Reducing ozone-depleting substances (ODSs)

Some UV radiation from the Sun is absorbed by stratospheric ozone causing the ozone molecule to break apart. Under normal conditions, the ozone molecule will reform. This ozone destruction and reformation is an example of a dynamic equilibrium.

Ozone-depleting substances (including halogenated organic gases such as chlorofluorocarbons, CFCs) are used in aerosols, gas-blown plastics, pesticides, flame retardants, and refrigerants. Halogen atoms (such as chlorine) from these pollutants increase destruction of ozone in a repetitive cycle so allowing more UV radiation to reach the Earth.

UV radiation reaching the surface of the Earth damages human living tissues, increasing the incidence of cataracts, mutation during cell division, skin cancer, and has other effects on health.

The effects of increased UV radiation on biological productivity include damage to photosynthetic organisms, especially phytoplankton which form the basis of aquatic food webs.

Pollution management may be achieved by reducing the manufacture and release of ozone-depleting substances. Methods for this reduction include:

– recycling refrigerants

– developing alternatives to gas-blown plastics, halogenated pesticides, propellants, and aerosols

– developing non-propellant alternatives.

Sources of ODSs include refrigerants, gas-blown plastics, and the use of CFCs as propellants in aerosol cans. Methods for reducing the manufacture and release of ODSs include:

* recycling refrigerants
* developing alternatives to gas-blown plastics, halogenated pesticides, propellants, and aerosols
* developing non-propellant alternatives.

The United Nations Environment Programme (UNEP) has had a key role in providing information, and creating and evaluating international agreements for the protection of stratospheric ozone.

In the past, huge quantities of CFCs were used as propellants in aerosol sprays but most of this demand is now met by hydrocarbons and other technologies (e.g. pump action sprays). After aerosols, refrigeration was the next most important use for CFCs; today it seems likely that a combination of HFCs, ammonia, carbon dioxide, and hydrocarbon refrigerants will replace the CFCs. Nitrogen oxides also deplete the ozone layer and can be reduced through reduced use of fossil fuels, less-polluting combustion engines, and cleaner plane engines.

Besides replacement compounds, a range of alternative procedures have been implemented (e.g. trigger sprays have replaced aerosol propellants, leaking CFCs have been collected, some CFC waste has been incinerated, and old refrigerators have been locally or centrally collected). The recovery of ODSs from products still in use (e.g. old refrigerators and air conditioning units) is an important part of the response to stratospheric ozone depletion. Since 1993, Australia has collected more than 3000 tonnes of ODSs which have either been recycled, stored or destroyed. Nonetheless, significant amounts remain to be collected.

The phase-out of methyl bromide

Methyl bromide (MeBr) is an odourless, colourless gas that has been used as a soil pesticide to control pests across a wide range of agricultural sectors. Because MeBr depletes the stratospheric ozone layer, its production and import in the USA and Europe was phased out in 2005. Allowable exemptions to the **phase-out** include:

* the Quarantine and Preshipment (QPS) Exemption, to eliminate quarantine pests
* the Critical Use Exemption (CUE), designed for agricultural users with no technically or economically feasible alternatives.

Among the non-chemical alternatives, soilless cultivation, crop rotation, resistant varieties, and grafting are effective means of pest control.

The role of UNEP

The United Nations Environment Programme (UNEP) has had a key role in providing information, and creating and evaluating international agreements, for the protection of stratospheric ozone.

An illegal market for ozone-depleting substances continues and requires consistent monitoring.

The Montreal Protocol on Substances that Deplete the Ozone Layer (1987) and subsequent updates is an international agreement for the reduction of use of ozone-depleting substances signed under the direction of UNEP. National governments complying with the agreement made national laws and regulations to decrease the consumption and production of halogenated organic gases such as chlorofluorocarbons (CFCs).

In 1987, 24 countries were brought together by UNEP to sign the initial Montreal Protocol on Substances that Deplete the Ozone Layer. Now, 197 countries have signed the Protocol. In 1987, production of ODSs exceeded 1.8 million tonnes annually. By 2010, it had fallen to 45 000 tonnes. Nevertheless, the work of the Montreal Protocol is not finished. UNEP is working towards finally ending production of HCFCs by 2040.

The Montreal Protocol is considered to be a success, as the production and consumption of ODSs has reduced by more than 95 per cent compared to 1986. However, illegal trade in ODSs has developed. It is believed that India and the Republic of Korea account for approximately 70 per cent of the total global production of CFCs. Countries in the region with a high consumption of CFCs include China, India, Malaysia, Pakistan, and the Philippines.



In many low-income countries, there is still a significant demand for CFCs as reliance on equipment using these chemicals remains high. The problem is made worse by the imports of used refrigeration and air-conditioning equipment.

Reasons for the illegal trade in ODSs are many:

* ODS substitutes are often costlier than CFCs
* updating equipment to enable use of alternative chemicals is generally expensive
* the lifetime of CFC-containing equipment is often long
* penalties in many countries for ODS smuggling are small.

The magnitude of the illegal trade in ODSs is between 7000 and 14 000 tonnes of CFCs annually. There are many inconsistencies in trade data between China, Indonesia, the Philippines, Malaysia, Vietnam, India, and Singapore. Meetings organized by UNEP Regional Office for Asia and the Pacific (ROAP) have identified the reasons for such trade data discrepancies.

A number of activities have been encouraged at national, regional, and global scale aimed at improving the process of monitoring and controlling ODSs in order to combat the illegal trade in these chemicals. In 2001, the UNEP Division of Technology, Industry and Economy (DTIE) launched the Green Customs Initiative to encourage coordinated intelligence gathering, information exchange, guidance, and training among the partner organizations involved to counter illegal trade and environmental crime.

Since 2006, the South Asia–South East Asia and Pacific network countries have agreed on a mechanism of informal prior informed consent (iPIC) on export and import of CFCs to assist member countries to implement licensing systems effectively. The European Commission fully participates in the iPIC. Project Sky Hole Patching, a joint operation of customs administrations and international organizations in the Asia Pacific region, was launched in 2006. It monitors suspicious shipments of ODSs, which are imported, re-exported, or trans-shipped across international borders.

International cooperation between governments on the reduction of ODSs has been successful. Much of this has been organized by UNEP. In 1985, UNEP implemented the Vienna Convention for the Protection of the Ozone Layer. This aimed to protect human health and the environment against adverse effects resulting from human activities which modified or were likely to modify the ozone layer.

As a result of the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer, the hole in the ozone layer has been decreasing. By the end of 2002, industrialized countries had reduced their ODS consumption by more than 99 per cent and developing countries had reduced their consumption by slightly more than 50 per cent. A total phasing out worldwide is due by 2040. Total phase out in Europe occurred by 2000. Nevertheless, CFCs are persistent and long-lasting so their impact will continue for many decades. Production and consumption of CFCs, halons, and other ODSs have been almost completely phased out in industrialized countries and the timetable for banning the use of methyl bromide, a pesticide, has been agreed.

Developing countries have been given a longer time period over which to phase out their release of ODSs. Many developing countries have complained that there are many valuable CFCs which would help them develop. Although there has been a fund to help industry in developing countries switch from CFCs to ozone-friendly technologies, the funds are somewhat limited hence reduction of CFC-use in some developing countries has been limited.

The most widely used ODSs (CFC-11 and CFC-12) have often been replaced with HCFCs. Although these are greenhouse gases, their global warming potential (GWP) is less than that of CFCs. However, even greater GWP reductions can be achieved by replacing CFCs with substances such as hydrocarbons, carbon dioxide, water, and air. These substances contribute only minimally to GWP.

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| Compound | Use | Atmospheric lifetime / years | ODP relative to CFC-11 | GWP relative to CO2 at 100 years | Current main substitute |
| *Compounds already phased out in developed countries* |
| CFC-11 | foam expander | 50 | 1 | 4000 | HCFC-141 |
| CFC-12 | refrigerant | 102 | 1 | 8500 | HCFC-134a |
| halon-1211 | fire extinguisher | 20 | 3.0 | no data | dry powder |
| *Compounds due to be phased out by the Montreal Protocol* |
| HCFC- | refrigerant | 5.9 | 0.02 | 480 | HFC-134a |
| *Potential replacements, emissions controlled under Kyoto Protocol* |
| HFC-32 | refrigerant | 5.6 | 0 | 650 |  |
| HFC-125 | refrigerant | 32.6 | 0 | 2800 |  |

New chemicals depleting ozone

In 2014, it was reported that scientists had identified and measured four previously unknown compounds in the atmosphere – three CFCs and one HCFC – and warned of the existence of many more. The level of one of the compounds had doubled in just 2 years. Over 74 000 tonnes of the new gases have been released in the past 40 years. CFC-113a and the HCFC are accumulating rapidly. Until 2014, a total of 13 CFCs and HCFCs were known to destroy ozone but were controlled by the Montreal Protocol.

Despite the production of all CFCs having been banned since 2010, the concentration of one – CFC113a – is rising at an accelerating rate. The source of the chemicals is a mystery and it may be being used in the production of agricultural crop and soil pesticides.

QUESTIONS

1. Identify the compound which has the highest ozone-depleting potential (ODP). State the level of its ODP relative to CFC-11.
2. Identify the two compounds that have the longest atmospheric lifetime in years. Give their lifetime in years.
3. Which compounds have the largest greenhouse warming potential (GWP)? State their GWP, at 100 years, relative to carbon dioxide.
4. Describe three methods of reducing the manufacture and release of ODSs.
5. Describe and evaluate the role of national and international organizations in reducing the emissions of ODSs.
6. What was the international treaty that led to a decline in the production of CFCs?
7. Outline the difficulties in implementing and enforcing international agreements.
8. Evaluate the effectiveness of international policies to reduce ODSs.