230N95002

ENVIRONMENTAL INDICATORS

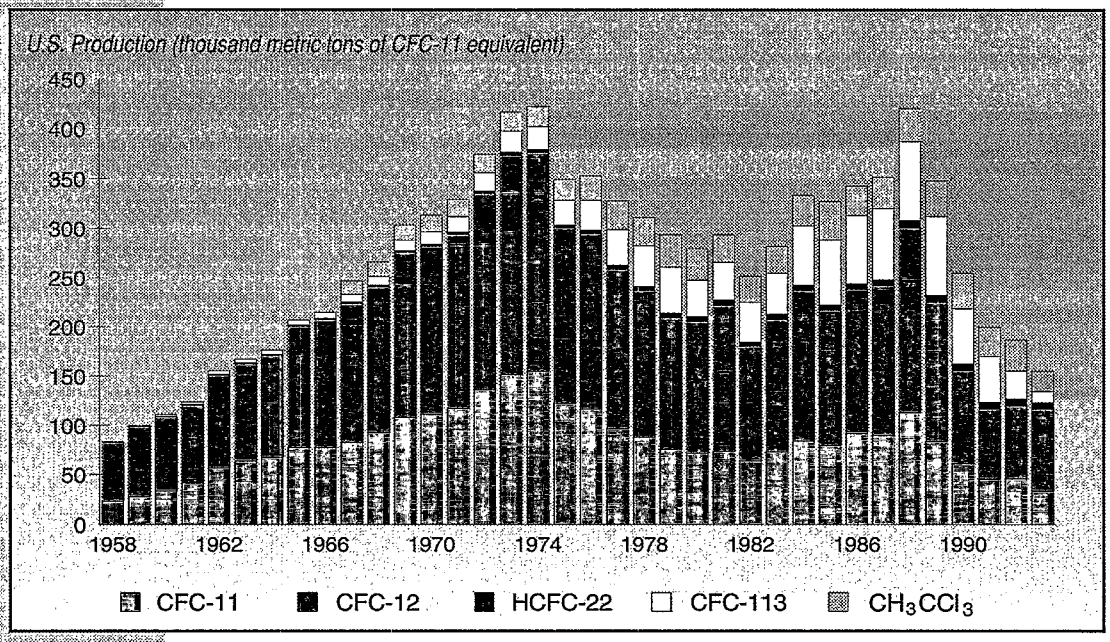
Protection of the Ozone Layer

Over 60 years ago, chlorofluorocarbons (CFCs) were invented in the United States, and they soon found many uses throughout the world in refrigeration, air conditioning, and other industrial processes. Due to scientific evidence that CFCs and other chemicals destroy ozone in the upper atmosphere, the United States, the country which has traditionally been the largest emitter of CFCs worldwide, is rapidly scaling back the use of these chemicals and phasing out their production.

The ozone (O_3) layer in the stratosphere protects life on earth from exposure to dangerous levels of ultraviolet light. It does so by filtering out harmful ultraviolet radiation from the sun. When CFCs and other

Indicator

U.S. Impact on the Ozone Layer



Source: U.S. International Trade Commission (USITC)

ozone-degrading chemicals are emitted, they mix with the atmosphere and eventually rise to the stratosphere. There, the chlorine and the bromine they contain catalyze the destruction of ozone. This destruction is occurring at a more rapid rate than ozone can be created through natural processes.

The degradation of the ozone layer leads to higher levels of ultraviolet radiation reaching Earth's surface. This in turn can lead to a greater incidence of skin cancer, cataracts, and impaired immune systems, and is expected also to reduce crop yields, diminish the

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productivity of the oceans, and possibly to contribute to the decline of amphibious populations that is occurring around the world.

The chemicals most responsible for the destruction of the ozone layer are chlorofluorocarbons, carbon tetrachloride, methyl bromide, methyl chloroform, and halons. Chlorofluorocarbons have long been widely used as coolants in refrigerators and air conditioners and as foaming agents, solvents, and aerosol propellants. Carbon tetrachloride and methyl chloroform are important industrial solvents. In the United States, carbon tetrachloride is now used almost entirely as a feedstock for the production of chlorofluorocarbons. Halogenated CFCs (HCFCs) have many of the same uses as CFCs and are increasingly employed as interim substitutes for CFCs. Halons have been used in fire extinguishers.

Long predicted, the degradation of the ozone layer was dramatically confirmed when a large hole in the layer over Antarctica was reported in 1985. Smaller but significant stratospheric decreases have been seen over more populated regions of the Earth. Subsequent research established that industrial chemicals are responsible for the observed depletions of ozone over Antarctica and play a major role in global ozone losses.

HUMAN ACTIVITIES

Chlorine and bromine are emitted to the atmosphere from both natural and human sources. These very stable human-made chemicals are not soluble in water and are not broken down chemically in the lower atmosphere. Thus they survive long enough to reach the stratosphere. The CFCs and carbon tetrachloride are relatively unreactive in the lower atmosphere (the troposphere) and move unscathed into the stratosphere where they are decomposed by intense sunlight, releasing chlorine to catalyze the destruction of ozone molecules. Certain ozone-depleting chemicals (HCFC-22 and methyl chloroform) are more reactive in the troposphere and deliver less of their initial chlorine load to the stratosphere. Halons also are generally reactive in the troposphere and deliver only a fraction of their initial load of bromine to the stratosphere, but bromine is 40 times more efficient at destroying ozone than chlorine. Increasing attention is being focused on the ozone-depleting role of methyl bromide, which has three potentially major human sources (soil fumigation, biomass burning, and the exhaust of automobiles using leaded gasoline), in addition to a natural oceanic source.

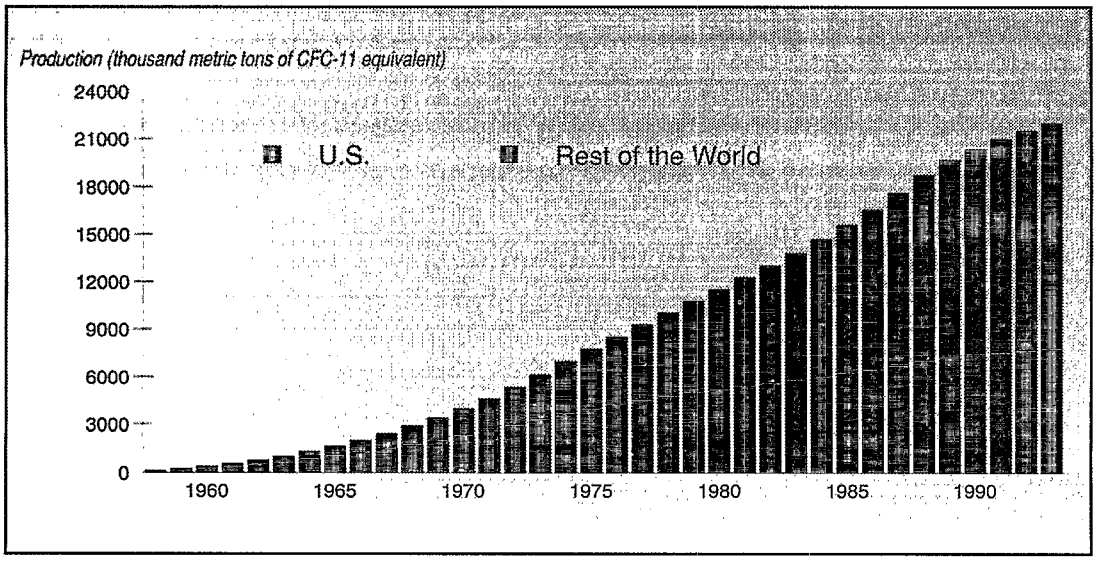
U.S. production of ozone-depleting gases has declined significantly since 1988, and has now reached levels (measured by their ozone depleting potential) comparable to those of 30 years ago. Because of international agreements to decrease production and ultimately to phase out production of CFCs and halons, scientists expect that total chlorine and bromine concentrations in the troposphere will peak by 1996 and begin a slow decline soon thereafter. Concentrations are expected to peak in the stratosphere 3-5 years later. Increasing ozone losses are predicted for the remainder of the decade, with gradual recovery by the mid-21st century.

STATE OF THE ENVIRONMENT

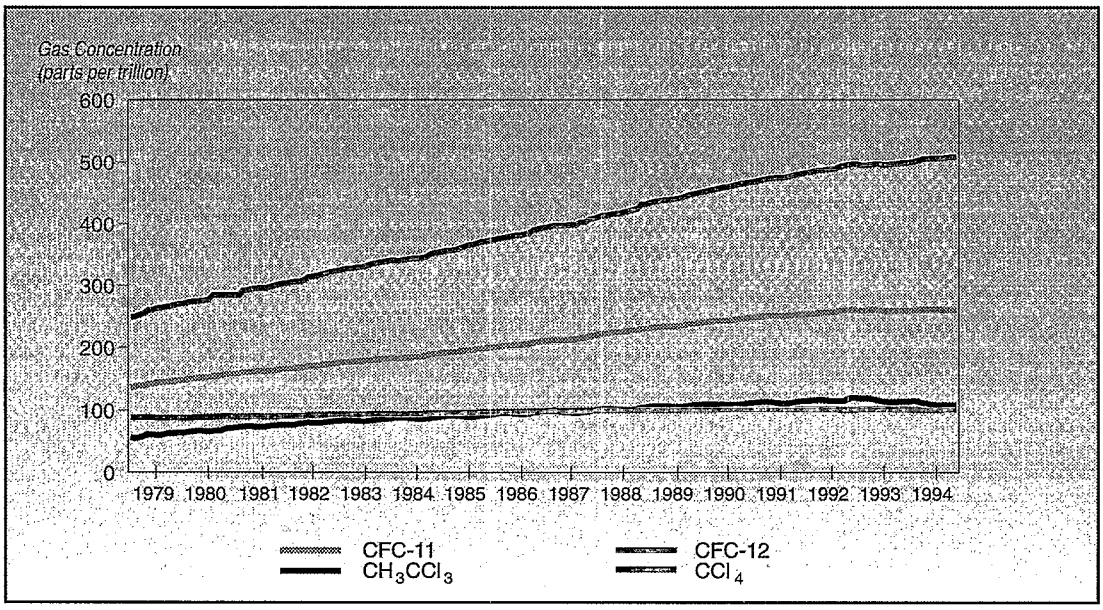
Worldwide monitoring has shown that stratospheric ozone has been decreasing for the past two decades or more.

Indicator

Cumulative U.S. Impact on the Ozone Layer



Source: Derived from USITC, AFEAS, and CMA data.



Source: Atmospheric Lifetime Experiment/Global Atmospheric Gases Experiment (ALE/GAGE)

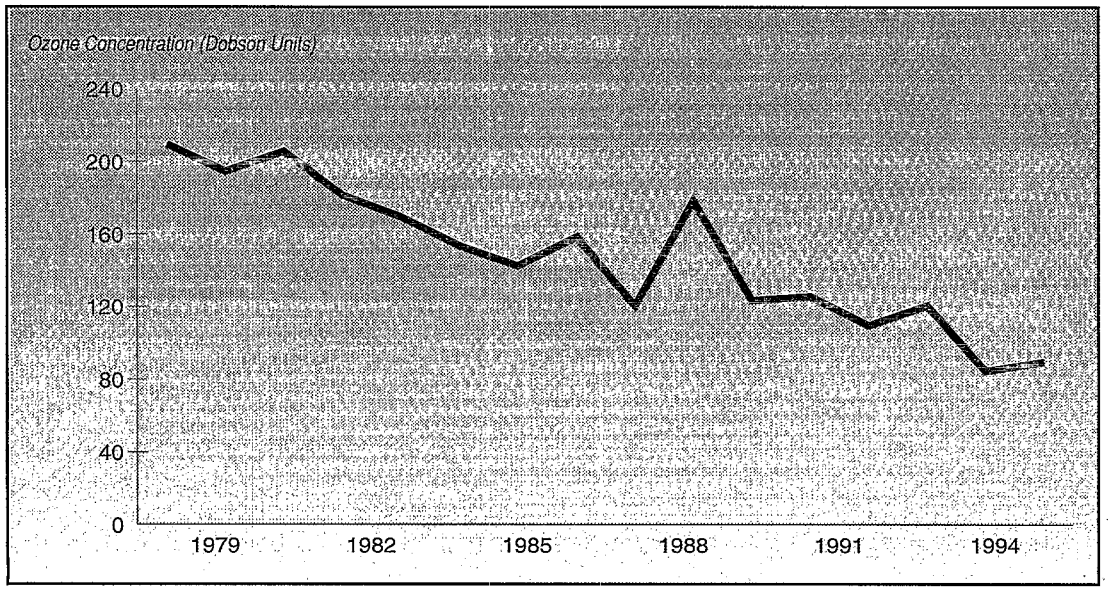
Indicator

Atmospheric Concentration of Selected Ozone-Depleting Chemicals

The average loss across the globe totaled about 5 percent since the mid-1960s, with cumulative losses of about 10 percent in the winter and spring and a 5 percent loss in the summer and autumn over North America, Europe, and Australia. Since the late 1970s, an ozone hole has formed over Antarctica each austral spring (September/October), in which up to 60 percent of the total ozone is depleted. Record low global ozone levels were recorded in 1992 and 1993. These lows were due, in part, to large amounts of stratospheric sulfate particles from the volcanic eruption of Mount Pinatubo in the Philippines in 1991; the sulfate particles temporarily accelerated the ozone depletion caused by human-made chlorine and bromine compounds.

As expected from the increasing use of CFC substitutes, observations from several sites have revealed rising concentrations of these compounds in the atmosphere. These substitutes have short tropospheric lifetimes, which tends to reduce their impact on stratospheric ozone as compared to CFCs and halons. However, some are potent greenhouse gases.

The link between a decrease in stratospheric ozone and an increase in surface ultraviolet (UV) radiation at the Earth's surface has been strengthened during the last several years by simultaneous measurements of total ozone and UV radiation in Antarctica and the southern part of South America during the period of the seasonal ozone "hole." The measurements show that when total ozone decreases, UV increases. Furthermore, elevated surface UV levels in mid-to-high latitudes were observed in the Northern Hemisphere in 1992 and 1993, corresponding to



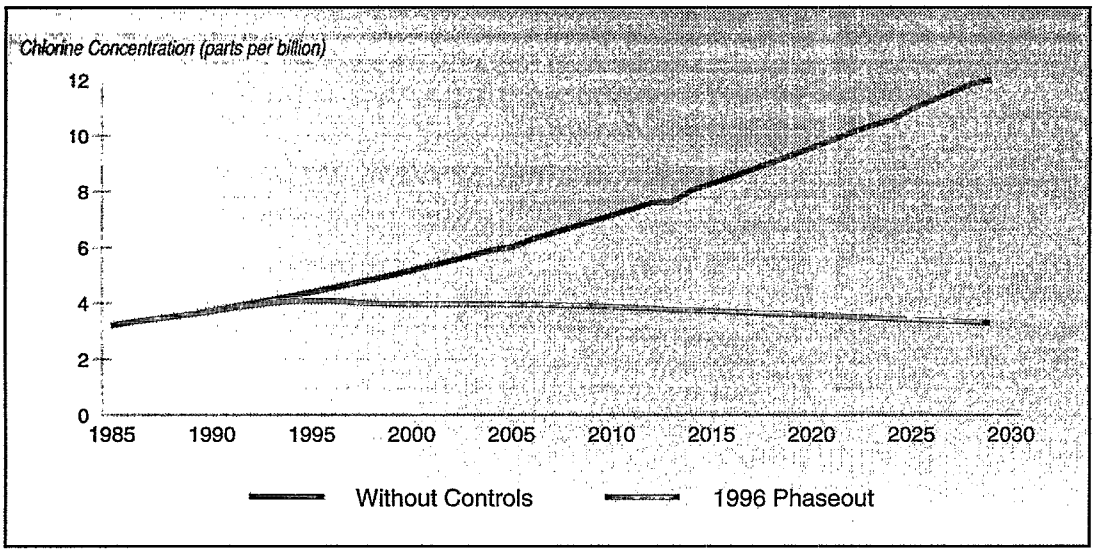
Source: National Aeronautics and Space Administration (NASA)

Indicator

Ozone Depletion Over Antarctica

Indicator

Impact of Montreal Protocol on Chlorine Content of the Atmosphere



Source: ICF

the low ozone levels of those years. However, the lack of long-term monitoring of surface UV levels and uncertainties introduced by clouds and ground-level pollutants have precluded the unequivocal identification of a long-term trend in surface UV radiation.

RESPONSE

Reacting to the environmental threat of ozone depletion, the nations of the world came together to create a global treaty, the Vienna Convention for the Protection of the Ozone Layer. The agreement entered into force in 1988 and the subsequent Montreal Protocol on Substances that Deplete the Ozone Layer entered into force in 1989. Currently 140 countries are parties to the Montreal Protocol. The parties to the Protocol decided on a timetable for countries to reduce and to end their production and consumption of eight major halocarbons. The Protocol also provides a ten-year delay in this timetable for those developing countries consuming less than 0.3 kilograms per capita.

The Montreal Protocol timetable was accelerated in 1990 and 1992. Amendments were adopted in response to scientific evidence that stratospheric ozone is depleting faster than predicted. As part of an effort to speed the phase-out of production and consumption of ozone-depleting chemicals, the parties to the Protocol decided to provide technology transfer and funds from industrial to developing countries. Under the accelerated schedule, the production of most controlled gases is to cease by January 1, 1996. The developing countries, however, may receive residual production from industrialized countries not to exceed 15 percent of 1986 levels. Some individual governments have committed to even earlier phaseout deadlines.

The U.S. Environmental Protection Agency (EPA), under authority of the U.S. Clean Air Act Amendments of 1990, issued regulations for the phaseout of production and importation of ozone-depleting chemicals controlled under the Protocol through a marketable permit program. In addition, EPA established controls on refrigerant recycling to prevent emissions, a ban on nonessential products, labeling requirements, a program to review safe alternative substances, and requirements to revise federal procurement specifications. Under the regulations, surplus or recycled substances can in general be stored to service existing machinery.

Because of the importance of the ozone layer and the complexity of the chemical reactions affecting it, the condition of the ozone layer must continue to be monitored.

Acknowledgements: This bulletin is first in a series of environment indicator bulletins covering major topics of environmental protection. It is a product of a collaboration between the World Resources Institute and the Environmental Indicators Team of EPA's Office of Policy, Planning, and Evaluation, Division of Environmental Statistics and Information. This report was prepared in collaboration with the EPA Office of Air and Radiation's Stratospheric Protection Division.

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