

## World Ozone Day

The United Nations General Assembly has designated 16 September as the International Day for the Preservation of the Ozone Layer.

Ozone, a gas naturally present in the atmosphere, is found in two regions – about 10% of the atmospheric ozone is in the troposphere and about 90% resides in the stratosphere. In the stratosphere, oxygen that is broken down by ultraviolet radiation from the sun recombines to form ozone.

In 1974, Mario Molina and Sherwood Rowland (University of California, Irvine, USA) published an article highlighting the threat to the ozone layer from chlorofluorocarbon (CFC) gases used in refrigerators and air-conditioning systems. They realized that chemically inert CFCs were gradually transported to the ozone layer and separated into their constituent chlorine atoms. They also concluded that since the stratosphere has only finite capacity for absorbing chlorine, if use of CFC gases continued, the ozone layer would be depleted after some decades. This finding led to the Nobel Prize in Chemistry in 1995 (ref. 1). In 1985, a team of English scientists led by Joseph Farman found drastic depletion of the ozone layer over the Antarctic that could lead to increased rates of skin cancer in human beings and animals<sup>1</sup>.

The Montreal Protocol that came into existence in 1987 and was ratified by all the countries in the world is an agreement to phase out the production and consumption of substances that deplete the ozone layer by the year 2035 (ref. 2). The scientific assessment panel of the Montreal Protocol estimates that the phasing out of ozone-depleting substances (ODS) will result in the ozone layer returning to the pre-industrial level by mid-century. On 15 October 2016, the Montreal protocol adopted the Kigali amendment to also phase down the consumption of hydrofluorocarbons (HFCs)

that are currently alternatives to ODS such as hydrochlorofluorocarbons (HCFCs) and CFCs<sup>3</sup>. Many countries are moving to HFC alternatives.

Other non-halogen gases influencing the stratospheric ozone have increased as a result of emission from human activities. Increasing CH<sub>4</sub> (methane), N<sub>2</sub>O (nitrous oxide) and CO<sub>2</sub> (carbon dioxide) are expected to significantly affect the future stratospheric ozone through combined effects on temperature, wind and chemistry<sup>4</sup>. Although part of the Kyoto Protocol, these gases are not classified as ODS under the Montreal Protocol. The Montreal Protocol also does not impose control on the production and consumption of very short-lived substances, although the concentrations of some (notably dichloromethane) have increased substantially in recent years.

The size of the ozone hole varies each year and is influenced by changes in meteorological conditions and volcanic activity. For example, the unusual size of the hole in the ozone layer in October 2015 was mainly due to the eruption of the Calbuco volcano in Chile. This makes it difficult to identify the healing trend in the ozone layer. In 2016, Susan Solomon and her colleagues (MIT, USA) provided evidence of healing of the ozone layer. The ozone hole forms every year over Antarctica. It begins in August and peaks in October. The MIT researchers collected September ozone measurements from the data gathered from balloons and satellites. They found that the September hole had shrunk (by approximately 4 million km<sup>2</sup>) and had reduced in depth as well, owing to a reduction in the atmospheric chlorine<sup>5</sup>. Though this trend is expected to continue, a full recovery cannot be expected until the middle of this century.

It has also been found that the healing of the ozone layer may be delayed due to further threats from industrial emissions

of dichloromethane, a chemical used in solvents, paint removers and production of pharmaceuticals. Ryan Hossaini and his colleagues (Lancaster University, UK) have gauged the current and future threat to high-altitude ozone due to dichloromethane<sup>6</sup>. In 2016, they analysed that about 3% of the summer ozone loss in the Antarctic could be traced to dichloromethane. In 2010 dichloromethane was responsible for only 1.5% of the ozone loss in this region. If dichloromethane emissions continue at the same rate, recovery of ozone hole would be delayed by 30 years. If emissions are held at the 2016 levels, healing of the ozone layer would be delayed by 5 years. Hossaini *et al.*<sup>6</sup> also assessed that if dichloromethane emissions continue in future, the Antarctic ozone recovery to the pre-1980 levels would be substantially delayed. This indicates that substances such as dichloromethane having an atmospheric lifetime of less than 6 months should also appear in the list of substances regulated by the Montreal Protocol.

1. [https://www.nobelprize.org/nobel\\_prizes/chemistry/laureates/1995/press.html](https://www.nobelprize.org/nobel_prizes/chemistry/laureates/1995/press.html)
2. <http://ozone.unep.org/en/treaties-and-decisions/montreal-protocol-substances-deplete-ozone-layer>
3. <http://www.unep.org/africa/news/kigali-amendment-montreal-protocol-another-global-commitment-stop-climate-change>
4. Global Ozone Research and Monitoring Project – Report No. 55, World Meteorological Organization, Switzerland, 2014
5. Solomon, S. *et al.*, *Science*, 2016, **353**, 269–274.
6. Hossaini, R. *et al.*, *Nat. Commun.*, 2017, **8**, 15962; doi:10.1038/ncomms15962

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