panel on Climate Change in 1995, however, countered the skepticism and concluded that "the warming of the last century, and especially of the last few years is unlikely to be entirely due to natural causes and a pattern of climatic response to human activities is identifiable in the climatic record".

Whatever the attributable causes of global heating, climatologists agree on certain of its general consequences should it continue. Increases in sea temperatures would cause ocean waters to expand slightly and the polar ice caps to melt a bit. Inevitably, sea levels would rise 0.5-3 meters within a hundred years. Even a conservative 1 meter rise would be enough to cover Maldives and other low-lying island countries. The homes of 50-100 million people will be inundated, a fifth of Egypt's arable land in the Nile Delta would be flooded, and the impact on the people of Bangladesh chargs would be catastrophic.

Other water problems would result from changes in precipitation patterns. Shift in weather conditions might well increase the aridity of some of world's already dry areas, such as Africa's Sahel, and increase rainfall in some already wet areas, such as the British Isles. Much of the continental interiors of mid-latitudes would receive less precipitation and suffer periodic droughts. Precipitation might decline by 40% in the US corn and wheat belts, drastically reducing agricultural productivity, bringing to near ruin the rural economy, and altering the world patterns of food supply and trade.

On the global and long-term scales, of course, some areas would benefit from general temperature rises. Parts of Russia, Scandinavia, and Canada would get longer growing seasons. In North America,

crop patterns would shift northward, making the northern Great Lakes states and Canada the favoured agricultural heartland climatically.

Global warming and climatic change would impact most severely on developing countries highly dependent on natural, unmanaged environments for their economic support. Studies suggest that warming would reduce yields in the agriculture, hunting and gathering, forestry, and coastal fishing sectors. Small countries with great dependence on agriculture are potentially most at risk from climatic changes. The impacts of climatic change on developed countries are likely to be small, as they do not have a close dependency on natural ecosystems. Nevertheless, on the global level, any significant continuing deviation from the present norm would disrupt existing patterns of economy, productivity, and population-supporting potential.

Such grim predictions were addressed at the Earth Summit held in Rio de Janeiro, Brazil, in 1992. The Convention was ratified by more than 120 nations, and called on industrialized countries to try to cut emissions of greenhouse gases at 1990 levels by the year 200.

## **2 Acid Rain**



### **3. Ozone Depletion**

Ozone is a molecule consisting of three oxygen atoms. Sunlight produces it from standard oxygen, and a thin layer of ozone accumulates at upper levels in the atmosphere. There, it blocks the cancer causing ultraviolet light that damages DNA. that upper atmospheric shield now appears in danger of destruction by chemical released into air by humans.

At lower levels, however, the problem is accumulation, not depletion, of ozone. Relatively harmless to humans, ozone is damaging to plants. Too much exposure of it plant's growth may be stunted, and their yields reduced, or they may even die. It is an important contributor to forest damage and destruction.

In the lower atmosphere, ozone is produced in photo-chemical smogs by sunlight and pollution, with the main pollutant being motor vehicle exhaust fumes. The increasing use of automobiles in Europe has done great damage to the continent's forests.

In the summer of 1986, scientists for the first time verified that a hole had been formed in ozone layer over Antarctica. As a result of the reduced ozone Antarctic life, particularly the microscopic ocean plants, (phytoplankton) was suddenly getting a trillion-fold increase above the natural rate of UV receipt.

Gradually, the 'hole' became larger, lasted longer, and spread toward South America and Australia. In 1992, it covered 4.5 million sq. km. In 1995, however, ozone levels were 10% lower than the previous year. Most scientists attribute the continuing decline to pollution from CFCs used as coolants and propellants for aerosol's, and also used in insulating foams.

The depletion of the ozone layer is expected to have a number of adverse consequences increased exposure to UV radiation increases the incidence of skin cancer, vulnerability to a variety of infectious diseases, threat to the existence of the microscopic plankton, *etc.*

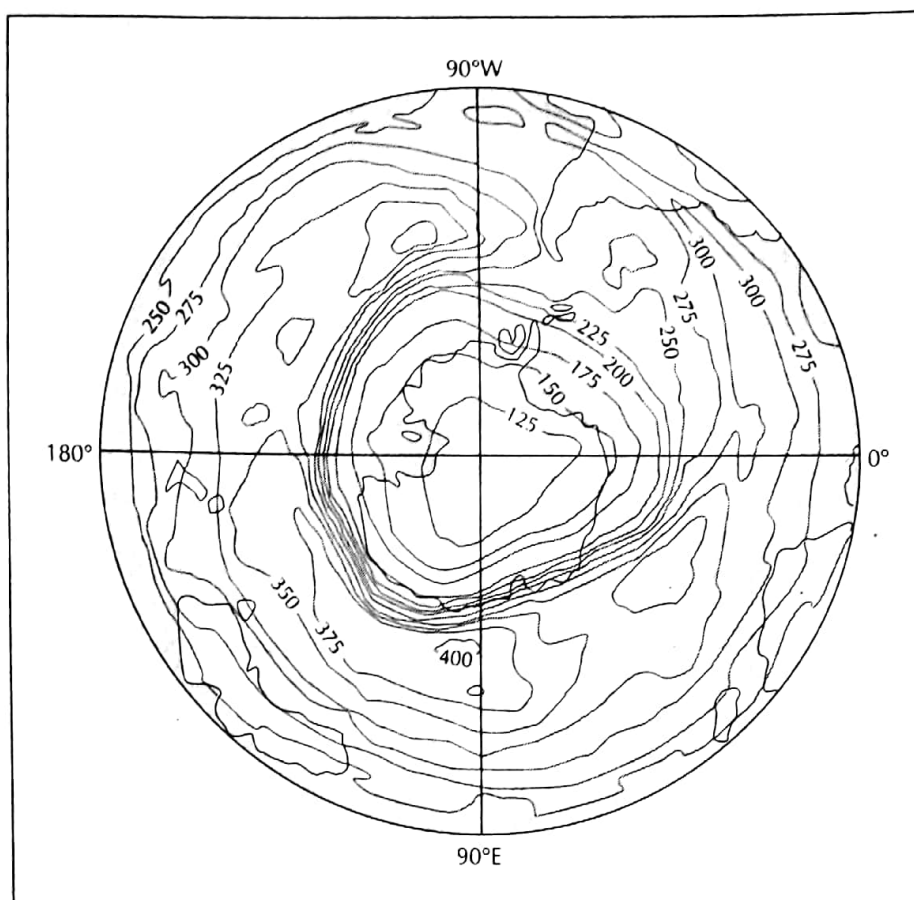


## Antarctic Ozone Hole

The most disturbing change in atmospheric ozone is that found over the Antarctic Continent called the **ozone hole** (Fig. 19.3). The ozone hole is a loss of stratospheric ozone over Antarctica, which has occurred in September and October since the late 1970s. The hole appears in September when sunlight first reaches the region and ends in October when the general circulation brings final summer warming over Antarctica. During the Antarctic spring, there is a decrease in ozone north from the pole to nearly  $45^\circ$  south latitude.

In August and September 1987, the amount of ozone over the Antarctic reached the lowest level recorded to this date. Nimbus-7 on September 17, 1987, recorded a large area in which the ozone concentration was only about half the surrounding region. That fall the ozone hole, the area of maximum depletion, covered nearly half of the Antarctic Continent.

In the winter over Antarctica, a very large mass of extremely cold, dry air keeps out warmer air surrounding the continent. This cold air gets even colder during the



**Figure 19.3**

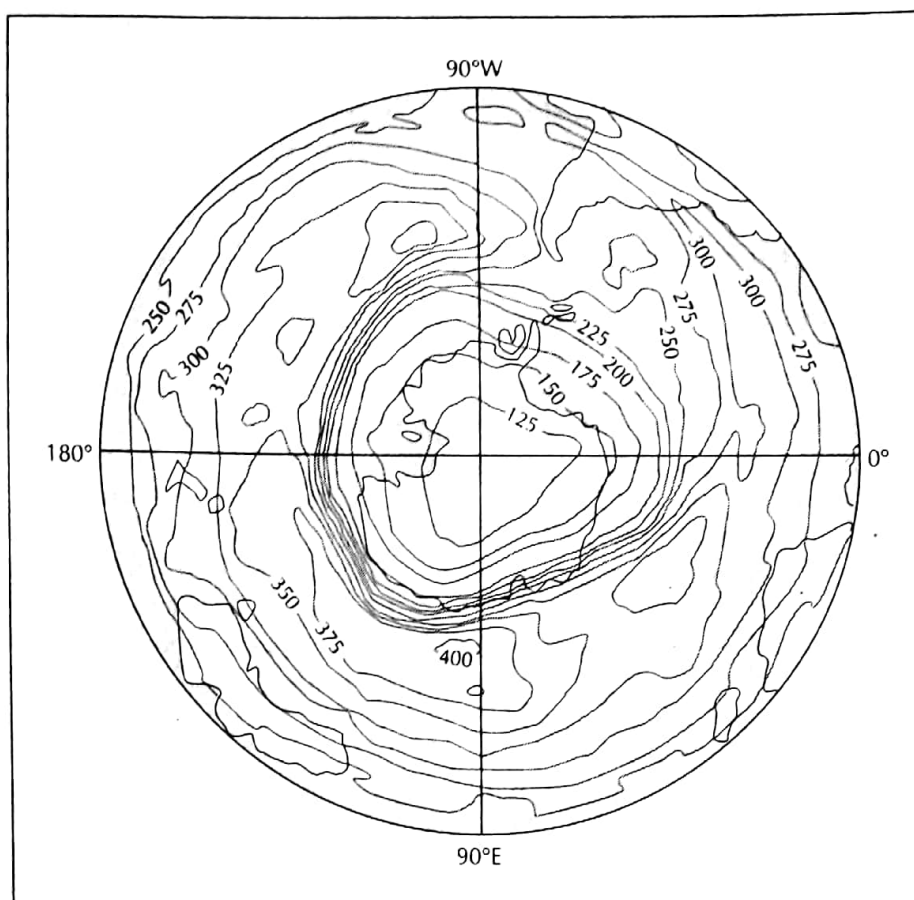
The Antarctic ozone hole over the southern hemisphere on September 28, 1992, as measured by the Total Ozone Mapping Spectrometer (TOMS) aboard the Nimbus-7 satellite. Notice that the area of lowest ozone concentration is larger than Antarctica, and that the ozone hole is nearly centered over the South Pole (from Hidore J. J., *Global Environmental Change*, © 1996, Prentice Hall, Upper Saddle River, N.J.).

months when there is no sunlight. Temperatures drop as low as  $-84^{\circ}\text{C}$  ( $-119^{\circ}\text{F}$ ). In the extreme cold, moisture condenses into ice crystals and nitric acid crystals also form. These crystals form very high thin clouds called **polar stratospheric clouds** (PSCs). The cloud crystals play a very important role in the chemistry of the CFCs and ozone depletion. The nitrogen oxide crystals drop out of the stratosphere leaving behind the chlorine and bromine compounds and the ice crystals. Each ice crystal provides a place for accelerated chemical reactions. The chemical processes are more rapid where there is a surface on which the reaction can take place. Ice particles are good surfaces and are some 10 times as efficient as the surface of water droplets. This partially explains the speed with which the process takes place in the Antarctic spring. It also explains why the process is less effective in low latitudes.

The chemical process begins when sunlight appears in the spring. The warming increases the rate of chemical reactions, and chlorine destroys ozone at a rapid rate. The depletion actually first begins near the Antarctic Circle, where sunlight begins to penetrate the stratosphere. It may begin here by mid-August. Spring over the South Pole occurs in September and October. During this time, the ozone level drops until there is no more ozone left or the clouds evaporate. There may be a total loss of up to 60 percent of the ozone in the center of the Antarctic hole. At some altitudes, it is 90 percent. Eventually, air from surrounding regions flows into the area and ozone levels recover. Polar stratospheric clouds disappear with the spring warmup. The same process takes place elsewhere in the atmosphere, but at higher altitudes and at slower rates.

In the spring of 1991, record depletion of ozone occurred in the Antarctic. Record lows in ozone occurred in September. By mid-November, the system broke up and ozone levels recovered. The depletion usually takes place at altitudes of 12 to 22 kilometers. This is the range where most of the polar stratospheric clouds form. In 1991, ozone concentrations dropped to record lows slightly below those of the worst 3 previous years. On August 28, the ozone concentration was about 270





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Dobson Units. On September 4, it had dropped to as little as 30 to 40 Dobson Units. This year depletion occurred at levels not affected before. Ozone reductions of nearly 50 percent took place at altitudes of 11 to 13 kilometers and 25 to 30 kilometers. The result of this depletion was a reduction of the total ozone column of 10 to 15 percent more than in past years.

## Global Decline in Ozone

Ozone depletion is not as much outside the Antarctic because the stratospheric aerosols are less abundant and consist of liquid sulfuric acid droplets rather than ice. This difference is significant. There is no Arctic ozone hole like that of the Antarctic. Temperatures are warmer, and there is more variable weather in the Arctic, which provide less favorable conditions for the necessary chemical and circulation processes. Ozone levels in the high latitudes of the northern hemisphere have dropped 5 percent since 1971. In 1988, researchers in Thule, Greenland, measured increased concentrations of reactive chlorine compounds. These are the same compounds known to be present over the Antarctic while depletion takes place. Experiments in 1989 showed the presence of the ozone hole and provided detailed measurement of the amount and extent of the depletion.

In the low- and mid-latitude stratosphere, there is greater solar radiation during the winter months and there is a general absence of polar stratosphere clouds. In this part of the atmosphere, the destruction of ozone is due to a combination of chemical processes. Models of the atmosphere show that nitrogen oxides play a leading role in the ozone destruction. Particular nitrogen oxides ( $\text{N}_2\text{O}_5$  and  $\text{ClONO}_2$ ) react on the surface of sulphuric acid solutions, which are similar to stratospheric aerosol particles. Sulphate particles exist throughout the lower stratosphere. They form from biological and volcanic activity. One of the processes is not dependent on extremely cold conditions so it operates much of the time to deplete ozone. The eruption of Mount Pinatubo in June 1991 injected some three times as much sulphur into the stratosphere as did El Chichon in 1982. Since the depletion process normally takes place on sulphuric acid particles, the increase in these particles did not alter the rate of depletion.

New evidence keeps appearing that supports a decline in the global ozone layer. In 1986, Canadian scientists detected a thinning of ozone over the Arctic region. In 1988, NASA established that the global ozone layer was declining faster than expected. By 1990, NASA reported spring losses of ozone in mid-latitudes of the northern hemisphere two to three times greater than before. Also in 1990, British scientists reported an accelerated rate of ozone loss over western Europe. By 1994, there was a 4 to 5 percent decline in stratospheric ozone worldwide.

## International Response to Ozone Depletion

Concern over the possible connection between CFCs and ozone loss led to a ban on the use of these compounds as aerosol propellants in the United States effective in 1978. This was part of an EPA ban on all nonessential uses of CFCs. The U.N. Environment Program called a conference in Montreal, Canada, in September 1987 to discuss the possible effects of CFCs on stratospheric ozone. Representatives of more than 30 countries took part in the conference, which drafted a treaty restricting the production of CFCs. The agreement is officially termed the *Montreal protocol*.