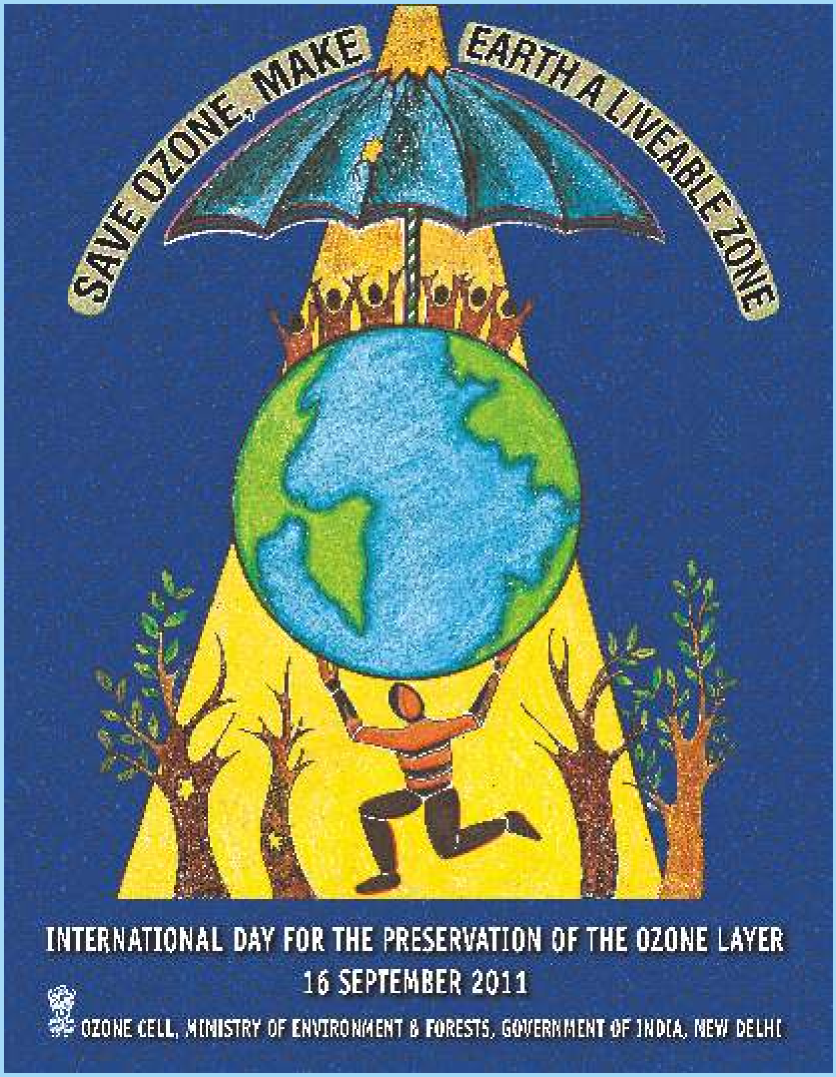
"HCFC phase-out : a unique opportunity"

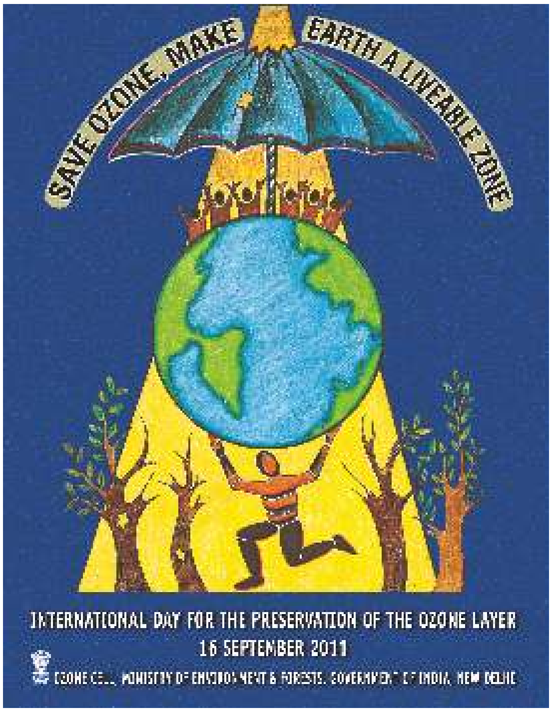
# THE MONTREAL PROTOCOL
# INDIA'S SUCCESS STORY




सत्यमेव जयते

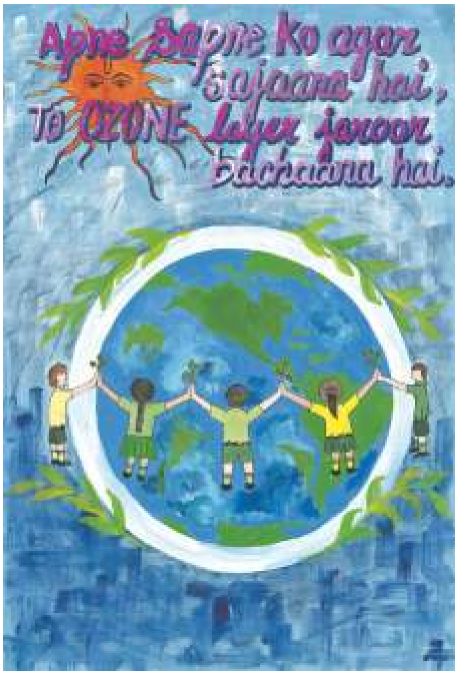
**OZONE CELL**
**MINISTRY OF ENVIRONMENT AND FORESTS**
**GOVERNMENT OF INDIA**
**NEW DELHI, INDIA**
**2011**

# POSTER COMPETITION




**1st Prize**
Nidhi Gulia, Oxford Senior Secondary School, New Delhi


**2nd Prize**
Ankur Singh, Henry Dunant Public School, New Delhi




**3rd Prize**
Rakshanda Verma, S.R.D.A.V. Public School, New Delhi

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जयंती नटराजन
Jayanthi Natarajan

सत्यमेव जयते

राज्य मंत्री (स्वतंत्र प्रभार)
पर्यावरण एवं वन मंत्रालय
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NEW DELHI-110 003

# FOREWORD

The Montreal Protocol on Substances that deplete the Ozone Layer has been recognized as the most successful international environmental treaty. As another testimony to its remarkable accomplishments, this landmark agreement has received the universal ratification. The Protocol is in operation since 1987 and with an extraordinary international cooperation, has led to complete phase-out of production and consumption of several Ozone Depleting Substances (ODS) such as Chlorofluorocarbons (CFCs), Carbontetrachloride (CTC) and halons globally as of 1st January, 2010 except the use of pharmaceutical CFCs in manufacturing of Metered Dose Inhalers (MDIs) through Essential Use Nomination (EUN) in some countries.

India being a Party to the Montreal Protocol and all its amendments has been successfully implementing the Country Program with the financial support received from the Multilateral Fund (MLF) and well established regulatory and fiscal measures. As a result, India has fulfilled so far all its commitments to the Protocol. I am pleased to note that the implementation of National Strategy for Phase-out of CFCs in manufacturing of MDIs has been implemented with an accelerated pace which would eliminate the use of CFCs in MDIs much earlier than the agreed schedule of 2013. India also did not seek pharmaceutical CFCs for 2011 through EUN.

The phase-out schedule for Hydrochlorofluorocarbons (HCFCs) was accelerated by 10 years with certain reduction schedules by the 19th Meeting of the Parties (MOP) to the Montreal Protocol in 2007. The transition from HCFCs to environmentally benign, economically viable and technically proven alternatives is a challenging task for a developing country like India, which needs to achieve the phase out of HCFCs without undue burden on the economy of the country and constraints on consumers and industry.

The Protocol has chosen a very befitting theme for this year "**HCFC Phase-out: a unique opportunity**".

India has proactively launched a Roadmap for the phase-out of HCFCs which delineates our long term vision and action plan. The HCFC Phase-out Management Plan (HPMP) is being finalized in consultation with all the stakeholders including line Ministries, Industry, Small and Medium enterprises, Industry Associations, NGOs and Implementing Agencies (UNDP, UNEP, UNIDO, the World Bank and Bilateral Agencies) for submission to the Executive Committee of the MLF for necessary funding as per the agreed policy guidelines.

On the occasion of the 17th International Day for the Preservation of the Ozone Layer, we reiterate our commitment to protect the ozone layer.

Jayanthi Natarajan

**(Jayanthi Natarajan)**

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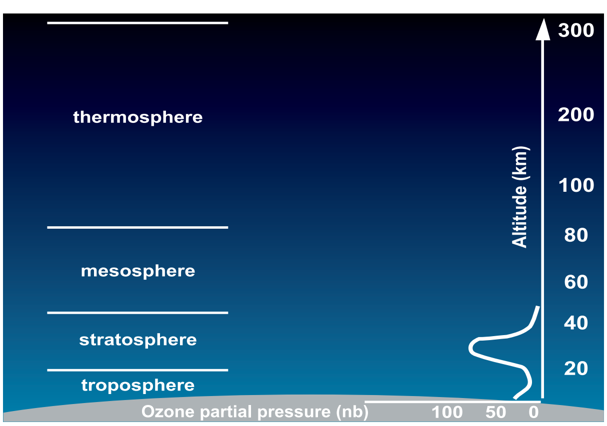
# 1. OZONE LAYER

The small blue and green planet we call home is a very special and unique place. We live on the only planet in our solar system and possibly in the galaxy where life is known to exist. All life exists within thin film of air, water, and soil. This spherical shell of life is known as the biosphere. The biosphere can be divided into three layers; the atmosphere (air), the hydrosphere (water), and the lithosphere (rock and soil). It is the unique attributes of the Earth's atmosphere that allow it to be a habitable place for humans, animals, microbes and plants as we know them.

The atmosphere is a mixture of gases and particles that surround our planet. When seen from space, the atmosphere appears as a thin seam of dark blue light on a curved horizon.

The Earth's atmosphere is divided into several layers. The lowest region, the troposphere, extends from the Earth's surface up to about 10 kilometers (km) in altitude. The height of Mount Everest is only 9 km. Virtually all human activities mainly affect the troposphere. The next layer, the stratosphere, continues from 10 km to about 50 km. Most commercial airline traffic occurs in the lower part of the stratosphere.

**Earth's Atmospheric Layers**




## Concentration of Ozone in the atmosphere

Ozone is a tri-atomic molecule of oxygen instead of normal two. It is formed from oxygen naturally in the upper levels of the Earth's atmosphere by high-energy ultraviolet radiation (UV) from the Sun. The radiation breaks down oxygen molecules, releasing free atoms, some of which bond with other oxygen molecules to form ozone. About 90 per cent of all ozone formed in this way lies between 15 and 50 km above the Earth's surface - the part of the atmosphere called the stratosphere. Hence, this is known as the 'Ozone Layer'. Even in the ozone layer, ozone is present in very small quantities; its maximum concentration, at a height of about 17-25 km, is only ten parts per million.

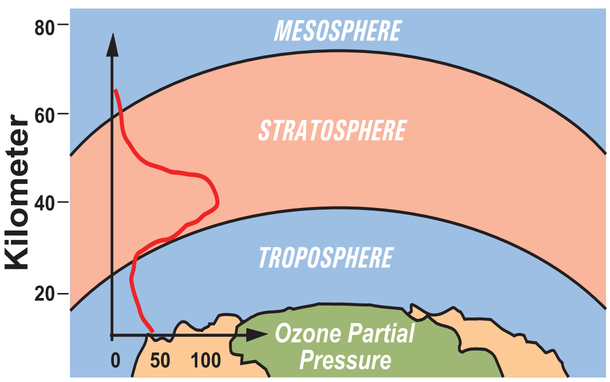
Since solar radiation is strongest over the tropics, the global ozone is formed here. However strong solar radiation also causes rise of air to high altitudes and ozone is transported away from the equator towards the poles where it accumulates in the cold sub-polar regions. At the equatorial region formation and photochemical depletion of ozone take place simultaneously and ozone cannot accumulate in this region. In the polar region there is accumulation of ozone because, photochemical depletion is low and due to transport of ozone from equator. Therefore in winter the highest ozone values are observed over the Polar Regions as long as there is no other disturbing influence.

Total ozone over any point from Earths surface to Stratosphere (45Km) is quantified in Dobson units (DU) : 100 DU equals the quantity of ozone that would form a layer 1mm thick at sea level if compressed at Standard Temperature and Pressure (STP).

Typical Distribution of ozone is about 240 DU year round near the equator with early spring maxima at high latitudes of about 440 DU in the Arctic and 360 DU in the Antarctic. When the concentration of ozone over any area falls below 220 DU we call it Ozone Hole.

Ozone is an unstable molecule. High-energy radiation from the Sun not only creates ozone, but also breaks it to oxygen, recreating molecular oxygen and free oxygen atoms. The concentration of ozone in the atmosphere depends on a dynamic balance between creation and destruction of ozone.

**Concentration of Ozone in the Stratosphere**




Ozone is also present in the lower levels of the atmosphere (i.e. the troposphere), but in very lower concentrations than in the stratosphere. Close to the Earth's surface, most of the Sun's high-energy UV radiation has already been filtered out by the stratospheric ozone layer, and therefore the main natural mechanism for ozone formation does not take place in the troposphere. However, elevated concentrations of ozone at ground level are found in some regions, mainly as a result of pollution. Burning of fossil fuels and biomass, releases compounds such as nitrogen oxides and volatile organic compounds, usually found in car exhausts, which react with sunlight to form peroxy intermediates which catalyses to form ozone. This is bad ozone. It forms smog, affects plants, crops and human health especially respiratory problems. It also damage to plastics especially rubber.

There is little connection between ground-level ozone and the stratospheric ozone layer. Whereas the stratospheric ozone shields the Earth from the Sun's harmful rays, the ground-level ozone is a pollutant. Ozone formed due to pollution at the Earth's surface cannot replenish the ozone layer. In addition, though ground-level ozone absorbs some ultraviolet radiation, the effect is negligible.

## How is Ozone measured in the atmosphere?

Ozone is spread from the surface of earth up to the top of stratosphere, 50 km as a very thin layer with maximum concentration at a height of 15-35 km. The question often asked is how is the concentration of ozone in this thin layer is measured and quantified with a reasonable accuracy.

Atmospheric ozone is measured both by remote sensing and by in-situ techniques.

Generally three characteristics of atmospheric ozone are routinely measured by various monitoring systems:

(a) Surface Ozone (b) Total Ozone over an area and (c) The vertical profile of Ozone.

Surface ozone is generally measured by in-situ techniques using optical, chemical or electro chemical methods. The most convenient method is the optical method which depends upon the strong absorption of UV light at 254 nm. The absorption is measured in a UV cell at 254 nm against another cell containing air free from ozone. By comparing the two irradiation signals it is possible to determine the concentration of ozone from 1 to 1000 parts per trillion by volume (pptv).

Total ozone is measured by remote sensing methods using ground based instruments measuring the intensity of absorption spectrum of ozone between 300 and 340 nm using direct sun or direct full moon light and satellite based instruments measuring the solar UV radiation scattered back to space by the Earth's atmosphere. The most commonly used ground based instruments; used by World Meteorological

Organization (WMO) global ozone network are the Dobson and Brewer spectrophotometers. The most accurate and the best defined method for determining total ozone is to measure direct solar radiation from ground at UV wave bands between 305 and 340 nm.

Dobson instrument measures spectral intensities at three wave length pairs and the Brewer spectrophotometer at five operational wavelengths. Moon light as a source of UV radiation can also be used but the accuracy is reduced due to lower intensity of light. For accuracy and comparison, all spectrometers are calibrated regularly at National Oceanic and Atmospheric Administration (NOAA) subtropical high altitude observatory at Mauna Loa, Hawaii where other interfering air pollutants like $SO_2$, $NO_x$, aerosols etc. are absent.

Vertical profile of ozone is measured with (a) Ozonesondes (b) ground based Dobson and Brewer spectrophotometers using light form zenith sky during twilight using the Umkher inversion method and (c) laser radars (LIDAR).

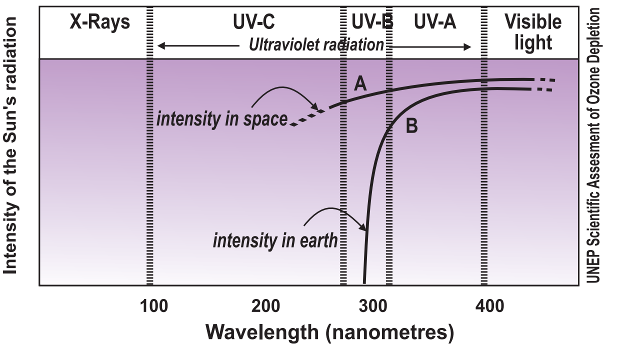
Ozonesondes measure the concentration of ozone as a function of height by a wet chemical method (ozone liberating iodine when bubbled through potassium iodide solution and measured electro chemically) during its balloon borne ascent to an altitude of about 35 km (mid stratosphere). They operate regularly in all climatic regions and have been the backbone of ozone profiling since 1960.

The latest method of vertical profiling of ozone is the LIDAR (optical radar) system in which a short laser pulse at a wave length in the UV ozone absorption spectrum is sent towards the zenith. Back scattered radiation is measured as a function of time which gives the height and its intensity gives the concentration of ozone. Two wavelengths are used, one of which is absorbed by ozone, and the other is not which serves as a reference. The concentration of ozone measured at different heights thus gives the vertical profile.

## What is Ultraviolet Radiation?

The Sun emits radiations of varying wavelengths in the form of electromagnetic spectrum. The ultraviolet radiation is one form of radiant energy coming out from the Sun. The various forms of energy, or radiations, are classified according to wavelength (measured in nanometer (nm) where one nm is a millionth of a millimeter). The shorter the wavelength, the radiation are more energetic. In order of decreasing energy, the principal forms of radiation are gamma rays, x-rays, ultraviolet (UV) rays, visible light, infrared rays, microwaves, and radio waves. The ultraviolet radiation, which is invisible, is so named because of its wavelengths are less than those of visible violet radiations.

Of these, UV-B and C being highly energetic are harmful to life on earth. UV-A being less energetic is not that harmful. Fortunately, UV-C is absorbed strongly by oxygen and also by ozone in the upper atmosphere. UV-B is absorbed only by the stratospheric ozone (ozone layer) and thus only 2-3% of it reaches the earth's surface. The ozone layer, therefore, is essential for protection of life on the Earth by filtering out the dangerous part of sun's radiation and allowing only the beneficial part to reach earth. Any disturbance or depletion of this layer would result in an increase of UV-B and UV-C radiation reaching the earth's surface leading to dangerous consequences for the life on earth. The ozone layer therefore acts as Earth's sunscreen.




A - Undisturbed Ozone Layer
B - Disturbed Ozone Layer

## Ozone Depletion

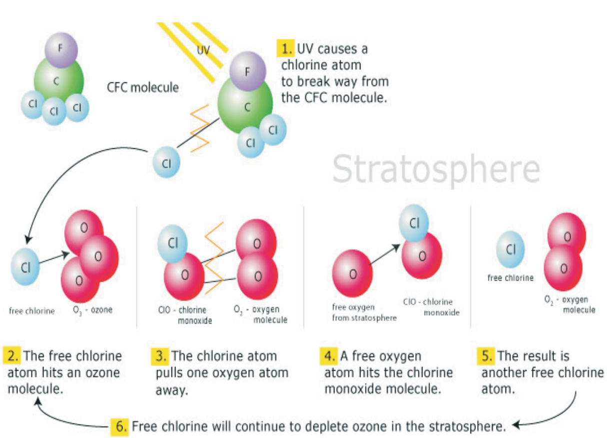
At any given time, ozone molecules are constantly formed and destroyed in the stratosphere. The total amount, however, remains relatively stable. The concentration of the ozone layer can be thought of as a stream's depth at a particular location. Although water is constantly flowing in and out, the depth remains constant.

While ozone concentrations vary naturally with sunspots, seasons, and latitudes, these processes are well understood and predictable. Scientists have established records spanning several decades that details normal ozone levels during these natural cycles. Each natural reduction in ozone levels has been followed by a recovery. Recently, however, convincing scientific evidence has shown that the ozone shield is being depleted well beyond changes due to natural processes.

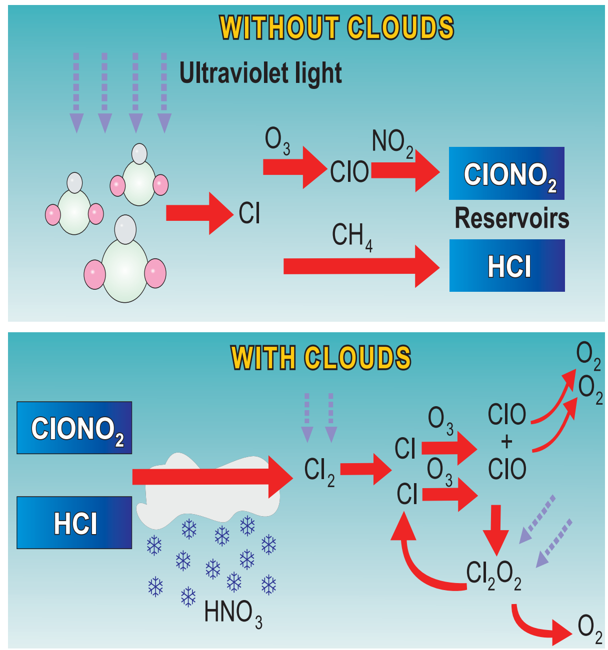
Ozone depletion occurs when the natural balance between the production and destruction of stratospheric ozone is shifted towards destruction. An upset in this balance can have serious consequences for life on Earth, and scientists are finding evidence of the changed balance. As a result, the concentration of ozone within the protective ozone shield is decreasing.

When very stable man-made chemicals containing chlorine and bromine enter into the atmosphere, and reach the stratosphere, these chemicals are broken down by the high energy solar UV radiation and release extremely reactive chlorine and bromine atoms. These undergo a complex series of catalytic reactions leading to destruction of ozone.

**Reaction of Chlorine with Ozone**



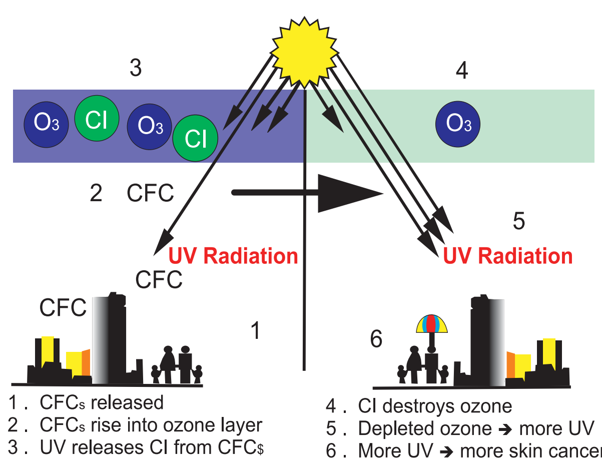

**Process of destruction of ozone**

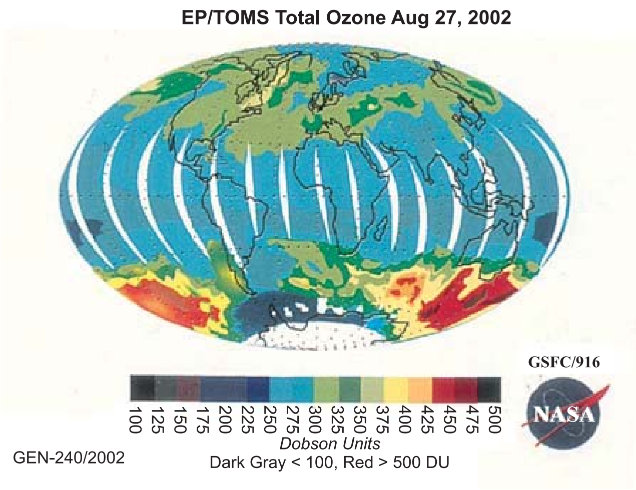



## Beginning of Threat to Ozone Layer

For over fifty years, Chlorofluorocarbons (CFCs) were thought of as miracle substances.

**Depletion Process** **Ozone**






These have been used in many ways since they were first synthesized in 1928. They are stable (inert), non-flammable, low in toxicity, and inexpensive to produce. Over time, CFCs have been used as refrigerants, solvents, foam blowing agents, aerosols and in other smaller applications. Other chlorine-containing compounds include methyl chloroform, a solvent, and Carbon tetrachloride (CTC), an industrial chemical, halons, extremely effective fire extinguishing agents, and methyl bromide, an effective fumigant used in agriculture and grain storage.

All of these compounds have long atmospheric life which allows them to be transported by winds into the stratosphere.

During the past few decades, Ozone Depleting Substances (ODSs) including CFCs have been emitted into the atmosphere in large quantity which has resulted in depletion of the ozone layer. The largest losses of stratospheric ozone occur regularly over the Antarctic every spring, leading to substantial increase in ultraviolet levels over Antarctic region. A similar, though weaker, effect has been found over the Arctic. There was enough evidence that ozone levels decrease by several percent in the spring and summer in both hemispheres at middle and high latitudes. There is also fall in ozone levels during the winter at these latitudes in the southern hemisphere. The higher levels of ozone have been noticed since late 1970s.

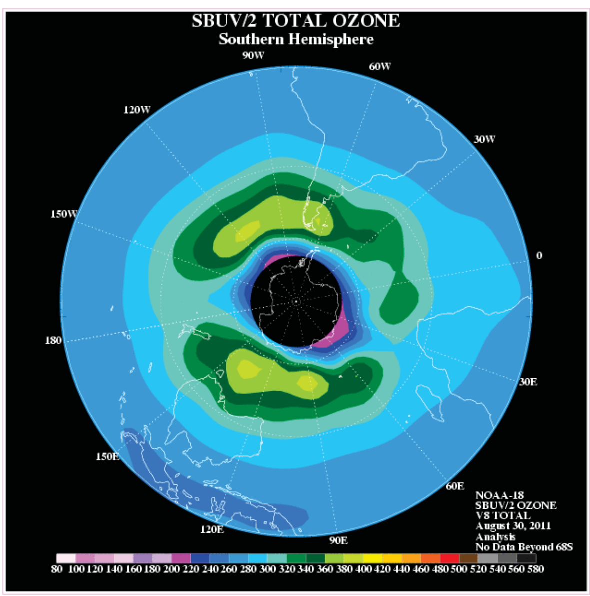
In the early 1970s, researchers began to investigate the effects of various chemicals on the ozone layer, particularly CFCs, which contain chlorine. They also examined the potential impacts of other chlorine sources like chlorine from chlorination of water, industrial plants, sea salt, and volcanoes etc. The chlorine released from such applications and from other sources readily combines with water and other chemicals and form compounds which do not reach the stratosphere. In contrast, CFCs are very stable and do not dissolve in rain. Thus, there are no natural processes that remove the CFCs from the lower atmosphere. Over a period of time, the CFCs diffuse into the stratosphere where these interact with UV rays of short wave length which breaks them.

The CFCs are so stable that only exposure to strong UV radiation breaks them. When that happens, the CFC molecule releases atomic chlorine. One chlorine atom can destroy over 100,000 ozone molecules. The net effect is the destruction of ozone, faster than it's natural creation. To return to the analogy comparing ozone levels to a stream's depth, CFCs act as a siphon, removing water faster than normal and reducing the depth of the stream.

No one could imagine that these miracle chemicals could one day turn out to be harmful substance to life on Earth. It all began when at the first United Nations on the Human Environment Conference at Stockholm in 1972; questions were asked about the effect of jet aircrafts on upper atmosphere. It was known that the high temperature jet exhausts contain an appreciable amount of nitrous oxide and it was also known that this substance can catalytically decompose ozone. The conference authorized United Nations Environment Programme (UNEP) to address this issue and focus on the possible damage to the ozone layer by hundreds of supersonic aircrafts that were expected to be in operation by the late 1980s. They were also entrusted with the task of finding out the effect of release of nitrous oxide from fertilizer manufacturing units on the ozone layer. These investigations did not make much headway and were dismissed as false alarms.

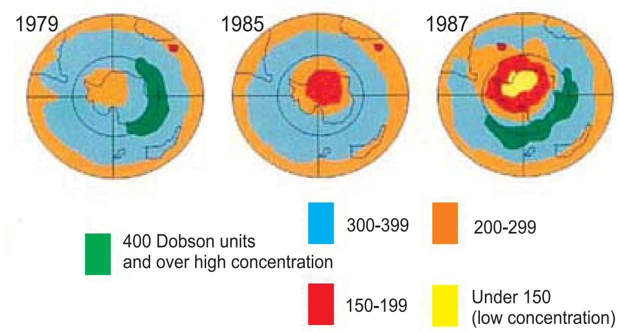
## The Antarctic Ozone Hole

The term "ozone hole" refers to a large and rapid decrease in the concentration of ozone molecules in the ozone layer. The Antarctic "ozone hole" occurs during the southern spring between September and November. The British Antarctic survey team first reported the hole in May 1985. The team found that for the period between September and mid November, ozone concentration over Halley Bay, Antarctic, had declined 40% from levels during the 1960s. Severe depletion has been occurring since late 1970s.




The problem is worst in this part of the globe due to extremely cold atmosphere and the presence of polar stratospheric clouds. The land under the ozone depleted atmosphere increased steadily to more than 20 million sq km in the early 1990s and in the Antarctic spring of 1998, the area of the ozone hole exceeded 26 million sq km and also covered some populated areas of the southern hemisphere. The total ozone dropped to about 97 DU on 1 October 1998.

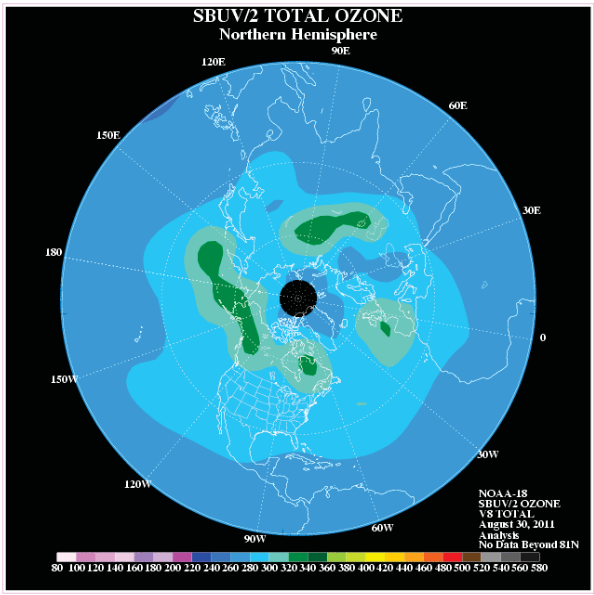
## Evolution of the Antarctic Ozone hole (1979 - 1987 October)




The Antarctic ozone hole grew to 28.4 million sq. km in 2000. In the year 2002 a peculiar effect was seen. The ozone hole split into two but the total coverage was only 15 million sq. km. In the year 2005, the size of ozone hole increased to 27.0 million sq. km. The ozone hole further grew to an extraordinary size, 29.3 million sq. km in 2006. The size of ozone hole slightly started declining and in 2008 became equivalent to the size of North America and NOAA reported that ozone hole reached to 26.5 million sq. km on 12.09.2008. It was also observed that the total column of ozone dropped to its lowest count of 100 DU. The size of Antarctic ozone hole in September, 2009 and September 2010 were reported to be 24 million sq. km and 22.2 million sq. km respectively. This indicates that the Montreal Protocol is effective and there is a gradual recovery of ozone layer.

In addition, research has shown that ozone depletion occurs over the latitudes that include North America, Europe, Asia, and much of Africa, Australia and South America. Thus, ozone depletion is a global issue and not just a problem at the South Pole. It was also reported that some ozone depletion also occurs in the Arctic during the Northern Hemisphere spring (March-May). Wintertime temperatures in the Arctic stratosphere are not persistently low for many weeks and this results in less ozone depletion.

Recent observations and several studies have shown that the size of annual ozone hole has stabilized and the level of ODS has decreased by 4 percent since 2001. But chlorine and




bromine compounds have long lifetime in the atmosphere, recovery of stratospheric ozone is not likely to be noticeable until 2020 or later.

## Environmental Effects of Ozone Depletion

As explained earlier ozone acts as a shield to protect the Earth's surface by absorbing harmful ultraviolet (UV-B and UV-C) radiation. If this ozone is depleted, then more UV rays will reach the earth surface. Exposure to higher doses of UV-B radiations will have effects on human health and impact on flora and fauna of terrestrial as well as aquatic eco-systems.

- **Human health effects:**

  - ❑ Sunburns, premature aging of the skin.
  - ❑ UV radiation can damage several parts of the eye, including the lens, cornea, retina and conjunctiva.
  - ❑ More cataracts leading to damage to the eye vision resulting in blindness.
  - ❑ Cataracts (a clouding of the lens) are the major cause of blindness in the world. A 10% thinning of the ozone layer could cause 1.6 to 1.75 million more cases of cataracts worldwide every year (WHO, 2002).
  - ❑ Weakening of the human immune system (immunosuppression). Early findings suggest that too much UV radiation can suppress the human immune system, which may cause non-melanoma and skin cancer.

- **Adverse impacts on agriculture, forestry and natural ecosystems:**

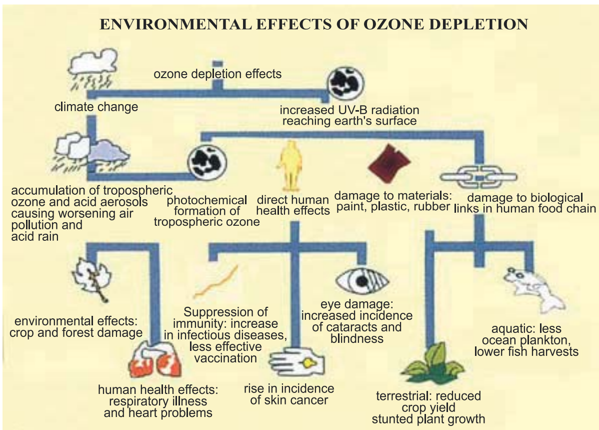
  - ❑ Several of the world's major crop species are particularly vulnerable to increased UV, resulting in reduced growth, photosynthesis and flowering. As a result, food production could be reduced by 1% for every 1% increase of UV-B radiation.
  - ❑ The effect of ozone depletion on the agricultural sector could be significant.
  - ❑ Many agricultural crops sensitive to the UV-B radiation of the Sun are rice, wheat, soybean, corn, sweet corn, barley, oats, cowpeas, peas, carrots, cauliflower, tomato, cucumber, broccoli etc.
  - ❑ A few commercially important trees have been tested for UV-B sensitivity. Results indicate that plant growth, especially in seedlings, is more vulnerable to intense UV radiation.

- **Damage to marine life:**

  - ❑ Plankton are the first vital step in aquatic food chains. In particular, plankton (tiny organisms on the surface layer of oceans) is threatened by increased UV radiation.
  - ❑ Decreases in plankton could disrupt the fresh and saltwater food chains, and lead to species shift.
  - ❑ Marine fauna like fish lings, juvenile stages of shrimp and crab have been threatened in recent years by increasing UV-B radiation under the Antarctic region. Loss of biodiversity in oceans, rivers and lakes could impact on aquaculture prospects.

- **Materials:**

- Wood, plastic, rubber, fabrics and many construction materials are degraded by UV radiation.
- The economic impact of replacing and/ or protecting materials could be significant.




## Ozone Depletion Process

Large fires, certain types of marine life and volcanic eruptions also produce chlorine molecules. Being chemically active but most of it gets converted into water soluble inorganic compounds which gets washed down by rain and only traces reach the stratosphere. However, United States Environment Protection Agency (USEPA) experiments have shown that CFCs and other widely used chemicals produce roughly 85% of the chlorine in the stratosphere.

It was also believed that large volcanic eruptions can have an indirect effect on ozone levels. Although, Mt. Pinatubo's 1991 eruption did not increase stratospheric chlorine concentrations, it did produce large amounts of tiny particles called aerosols (different from consumer products also known as aerosols). These aerosols increase chlorine's effectiveness in destroying ozone.

The aerosols only increase depletion because of the presence of CFC- based chlorine. In effect, the aerosols increase the efficiency of the CFC siphon, lowering ozone levels even more than that would have otherwise occurred. Unlike long-term ozone depletion, however, this effect is short-lived. The aerosols from Mt. Pinatubo have already disappeared, but satellite, ground-based, and balloon data still show ozone depletion occurring closer to the historic trend.

## The Real Alarm

In 1974, two United States (US) scientists Mario Molina and F. Sherwood Rowland at the University of California were struck by the observation of a British scientist, James Lovelock that CFCs were present in the atmosphere all over the world more or less evenly distributed by appreciable concentrations. They suggested that these stable CFC molecules could drift slowly upto the stratosphere where they may breakdown into chlorine atoms by energetic UV-B and UV-C rays of the sun. The chlorine radicals thus produced can undergo complex chemical reaction producing chlorine monoxide, which can attack an ozone molecule converting it into oxygen and in the process regenerating the chlorine atom again. Thus, the ozone-destroying effect is catalytic and a small amount of CFC would be destroying large number of ozone molecules. Their basic theory was put to test by the National Aeronautic Space Authority (NASA) scientists and found to be valid, ringing alarm bells in many countries and laying the foundation for international action.

The decline of ozone layer over North Pole has also been reported. The effect has been ascribed to solar flares and record frigid temperatures working with manmade chemicals. According to reports published in Geophysical Research Letters, the arctic ozone level declined more precipitously than ever in upper atmosphere.

As a result of implementation of provisions/ measures under the Montreal Protocol, the atmospheric concentration of some of these man-made substances has begun to decline. Chlorine/bromine should reach maximum levels in the stratosphere in the first few years of the

21st century, and ozone concentrations should correspondingly be at their minimum levels during that time period. It is anticipated that the recovery of the Antarctic ozone hole can then begin. But there is a slow rate of healing because of long life of chemicals like CFCs, CTC, halons etc. It is expected that the beginning of this recovery will not be conclusively detected for a decade or more, and that complete recovery of the Antarctic ozone layer will not occur until the year 2050 or little later. The exact date of recovery will depend on the effectiveness of present and future regulations on the emission of ODSs from banks (CFCs, halons etc.) and phase-out schedule of HCFCs. It will also depend on climate change in the intervening years, such as long-term cooling in the stratosphere, which could exacerbate ozone loss and prolong the recovery of the ozone layer.

## International Action

The first international action to focus attention on the dangers of ozone depletion in the stratosphere and its dangerous consequences in the long run on life on earth was initiated in 1977, when in a meeting of 32 countries in Washington D.C. a World Plan on action on ozone layer was adopted with UNEP as the coordinator.

As experts began their investigation, data piled up and in 1985 in an article published in the prestigious science journal, "Nature" by Dr. Farman, pointed out that although there is overall depletion of the ozone layer all over the world, the most severe depletion had taken place over the Antarctic. This is what is famously called as "the Antarctic Ozone Hole". His findings were confirmed by Satellite observations and offered the first proof of severe ozone depletion. These findings stirred the scientific community to take urgent remedial actions. A framework for such actions were designed and agreed in an international convention held in Vienna on 22nd March, 1985.

This, subsequently, resulted in an international agreement on 16th September, 1987 on specific measures to be taken in the form of an international treaty known as the Montreal Protocol on Substances that Deplete the Ozone Layer. Under this Protocol the first concrete step to save the Ozone layer was taken by immediately agreeing to completely phase out CFCs, halons, CTC and Methyl chloroform (MCF) as per a given schedule.

## Evolution of the Montreal Protocol

The urgency of controlling the ODSs particularly CFCs was slow to pick up. The CFCs were so useful that society and the industry were reluctant to give up consuming them. However, even as the nations adopted the Montreal Protocol in 1987, new scientific findings indicated that the Protocol's control measures were inadequate to restore the ozone layer. In addition, the developing countries had a special situation as they needed the technology of substitutes as well as financial assistance to enable them to change over to non-ODS substances.

Meanwhile, the report of the Scientific Assessment Panels (SAP) entrusted with the task of finding the extent of ozone depletion showed that the actual harm to the ozone layer was much more than predicted by theoretical models and the control measures envisaged by the Protocol in 1987 would not stop the process. More urgent action was therefore necessary. Therefore, at the 2nd Meeting of the Parties in London in 1990, 54 Parties as well as 42 non-Party countries agreed on a package of measures satisfactory to all. It was agreed in this meeting that the 5 important CFCs and halons would be phased out by the year 2000 and other minor CFCs and CTC would be controlled and eventually phased out. A special provision was made to provide financial and technical assistance to the developing countries with an annual consumption of CFCs and halons was less than 0.3 kg per Capita (also called as Article 5 countries) in their efforts to phase out these harmful chemicals.

These countries were also given a grace period of 10 years to phase out ODS.

In 1991, more alarming reports came up to show that the depletion of ozone is continuing in all altitudes except over the tropics. It was recognized that it is not enough to control emissions of CFCs and halons. Other fluorocarbon chemicals like Hydrochlorofluorocarbons (HCFCs) and Methyl bromide, which are also ODSs need to be controlled. They have also been brought under the ambit of the Montreal Protocol in 1992.

## Status of ratification of Vienna Convention, Montreal Protocol and amendments

| S. No. | Particulars | Date of Enforcement | No. of Parties |
|---|---|---|---|
| 1 | Vienna Convention 1985 | 22.09.1988 | 196 |
| 2 | Montreal Protocol, 1987 | 01.01.1989 | 196 |
| 3 | London Amendment, 1990 | 10.08.1992 | 196 |
| 4 | Copenhagen Amendment, 1992 | 14.06.1994 | 194 |
| 5 | Montreal Amendment, 1997 | 10.11.1999 | 184 |
| 6 | Beijing Amendment, 1999 | 25.02.2002 | 168 |

## Multilateral Fund

With a view to assist the developing countries in their phase out efforts, a Multilateral Fund (MLF) was established. This is known as the Multilateral Fund for Implementation of the Montreal Protocol. The Fund is financing incremental cost for ODS phase out in Article 5 Countries. The incremental cost include, cost of transfer of technology, capital equipment costs and incremental operating costs for switching over from ODS to non-ODS technologies for enabling the developing countries to phase out controlled substances. Enterprises which were using ODS technology are eligible for funding for conversion to non-ODS technology from MLF.

India being an Article 5 country is eligible for receiving technical and financial assistance from MLF to phase out ODS and switch over to non-ODS technologies.

## Alternatives to currently used Ozone Depleting Substances

During the last two decades intensive research has yielded a large number of substitute chemicals as replacements to CFCs, Halons, CTC, Methyl chloroform and HCFCs. These are summarised below on end-use basis:

## Technology Options for Phase-out in Refrigeration and Air-conditioning (RAC) Sector

| Sub-sector | ODS used at present | Preferred alternatives / substitutes |
|---|---|---|
| Domestic refrigerators | Refrigerant CFC-12<br><br>Foam Blowing CFC-11 HCFC-141b | HFC-134a, Isobutane, HC blend Drop-in HFC/ HCFC, HC blends (for servicing)<br>Cyclopentane HFC-245fa, HFC-365mfc, HFC-1234ze Methyl Formate, Methylal |
| Refrigerated Cabinets (Deep Freezer, Ice-cream cabinets, Chest coolers, Visi coolers) | Refrigerant CFC-12<br><br>Foam Blowing CFC-11 HCFC-141b | HFC-134a, HC-600a Blends of HC-290 and HC-600a, CO2 Cyclopentane, HFC-245fa, HFC-365mfc, HFC-1234ze, Methyl Formate, Methylal |
| Water Coolers | CFC-12 | HFC-134a Blends of HC-290 & HC-600a |
| | HCFC-22 (for bigger capacity) | HC-290, HFC-32 R-407C, R-410A |

| | | |
|---|---|---|
| Mobile (car, bus, van, refrigerated trucks, train) | CFC-12<br><br>HCFC-22 (train) | HFC-134a, HFC-1234yf R-407C, R-410A, CO2 |
| Central A/C plants | CFC-11, CFC-12<br><br>HCFC-22 | HFC-134a HCFC-123, HC-600a, Ammonia, R-410A, R-407C, HC-290 |
| Process Chillers | CFC-12 | Ammonia, R404A, HFC-32 HC-290 |
| Ice Candy Machines | CFC-12 | HFC-134a, R-404A |
| Walk-in Coolers | HCFC-22, CFC-12 | HFC-134a R-404A |
| Room A/C | HCFC-22, CFC-12 | R-410A, HC-290, HFC-32 |
| Packaged A/C | HCFC-22 | R-410A, R407C, HFC-32 HC-290, HC-1270 |
| Shipping | HCFC-22, CFC-12 | HFC-134a, R-410A , CO2 |

Alternatives with zero ODP like HFC-134a, R-404A, R-407C, R-410A R-507A, $CO_2$ Ammonia and hydrocarbons have been used in various applications in many countries. The low Global Warming Potential (GWP) refrigerants like ammonia, $CO_2$ and hydrocarbons are also used in some applications especially in Europe and for water heating in Japan. Recently, low-GWP HFCs also known as HFOs are being investigated.

HCFCs are scheduled now for accelerated phase-out by 2030. Potential alternatives for some of the commonly used HCFCs are:

(a) HCFC-245fa, HFC-1234ze, Methyl Formate, Methylal Cyclopentane for HCFC-141b

(b) HFC-32, R-410A, R-407C, $CO_2$, HC-290 and HC-1270 for HCFC-22

## Technology Options for Phase-out in Aerosol Sector

| Sub-sector | ODS used at present | Preferred alternatives / substitutes |
|---|---|---|
| Perfumes, shaving foams, insecticides, pharmaceuticals, paints, etc. | CFC-11/12 | HAP. (Di-methyl Ether) Small, Tiny & Cottage sectors use contract fillers, establish common filling facility for a cluster of units and switch to not-in-kind substitutes. (destenched LPG) |
| Metered Dose Inhalers | CFC-12 | Hydrofluoro-alkanes (HFA) |
| Dry Powder Inhalers (DPIs) | | No need of propelling agent. |

## Technology Options for Phase-out in Foam Sector

| Sub-sector | ODS used at present | Preferred alternatives / substitutes |
|---|---|---|
| Flexible PUF Slabstock | CFC-11 | Methylene Chloride |
| Flexible Moulded PUF | CFC-11 | Water blown technology |
| Rigid PUF General Insulation (other than refrigeration) | CFC-11 HCFC-141b | Cyclopentane HFC-245fa HFC-365mfc, HFC-1234ze, Methyl Formate Methylal |
| Thermoware | CFC-11<br><br>HCFC-141b | HFC-245fa, HFC-365mfc, Water, Methyl Formate |
| Integral Skin PUF | CFC-11 HCFC-141b | HFC-245fa, water, hydro-carbons-n-pentane |
| Thermoplastic Foams -EPE/EPPN Foams -Phenolic Foams | CFC-11 CFC-12<br><br>CFC-11 | Hydrocarbons $CO_2$ |
| Phenolic Foams | CFC-11 | Hydrocarbons |

CFC-11 (ODP-1.0) as a foam blowing agent was substituted first by HCFC 141-b (ODP-0.11). The trend now is to replace HCFC-141b with zero ODP and low GWP foam blowing agents like cyclopentane, HFC-245fa in European Union (EU) (2003) and Japan (2004). A similar substitute, pentafluoro butane (HFC-365 mfc) for foam blowing has also been used in some countries which banned foam products manufactured with HCFC-141b. Both these substitutes are made from CTC as feed stock. The next generation foam blowing agents will be low GWP like HFC-1234ze, Methyl formate, Methylal and Hydrocarbons.

### Technology Options for Phase-out in Fire Extinguishing Sector

| Sub-sector | ODS used at present | Preferred alternatives / substitutes |
|---|---|---|
| Fire Extinguishers | Halon-1211, Halon-1301, Halon-2402 | Portable type ABC powder, $CO_2$ |
| | | Fixed type FM200,HFCs, NAF- SI/SIII |

Some good substitutes for halon-1211 used in portable fire extinguishers have also been developed. Some global chemical producers have developed hexafluoro propane (HFC-236fa) as an excellent substitute for halon-1211 fulfilling a long felt need. It is now being manufactured commercially using CTC as feed stock.

### Technology Options for Phase-out in Solvent Sector

| Sub-sector | ODS used at present | Preferred alternatives / substitutes |
|---|---|---|
| Electronic and precision cleaning | CFC-113 CTC Methyl chloroform | DI Water Aqueous cleaning process Semi-acqueous cleaning process, organic non-halogenated, solvents, perfluoro-carbons |
| Coatings | CFC-113 Methyl chloroform | Aqueous solvents Tri chloro ethylene |
| Manufacture of pesticides and pharmaceuticals | CTC | Ethylene-dichloride Monochloro-benzene |
| Metal cleaning | CTC | Tri chloro ethylene |
| Chlorinated | CTC system | Aqueous rubber |
| Textile cleaning | CTC | Aqueous system, chlorinated solvents |

During the last several years due to intensive R&D efforts new solvent systems are being discovered as alternatives to CFCs solvents used earlier. First hydroflouroethers (HFEs) were considered as alternative solvents. Although, satisfactory in many respects, these were very high cost alternatives. An UK based company, has come out with alternative solvents for electrical cleaning especially for tape head and disk drives (Video 40), flux removal and PCB cleaner (Deflex 160); degreasing agent (Cold kleen 110); adhesive sticker removing, computer disk cleaning (CD-150) etc. Although, these are patented products and their chemical compositions are not available but the trend is good. Future may see many more alternative solvents readily available in the market so that the absence of ozone depleting solvents like MCF and CFC-113 will not be felt.

# 2. INDIA'S COMMITMENT TO THE MONTREAL PROTOCOL

India became party to the Vienna Convention for the Protection of the ozone layer on 19th June 1991 and the Montreal Protocol on Substances that Deplete the ozone layer on 17th September 1992. The per capita consumption of the controlled substances in Annex A did not cross 20 g during 1995-97 (base line), as against 300 g permitted for Article 5 Parties under the Protocol. India was self sufficient in production of CFCs. India was mainly producing and using nine of the 96 substances controlled under the Montreal Protocol. These are CFC-11, CFC-12, CFC-113, HCFC-22 halon-1211, halon-1301, CTC, Methyl Chloroform and Methyl Bromide.

India had prepared a detailed Country Programme (CP) in 1993 to phase-out ODS in accordance with its National Industrial Development Strategy. The objectives of the CP were to phase-out ODSs by accessing the Protocol's Financial Mechanism without undue economic burden to both consumers and industry manufacturing equipments using ODSs. The other objectives of the CP were minimisation of economic dislocation as a result of conversion to non-ODS technologies, maximisation of indigenous production, preference to one time replacement, emphasis on decentralised management and minimisation of obsolescence.

The Government of India has entrusted the work relating to ozone layer protection and implementation of the Montreal Protocol on substances that deplete the Ozone Layer to the Ministry of Environment and Forests (MoEF). The MoEF has set up an Ozone Cell as a National Ozone Unit (NOU) to render necessary services for effective and timely implementation of the Protocol and its ODS phase-out programme in India.

The MoEF has also established an Empowered Steering Committee (ESC), which is supported by two Standing Committees, namely the Technology and Finance Standing Committee (TFSC) and the Standing Committee on Monitoring. The ESC is Chaired by the Secretary of the MoEF. The ESC is responsible for the implementation of the Montreal Protocol provisions, review of various policy and implementation options, project approvals and project monitoring.

Although, these miracle chemicals were used in large scale in the developed countries since 1930s, India was slow to derive benefits from their use. The early use of these chemicals in India was in refrigeration and air-conditioning and CFCs needed for this sector were imported. The use of CFCs in refrigeration industry can be traced back to 1960s. Other industries using CFCs such as foam manufacturing industry, aerosol industry etc., were developed only during the last 20 to 25 years in India. With the availability of CFC-11 and CFC-12 from indigenous production, the growth of these industries consuming CFCs increased very rapidly.

When the CP was prepared, use of ODS as solvents is estimated to account for the maximum consumption, both in metric tonne (MT) as well as Ozone Depleting Potential (ODP) tonne. Refrigeration and Air-conditioning and Foam were the next large user sectors, followed by Aerosol sector. The consumption of ODS in fire extinguishing sector was relatively small in terms of MT.

### Status of ODS Phase-out in India

India has phased out production and consumption of CFCs, CTC and halons except use of pharmaceutical grade CFCs in manufacturing of Metered Dose Inhalers (MDIs) for Asthma and Chronic Obstructive Pulmonary Diseases (COPD) patients. A total of 301 projects have been approved and funded by the MLF. A total amount of USD 257,427,713 has been approved by the Executive Committee (Ex-Com) of the MLF to phase out 58,638 ODP tonne.

## Sector-wise Approved Projects as on 31.8.2011

Sector wise break-up of the funds approved by the MLF for ODS phase-out projects in India is given in the table below:

### Sector-wise Approved Projects as on 31.8.2011

| Sl. No. | Sector | No. of Projects | Grant Amount (US $) | Phase out of ODP (in Tonne) |
|---|---|---|---|---|
| 1. | Industrial Aerosol | 27 | 3,227,739 | 689 |
| 2. | Medical Aerosol (MDIs) | 1 | 10,202,267 | 704 |
| 3. | Foam | 159 | 34,785,641 | 4373 |
| 4. | Halon | 18 | 2,639,389 | 2162 |
| 5. | RAC | 49 | 32,254,823 | 3203 |
| 6. | Solvent | 41 | 71,007,980 | 12,966 |
| 7. | Production Sector | 3 | 100,546,874 | 34,541 |
| 8. | Accelerated phase-out of CFCs | 1 | 2,113,000 | -- |
| 9. | Preparation of ODS Destruction | 1 | 80,000 | -- |
| 10. | HPMP Preparation | 1 | 570,000 | -- |
| | **Total** | **301** | **257,427,713** | **58,638** |

## SECTOR PHASE-OUT PLANS

### CFC production sector phase-out project in India

The Ex-Com of the MLF in its 29th Meeting held in November 1999, approved the India's CFC Production Sector gradual phase-out project for total grant amount of US $82 million. The grant amount US $ 80 million was to be provided as a performance based grant to CFC producers for meeting the CFC production phase-out targets. The remaining US $2 million was for Technical Assistance (TA) component to establish Project Management Unit (PMU) under the Ozone Cell to develop and implement monitoring, auditing and reporting mechanism in addition to conducting awareness and training programmes. The World Bank is the Lead Implementing Agency for the project. UNEP has been designated as the implementing agency for TA component. In this project, it was agreed to reduce total CFC production in accordance with an agreed upon schedule.

### Agreed Schedule

| Year | CFC Production Quota (MT) | Phaseout Amount (MT) |
|---|---|---|
| 1999 | 22,588 | - |
| 2000 | 20,706 | 1,882 |
| 2001 | 18,824 | 1,882 |
| 2002 | 16,941 | 1,883 |
| 2003 | 15,058 | 1,883 |
| 2004 | 13,176 | 1,882 |
| 2005 | 11,294 | 1,882 |
| 2006 | 7,342 | 3,952 |
| 2007 | 3,389 | 3,953 |
| 2008 | 2,259 | 1,130 |
| 2009 | 1,130 | 1,129 |
| 2010 | 0 | 1,130 |

### Accelerated Phase-out of CFCs

India agreed at the 54th Ex-Com meeting held from 7th to 11th April, 2008 Montreal, Canada to accelerate the phase-out of production of CFCs by 1st August, 2008. As per the decision, India agreed that it will produce no more than 690 MT of CFC primarily for the manufacturing of MDIs up until 1st August, 2008. India's CFC producers would sell no more than 825 MT of CFCs for MDI production in the years 2008 and 2009, comprising 690 MT of new production and 135 MT reprocessed from existing stock. In addition India would not import any more CFCs.

India has completely phased-out production and consumption of CFCs with effect from 1st August, 2008, 17 months ahead of the agreed phase-out schedule except the use of pharmaceutical grade CFCs in manufacturing of MDIs. The MLF has released first tranche of accelerated phase-out of US $2.113 million for the producers.

The National Strategy for Transition to Non-CFC MDIs and Plan for Phase-out of CFCs in the Manufacture of Pharmaceutical MDIs is being implemented by United Nations Development Programme (UNDP) as lead implementing agency in close cooperation with the MDI manufacturing industry with an accelerated pace.

## Halon Production and Consumption Sector Phase-out project in India

The Ex-Com of the MLF in its 34th meeting held in Montreal, 2001 had approved US $2.6 million for phasing out production and remaining consumption of halons. The enterprises producing halons have dismantled their production plants. At present, there is no halon production in India. The phase-out activities of production and consumption of halons at all enterprises have been completed.

**Fire Extinguishing Industry Structure:** As of 1991, there was only one producer of halons having two halon plants one for producing halon-1211 and another for halon-1301. The total installed production capacity of halons was 500 MT.

There were about 200 manufacturers of fire-fighting equipments, of which over 85% were manufacturers of portable fire extinguishers in the country. A wide variety of fire extinguishing technologies was identified at the time of preparation of the CP such as ABC powder, aqueous systems, CO2-based and foam-based systems, etc. Halons, which are potent ODS, were used only in about 5% of the fire-extinguishing applications.

**Halon Consumption:** In 1991, the total consumption of halons in India was 750 MT equivalents to 3,650 ODP tonne. This constituted 7.2% of India's total ODS consumption and almost 28% of the total ODP consumption. Imports accounted for 550 MT of the total, while 200 MT was indigenously produced. The growth rate in this sector was forecasted at 15% annually.

**Technology:** As noted earlier, the use of halons in fire-fighting constituted about 5% of the fire-fighting applications in India. There were no drop-in replacement technologies identified. The alternative technologies identified were ABC powder, inert gases, HFC-based systems, aqueous systems, $CO_2$-based systems, fast-response sprinklers, etc. Among the priority actions identified to address the ODS phase-out in this sector were:

- Revision of national fire-extinguisher codes and standards to promote halon alternatives
- halon conservation programme to limit Emissions
- Establishment of a halon management program including halon banking

The production of halons has been phased-out globally at the early stage of the Protocol because of high ODP values of halons. Moreover, there is a large quantity of halons banked in fire extinguishing equipment.

The MoEF has established National Halon Banking Facility at Centre for Fire, Explosive and Environment Safety (CFEES), Defence Research and Development Organization (DRDO), Ministry of Defence, New Delhi with the financial assistance from the MLF of the Montreal Protocol. This facility has the capability to recover, recycle and store the halons for future use in the existing equipment. It is worth mentioning that all the three Defence forces have also established their own Halon Banking Facility to meet the future requirements.

## Foam Manufacturing Sector Phase-out Project

The Ex-Com for the implementation of the Montreal Protocol at its 37th meeting held in July 2002 approved the foam sector phase-out plan at a total funding level of US $5,424,577 to phase-out the remaining 612 ODP tonne of CFC-11 in foam manufacturing. UNDP was responsible for implementation of this project.

A total of 122 foam manufacturing enterprises under this sector plan have phased-out 702 MT of CFC from their process. The project is successful in completely phasing out the CFCs in Foam manufacturing sector in the country.

**Industry Structure:** The survey of the Foam Sector carried out at the time of the original CP, identified about 235 foam manufacturers in India, using CFCs as blowing agents. About 20% of the enterprises were large/medium-size, while the rest were Small and Medium Enterprises (SMEs) in the unorganized and informal sector.

The sub-sectors identified were rigid polyurethane foam, flexible polyurethane foam, integral skin polyurethane foams, thermoplastics foams (extruded polyethylene and polystyrene foams) and phenolic foams. An important sub-sector in the Foam sector, namely, the flexible slab-stock foam mostly converted from CFCs to methylene chloride as the blowing agent during the 1980s due to economic reasons. The domestic refrigerator manufacturers were important users of CFCs in the rigid polyurethane foam sub-sector. Another important sub-sector within the Foam sector, namely rigid polyurethane foam used in the production of insulated thermo-ware (flasks, casseroles, water-bottles, lunch-boxes, etc), was considered important due to the large number of SMEs involved.

There were four major producers of polyol systems, who formed the main upstream source of raw materials for the polyurethane foam manufacturers and met about half of the total demand. The remaining half of the raw material demand was met through imports.

**ODS Consumption in Foam Sector:** In 1991, the Foam sector consumed 1,580 MT of CFCs (predominantly CFC-11), which amounted to about 31% of India's total CFC consumption at that time. It was estimated that the demand for foam products would grow at 15-20% annually until 2010. The Foam sector was therefore identified as a priority sector in India for initiating phase-out activities.

**Technology:** The following substitute technologies have been identified for phasing-out ODS in the Foam sector. Some of the technologies especially the low GWP technologies are still emerging.

### Technological options in Foam Sector

| Sub-sector | Interim Technology | Long Term Technology |
|---|---|---|
| Flexible Molded PU Foam | Water-based | Water-based |
| Integral Skin PU Foam | HCFC-142b HFCs | Hydrocarbons, Water, Methyl Formate and Methylal |
| Rigid PU Foam | HCFC-141b HFCs | Hydrocarbons, Water, Methyl Formate, Methylal |
| Phenolic Foams | HFCs | Hydrocarbons, Methyl Formate, Methylal |
| Thermoplastic Foams | HFCs | Hydrocarbons, Methyl Formate, Methylal |

It was considered strategically important to support the conversion of manufacturing facilities of the polyol system producers on a priority basis, to enable them to customize non-CFC formulations, thus facilitating ODS phase-out in the downstream foam manufacturers more economically. Also, ODS phase-out in the large number of SMEs operating in this sector, many of which were not identified at the time of the CP preparation, was considered to be a challenge.

The accelerated phase-out of HCFCs would require conversion of foam manufacturing facilities from HCFCs to non-HCFCs like hydrocarbons, HFCs, Methyl Formate, Methylal etc.

## Commercial Refrigeration Sector (Manufacturing) Phase-out Plan

The Ex-Com of the Montreal Protocol at its 38th meeting held in November 2002 approved the Commercial Refrigeration (manufacturing) sector phase-out plan at a total funding level of US $3,609,186 to phase-out remaining 535 ODP tonne of CFC-12. UNDP was responsible for implementation of the commercial refrigeration component and United Nations Industrial Development Organisation (UNIDO) was responsible for implementation of the transport refrigeration sub-sector under this sector-plan.

A total of 157 enterprises for commercial refrigeration have phased out 593 MT of CFC-11 and 258 MT of CFC-12 successfully. In transport refrigeration, 39 enterprises have phased out 138 MT of CFC-12.

**Refrigeration and Air-Conditioning Industry Structure:** The Refrigeration and Air Conditioning sector in India has a long history from the early years of last century. Major investments in establishing manufacturing capacities started in 1950s. On the upstream side, there were only two manufacturers exclusively for hermetic compressors apart from some appliance manufacturers who also had the dedicated facilities for manufacturing facilities for hermetic compressors. However, there were several manufacturers of open-type compressors. Many other components of refrigeration systems are also manufactured in the country.

**ODS Consumption in Refrigeration and Air-conditioning Sector:** In 1991, the total ODS consumption in the Refrigeration and Air Conditioning sector in India was 1,990 MT. This constituted about 39% of India's total consumption of CFCs. About two-thirds of this consumption was estimated to be used in servicing of existing equipment. The growth rate in this sector was forecasted at 10-20% annually until 2010. The Refrigeration and Air Conditioning sector was therefore identified as a priority sector in India for initiating phase-out activities.

## National CFC Consumption Phase-out Plan (NCCoPP)

The Ex-Com of the Montreal Protocol at its 42nd meeting held in March 2004 approved the National CFC Consumption Phase-out Plan (RAC servicing sector) at a total funding level of US $6.388 million to phase-out 1502 ODP tonne of CFCs by 31st December 2009. The Government of Germany was responsible for implementation of this project as the lead Implementing Agency along with UNDP, UNEP, UNIDO and Government of Switzerland as associated agencies. The Government of Switzerland was responsible for training activities and UNDP was responsible for equipment support. UNEP was responsible for creation of awareness. Besides, UNEP was organizing customs and policy training activities in collaboration with National Academy for Customs, Excise and Narcotics (NACEN).

The project's main focus was on training of refrigeration servicing technicians in servicing refrigeration and air-conditioning equipments based on ODS and non-ODS alternatives. It also covers training for Mobile Air-Conditioning (MAC), Open Type Compressor (OTC) and specifically targeted the Railways as a key institutional user of CFC refrigerants. The project adopted a multi-pronged approach to achieve its targets. In addition to training, it includes equipment support, awareness building and information dissemination, and capacity building of customs officers on illegal ODS trade.

Information dissemination and creating awareness regarding CFC phase-out in India is of utmost importance to ensure the project's success. Various methods were employed to create awareness viz. video film, posters, newsletter, flyers, dealer workshops, equipment support workshops, articles in newspapers and dedicated website.

NCCoPP was funded by the MLF of the Montreal Protocol. NCCoPP took over from the Indo-Swiss Human and Institutional Development in Ecological Refrigeration (HIDECOR) project. The HIDECOR operation, initiated in 1998, was geographically restricted to selected states and the target group was limited to Micro, Small and Medium-sized service Enterprises in the RAC sector. NCCoPP currently has a presence in 15 States of India. It aimed to encourage good servicing practices among all Refrigeration Service Enterprise, with a special focus on those firms consuming more than 50 kg CFC per annum. The project has been successfully implemented as per schedule.

A total of 955 units were provided to the enterprises through UNDP in four phases till December 2009. The work plan targets for the year 2009 were achieved. Awareness generation workshops were conducted for small servicing enterprises so that most of the enterprises across the country can participate in the project and get the advantage of assistance provided under the Montreal Protocol to phase-out ODS in servicing sector. Equipment support to another 120 Industrial Training Institutes (ITI) has also been provided.

As stated earlier the focal activity of NCCoPP was training of Refrigeration Service Enterprise technicians. During training the participants/ technicians are taught how to handle the alternative refrigerants, good servicing practices and emphasis is laid on recovery of CFCs. Therefore the training programs have helped in creating a demand for recovery and reclaiming of refrigerants. With over 20,000 technicians already trained under NCCoPP and its forerunner projects, the requirement of CFCs for servicing is being addressed through reclamation of used CFCs. A number of reclamation centres have been established at various locations in the country like Bangalore, Chandigarh, Hyderabad, Ahmedabad, Jaipur, Kolkata, and Lucknow. The reclamation units have also been provided to Indian Railways and Defence forces.

## National CTC Phase out Plan

The Ex-Com of the MLF at its 40th meeting held in November / December, 2003 approved the CTC National Phase out Plan at a total funding level of US $52 million to phase-out 11553 ODP tonne of CTC production and 11505 ODP tonne of CTC consumption by 31st December 2009. This includes US $10 million under the bilateral assistance program with the Governments of Germany, France and Japan contributing US $2 million, US $3 million and US $5 million respectively.

Out of the total funds, US $28.5 million was allocated for CTC production phase-out, US $21.5 million for CTC consumption phase-out and US $2 million were made available for technical assistance component. The World Bank is the lead Implementing Agency, the Governments of Germany, France and Japan and UNIDO were cooperating agencies for Implementation of the National CTC consumption phase-out activities. Besides, UNDP on behalf of Government of Japan is responsible for executing conversion activities in large and medium metal cleaning sub-sectors.

**Production Sector:** The CTC producing enterprises namely M/s. SRF Ltd., New Delhi, M/s. Chemplast Sanmar Ltd., Chennai, M/s. Gujarat Alkalies and Chemicals Ltd., Vadodara have signed the performance agreement and submitted an Indemnity bond for meeting the production phase-out targets. M/s. Shriram Rayons Ltd., Rajasthan, M/s. NRC Ltd., Mumbai, have already closed down their production facilities.

**Consumption Sector:** CTC was used as feedstock primarily in the production of CFCs and DV Acid chloride. CTC was also used in India as a process agent and a solvent. For process agents, CTC was used in sectors such as chlorinated rubber, chlorinated paraffin, pharmaceutical, and agro-industries. CTC was used as a solvent in the textile, garment industries, metal-cleaning etc.

In 2006, a total of 103 CTC projects covering both process and solvent applications were identified and were placed under the responsibility of the agencies. Most of these projects have been completed that have resulted in phasing out of 2,080 ODP tonne of CTC. With respect to the four solvent projects under UNDP equipment have already been provided to the enterprises. The consumption of CTC has already been phased out completely in these plants since 1st January 2010 as per the Montreal Protocol schedule.

Ozone Cell also identified through a survey 44 eligible SMEs using CTC in metal cleaning. These enterprises have already provided funding by UNDP as Implementing Agency with the approval of the Ozone Cell for phasing out of CTC in their works.

During 2009, technical assistance was provided to replace CTC used in stain removal work for small garment manufacturers and metal cleaning. The fast reduction in the supply of CTC had increased the CTC price significantly in the country and enabled many SMEs to move away from CTC. GIZ has done extensive work in testing alternatives that meet health, safety and environment standards. The achievement of the CTC phase-out in these two widely dispersed industry sectors that is garment and metal cleaning has also been realized through awareness programmes and Government of India policy measures, especially those which influenced the availability and pricing of CTC and its alternatives. The production and consumption of CTC has been completely phased-out as of 1st January, 2010.

In 2011, the Ozone Cell, MOEF continued to implement a number of policies related to activities in the CTC sector plan, to sustain the phase-out of CTC in all applications except in feedstock use.

Of the total approved funding of US$52 million, approximately US$48.7 million had been disbursed to the Producers as of 31st December 2009.

### Strategy for Solvent Sector to phase-out ODS in SMEs in India

The Ex-Com of the Montreal Protocol approved the "Overall Strategy for the Solvent Sector to support the phase out of ODS in the SMEs in India" project at a cost of US$169,500 at the 35th Meeting of the Ex-Com to be implemented by UNEP-DTIE in consultation with World Bank and UNIDO. This project was to assist India in developing an overall strategy for the solvent sector which would cover both non-investment and investment activities to support the phase-out of ODS in the solvent sector in India and assist India in meeting its 2005 and 2007 commitments for the solvent sector. The aim of the project, at the operational level, is to develop approaches for assisting SMEs which use solvents in India through training, Solvent Alternative Technology Service (SATS), information dissemination and investment and non-investment activities.

The project has been completed by UNEP and submitted the reports to the Ozone Cell and the World Bank. The inputs provided through the Strategy document were incorporated in the National CTC Phase-out Plan prepared by the World Bank. The Project Completion Report (PCR) has been submitted by UNEP. As such there are no major observations recorded in the PCR and a balance amount of US $10140 has been returned to the MLF at the 50th Ex-Com Meeting.

### Aerosol Sector Phase-out Project

Aerosols are widely used in several applications involving propellants including perfumes, shaving foams, insecticides, pharmaceuticals, paints and inhalers. Twenty three projects were supported covering 44 enterprises to phase out CFC-11 and CFC-12 in this sector.

**Industry Structure:** The total production of aerosol containers in 1991 was estimated to be 45 million, of which over 90% used CFCs as propellants. About 200 aerosol manufacturers were identified, concentrated mainly in the western and northern parts of India. All enterprises were in the private-sector. A significant majority of these enterprises (about 70%) were SMEs, many of which were in the informal sector, principally manufacturing personal care products such as perfume and deodorant sprays.

**ODS Consumption in Aerosol Sector:** In 1991, the Aerosol sector consumed 1,100 MT of CFCs (about 40% CFC-11 and 60% CFC-12), which amounted to about 22% of India's total CFC consumption at that time. It was estimated that the demand for aerosol products would grow at 20% annually until 2000, 18% annually until 2005 and 15 % annually until 2010. These estimates were based on considerations such as emerging customer base for personal care products, entry of multinational corporations in India leading to expansion of the manufacturing base in this sector, reduction in taxes on cosmetics, etc.

**Technology:** Hydrocarbon-based aerosol propellants were identified in most of the aerosol sub-sectors as the preferred substitute technology for phasing out CFCs, specifically, butane, destenched liquefied petroleum gas (LPG), etc.

The SMEs predominantly used locally developed manual propellant filling machines, which, were suitable for CFC propellants, but considered unsafe and unsuitable for hydrocarbon-based substitute propellants. Moreover, many of the SMEs had manufacturing facilities in locations which could be considered unsafe for handling hydrocarbon-based propellants. Thus, safety measures for handling hydrocarbons including safety training and audits were identified as important inputs in addition to investments needed for conversions.

The consumption of CFCs in this sector has already been completely phased out except use in manufacturing of MDIs for Asthma and COPD patients.

### National Transition Strategy for phase-out of CFCs in MDIs

India developed the National Strategy for Transition to Non-CFC MDIs and Plan for Phase-out of CFCs in the Manufacture of Pharmaceutical MDIs. UNDP as the lead implementing agency submitted the project on behalf of India to the 56th Ex-Com of the MLF in November, 2008 and the same was approved by the Ex-Com with a total funding of US$10.2 million. This project articulates India's national strategy for transition to non-CFC MDIs gradually without affecting the Asthma and COPD patients and the elimination of CFC consumption in manufacturing of MDIs in India by 2013. The National Strategy is being implemented successfully by UNDP as lead implementing agency in close cooperation with Ozone Cell, MoEF and MDI manufacturers. The MDI manufacturers have converted a large number of MDI formulations from CFCs to CFC-free and placed in the market. Currently, many of the formulations of MDIs are available in the market both with CFCs as well as CFC-free.

The pharmaceutical grade CFCs were needed during transition phase in 2010 and beyond by the MDI manufacturing industry. The same were obtained through the EUN process of the Montreal Protocol for 2010. India submitted the EUN for 2010 for 350.6 MT of CFCs and the 21st MOP held in November, 2009, approved 343.6 MT of CFCs for India for 2010. India had also submitted the EUN for the year 2011 for 192.3 MT but the same was withdrawn in consultation with MDI manufacturers as the progress made by MDI manufacturers was commendable and the MDI manufacturers decided not to seek any CFCs for manufacturing of MDIs for 2011 and beyond. The 22nd MOP congratulated India on its outstanding achievements.

## Accelerated Phase-out of HCFCs

India ratified all the amendments to the Montreal Protocol including Copenhagen Amendment and need to phase-out HCFCs as per the reduction schedule specified in the Protocol. The control schedule of the Montreal Protocol for Article 5 Parties for phase-out of HCFCs prior to the 19th MOP was as follows:

### Consumption

- Base-level-2015
- Freeze- January 1, 2016
- 100% reduction January 1, 2040

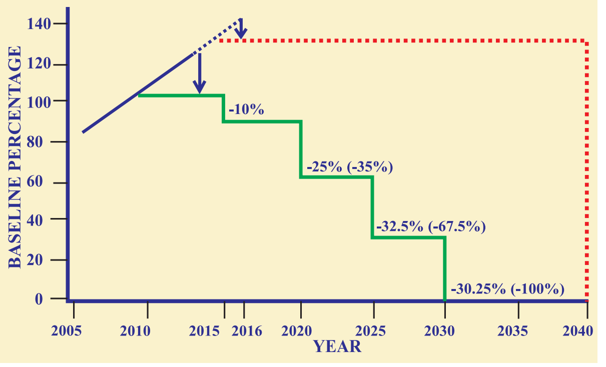
### Production

- Base-level-Average of production and consumption in 2015
- Freeze- January 1, 2016, at the base level for production
- 100% reduction January 1, 2040.

The 19th MOP took a decision to accelerate the phase-out of production and consumption of HCFCs for developed and developing countries. The new phase-out schedule for Article 5 Parties as per the decision of the 19th MOP is as follows:

- Base-level for production & consumption: the average of 2009 and 2010.
- Freeze=2013 at the base-level
- 10% reduction in 2015
- 35% reduction in 2020
- 67.5% reduction in 2025
- 100% reduction in 2030 with a service tail of 2.5% annual average during the period 2030-2040.

The accelerated phase-out schedule of HCFCs for Article 5 parties can be seen at a glance below:-




*Allowing for servicing an annual average of 2.5% during the period 2030-2040*

The implementation of the accelerated phase out schedule for HCFCs is a challenging task especially the Stage-I targets the 2013 freeze and 10 percent reduction in 2015, in emerging economies like India where there is a high growth in the use of these chemicals in RAC manufacturing, foam manufacturing, RAC servicing and other fields to cater the needs of growing industrialization and GDP of the country. The annual consumption growth of these chemicals is in the range of 10 to 15 percent. In actual sense this sets the phase-out targets of 30 to 40% by 2015 which is quite significant reduction in a very short time frame. This would require a long term vision and planning to successfully meet the obligations of phasing-out the HCFCs as per the revised schedule of the Montreal Protocol.

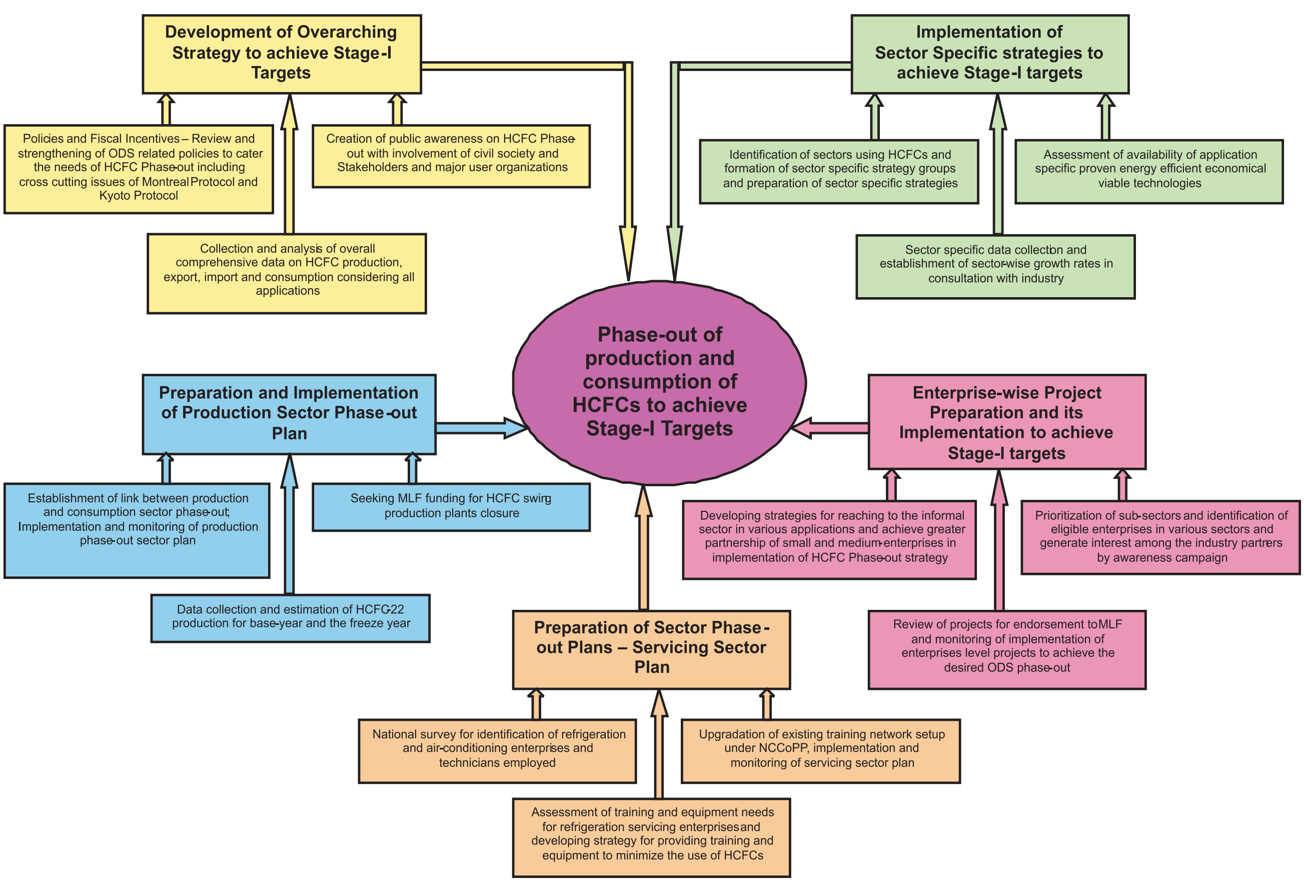
Based on the decision of the 19th MOP, the Ex-Com of the MLF has initiated discussions on guidelines for preparing HCFC Phase-out Management Plans (HPMP) and policy guidelines for determining the cost for phasing out of HCFCs in different applications. The 54th Ex-Com vide its decision 54/39 approved the guidelines for HPMP. The 60th Ex-Com held in April 2010 finalized the guidelines for phase-out of HCFCs except for the production sector which is still under consideration.

Considering the future activities relating to phase-out of HCFC production and consumption in India to meet the compliance target as per the accelerated phase-out schedule, the ESC of the MoEF at its 33rd meeting held on 21st November, 2007 decided to involve the World Bank, UNDP, UNEP, UNIDO, bilateral agencies like Government of Germany and France etc. UNDP has been designated as Lead Agency for the HCFCs in India. Accordingly, all the agencies have included activities to phase-out HCFCs in their respective business plans for 2008-2010 and now 2010-2014.

A Roadmap for phasing-out of HCFCs was developed describing the long term vision and action plan including the policy instruments for phasing out of production and consumption of HCFCs in India in accordance with 19th MOP to the Montreal Protocol vide Decision XIX/6.

The 56th meeting of the Ex-Com held in November, 2008 approved the preparation of HPMP for India with UNDP as the lead implementing agency in association with UNEP, UNIDO, the World Bank and GIZ. Subsequently, the Action Plan for implementation of the Roadmap for phasing out of HCFCs in India has been developed indicating the responsibilities of agencies and the timeline for its smooth and effective implementation.

The Sectoral Working Groups Meeting was organized in September 2009 which was very well attended by the stakeholders from Industry, Industry Associations, Research Organizations, NGOs and concerned line Ministries. The main objective of the meeting was to create awareness among the stakeholders and take them on board and identify the sectors which are consuming HCFCs in manufacturing of equipment/products and in other applications.




**ROADMAP FOR PHASE-OUT OF HCFCs IN INDIA AT A GLANCE**

Based on the outcome of the Sectoral Group Meetings, the Roadmap was updated and launched in October 2009.

The Memorandum of Agreements (MOAs) have been signed between the Ozone Cell and Refrigeration and Air-Conditioning Manufacturers' Association (RAMA) and Indian Polyurethane Association (IPUA) for preparing the RAC Manufacturing and Foam Manufacturing sectoral strategies respectively for phasing out HCFCs.

RAMA and IPUA organized Awareness Workshops in Chennai, Delhi and Mumbai. These workshops were well attended by the stakeholders especially from foam and RAC industry. RAMA and IPUA also carried out detailed surveys for collection of data on number of enterprises using HCFCs, their date of establishment and annual consumption of HCFCs for the past 3 years. This information have been collated and analysed by RAMA and IPUA and have been used for development of sectoral strategies.

The RAC servicing sector strategy is being prepared by the servicing sector group under the guidance of GIZ as implementing agency and in close cooperation with the Ozone Cell, MoEF.

The HPMP is being finalized in consultation with the stakeholders.

## Fiscal Measures

The Government of India has granted exemption from payment of Customs and Excise duties on capital goods required for ODS phase out projects funded by the MLF since 1995. In 1996, the Government further extended the benefit of Customs and Excise duty exemptions for ODS phase-out projects which were eligible for funding under the MLF, but not funded. The benefit is available subject to the condition that enterprises give clear commitment to stopping use of ODS in all future manufacturing operations after the projects are implemented.

The benefit of duty exemption has been extended for new capacity with non-ODS technology since 1997. These benefits are also available for financial year 2011-2012.

The Indian financial institutions have decided not to finance/re-finance new ODS producing/ consuming enterprises.

The Tariff Advisory Committee (TAC) - a statutory body under the Insurance Act, 1938 - has decided to grant suitable discounts on fire insurance premiums if alternative fire extinguishing agents are used in place of halons in fire extinguishing systems.

## Ozone Depleting Substances (Regulation and Control) Rules, 2000

In accordance with the National Strategy for ODS phase-out, the MoEF, Government of India, has notified Rules covering various aspects of production, sale, consumption, export and import of ODS.

## Important provisions of the Ozone Depleting Substances (Regulation and Control) Rules, 2000

These Rules prohibit the use of CFCs in manufacturing various products beyond 1.1.2003 except in MDI and for other medical purposes. Similarly, use of halons is prohibited after 1.1.2001 except for servicing. Other ODS such as CTC and methyl chloroform and CFC for MDIs can be used upto 1.1.2010. Further, the use of methyl bromide has been allowed upto 1.1.2015. Since HCFCs are low-ODP substances and are also used as interim substitutes to replace CFC, these are allowed to use upto 1.1.2030 as per the Montreal Protocol accelerated phase-out schedule.

The Rules also provide for compulsory registration of ODS producers, manufacturers of ODS based products, importers, exporters, stockist and sellers and the same provision is applicable to manufacturers, importers and exporters of compressors. They are also required to maintain records and file periodic reports for monitoring production and use of ODS. Enterprises which have received financial assistance from MLF for switchover to non-ODS technology have to register the date of completion of their project and declare that the equipment used for ODS has been destroyed. Creation of new capacity or expansion of capacity of manufacturing facilities of ODS and ODS based equipment has been prohibited. Purchasers of ODS for manufacturing products containing ODS, are required to declare the purpose for which ODS is purchased. All imports and exports of ODS and products containing ODS require a licence.

All items can be imported under Advance Licence Scheme except prohibited items. It is required to obtain the consent of the MoEF before issuing an advance license for ODS.

These rules indicate specific phase-out dates for manufacturing products using ODSs.

Trade in ODS with non-Parties is banned. The import and export of ODS are subject to licensing requirement. The export of ODS to Non-Article-5 Parties is also banned. This regulatory measure is part of the Ozone Depleting Substances (Regulation & Control) Rules, 2000 which have been notified in the Gazette of India on 19th July, 2000.

### Amendments

Registration is compulsory under the ODS Regulation and Control (Amendment) Rules, 2004. This amendment was issued so that all enterprises using CTC and HCFC for manufacturing activities are required to register with the designated authority vide amendment Rules, 2004 on or before 31 December, 2005. The rules were further amended on 18th September, 2007. As per the amended rules, registration for all ODS will be open till 31st December, 2009 and the existing registered enterprises need not apply for renewal. The ODS Rules and Regulations are being amended to align with the accelerated phase-out of HCFCs.

### Awareness Generation

The National Ozone Unit (NOU) has undertaken comprehensive public awareness campaign to ensure that both the public and the industries responsible for actually phasing out the ODS understand and support the policies to protect the ozone layer.

The International Ozone Day for the year 2010 was celebrated in Delhi. During the celebrations, a pledge was taken by participants for protection of environment and following environment friendly measures and practices:

A sticker, poster and India's Success Story are being brought out for distribution every year on the International Ozone Day.

A bimonthly newsletter Value Added Technical Information Service (VATIS) is published and distributed to about 2000 individuals and institutions in collaboration with United Nations Asia Pacific Centre for Technology Transfer. This newsletter covers the latest technologies and developments relating to ozone layer protection.

The Ozone Cell in close cooperation with UNEP and GIZ under the NCCoPP published a bumper issue of Eco-Cool, a technical bulletin for refrigeration technicians in 2009. This bulletin contains technical information on good service practices, retrofitting of existing CFC based appliances with non-ODS alternatives, recovery, recycling and reclamation of refrigerants, Roadmap for Phase-out of HCFCs in India etc. This information will be quite useful for both small and medium manufacturers as well as servicing technicians.

States play a key role in Montreal Protocol implementation by virtue of their geographic proximity to the industries consuming ODSs particularly SMEs and their ability to control and monitor activities relating to phasing out ODSs. To increase awareness of State authorities on Ozone related matters, the Ozone Cell, under TA component for CFC production sector phase-out project, conducted workshops in all 25 States during last 5 years. This has also been followed up through periodic dialogue and meetings with the State authorities with primary focus on implementation of projects for SMEs and remaining ODS consuming industries and regulation implementation. Awareness workshops were organised with following objectives:

- To create awareness about the present and future of Foam and Refrigeration Sector
- To inform the HCFC accelerated phase out
- Demonstration of a successful projected implementation by a field visit and on hands training and troubleshooting
- To take stock of lessons learnt from the implementation of sector plans.
- Provide technical assistance, information and technical resources as may be required related to application of sustainable alternative technologies.
- To discuss the future technology to replace HCFC
- To acquire input for the National Phase out plan

## Indo-US Workshop on Hydrofluorocarbons (HFCs)

HFCs have emerged as the main alternatives to CFCs and HCFCs for various applications. The HFCs are zero ODP chemicals but these are potent Green House Gases (GHGs) with certain GWP. However, the GWP of these chemicals is much lower than that of ODSs which have been phased-out. This is how the Montreal Protocol has not only saved the Ozone Layer but also saved the climate system.

HFCs are one of the six GHGs and their emissions are already controlled under the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC). Moreover, HFCs being non-ODSs do not fall within the purview of the Montreal Protocol on substances that deplete the Ozone Layer.

A one day "Indo-US Workshop on HFCs" was organized on 18th February 2011 in Delhi to understand the issues related to the production and consumption of HFCs and the availability of technically-proven, environmentally-benign and economically-viable alternatives to HFCs. The workshop was well attended by the stakeholders especially by the Industry representatives from USA and India.

## India-US Task Force on HFCs

The Government of India and the USA committed to work together on effective approaches and facilitate to enhance the understanding of stakeholders on issues related to HFCs. To this end, an India-US Task Force was established under the Co-Chairmanship of Mr. J.M Mauskar, special Secretary, MoEF and Mr. Daniel A. Reifsnyder, Deputy Assistant Secretary, USA. The Members of the Task Force include representatives of Govt., industry associations and experts from India as well as USA. The Terms of Reference (TOR) were finalized for the Task Force. The first report was prepared and circulated among the Members of the Task Force.

The First Meeting of the Task Force was held in New Delhi where Members of the Task Force from USA and India participated in the meeting. The report of the Task Force is being finalized in consultation with the stakeholders and Members of the Task Force from India and USA.

## Website

The Ozone Cell first launched its website in the year 1999. An interactive website of ozone cell has been re-developed and uploaded on the web in public domain for viewing and retrieving information. www.ozonecell.com

## Monitoring System in India

A detailed monitoring mechanism has been established by the Ozone Cell to ensure that the funding support provided from the MLF through implementing agencies, is being fruitfully utilized by the enterprises. The key aspects relating to monitoring mechanism are given below:

The MoEF has constituted a Standing Committee on Monitoring under the Chairmanship of Chairman, Central Pollution Control Board (CPCB) with Members from concerned Departments, Industry Associations and the Ozone Cell, MoEF. The committee meets once in a year or as desired to closely monitor the phase-out of ODSs. It examines the data collected and analysed by the Ozone Cell from ODS producers, Directorate General of Foreign Trade (DGFT) on imports and exports and user industry in the country. The production, imports and export data is collated in the Article 7 format of the Montreal Protocol for submission to the Ozone Secretariat. The Standing Committee is an advisory body to the ESC on the Montreal Protocol, which is fully responsible for the implementation of the Montreal Protocol in India. The Article 7 data thus wetted by the Standing Committee on Monitoring is submitted to the ESC for its consideration and then it is submitted to the Ozone Secretariat after the approval of the ESC.

The Director, Ozone Cell has been convening regular meetings with representatives of the World Bank, UNEP, UNDP, UNIDO and Bilateral Agencies with a view to note the progress of implementation and to sort out short term problems, which might occur during the implementation process. Further, Director, Ozone Cell is holding periodic meetings with industries to monitor their implementation progress for ODS phase-out.

## Key to Success

India attributes its success in achieving rapid progress of ODS phase out to the following:

- Identifying the priority sub-sectors for early phase-out.
- Choosing wisely a project portfolio with the right mix of investment and non-investment activities.
- Involving key stakeholders early in the phase-out process at both the planning and implementation level.
- Sending clear messages from the Government to various stakeholders by notifying appropriate regulations and policies.
- Awareness raising activities for key target audiences.
- Recognizing early the importance of building local capacity through training.
- Increasing the capacity of the Ozone Cell by its active involvement in the Regional Network of ODS officers and other international fora.
- Implementation of National Strategy for Transition to Non-CFC MDIs and Plan for Phase-out of CFCs in the Manufacturing of Pharmaceutical MDIs in India.
- The EUN for use of pharmaceutical grade of CFCs for manufacturing of MDIs for catering the needs of Asthma and COPD patients during the transition period.
- Preparation of HPMP Stage-I in consultation with the industry associations and other stakeholders for the freeze in 2013 on the baseline followed by 10% reduction in 2015.
- To create awareness among the stakeholders producing and using HCFCs.
- Monitoring of production and consumption sectors for complete phase-out of ODS.
- Mechanism for more involvement of State level organizations in ODSs phase-out activities.

## AWARDS AND RECOGNITIONS

- **Certificate of Appreciation** awarded to Dr. A. Duraisamy, Director, Ozone Cell by the Montreal Protocol, Ozone Secretariat, United Nations Environment Programme (UNEP) on 30 November, 2006 for his invaluable contribution as the Host Government Focal Point and Conference Coordinator towards organization of the 18th Meeting of the Parties (MOP) to the Montreal Protocol on Substances that Deplete the Ozone Layer from 30th October, 2006 to 3rd November, 2006 in Vigyan Bhawan, New Delhi, India.

- The Ozone Cell of India was conferred **"The Montreal Protocol Implementers Award, 2007"** by the Montreal Protocol, Ozone Secretariat, UNEP, on the occasion of the 20th Anniversary of the Montreal Protocol held on 16th September, 2007 at Montreal, for its extraordinary contributions in effective implementation of the Montreal Protocol and the global effort to protect the Ozone Layer.

- The Ozone Cell of India was conferred **"The Montreal Protocol Exemplary Project Recognition Award"** by the Montreal Protocol, Ozone Secretariat, UNEP, on the occasion of the 20th Anniversary of the Montreal Protocol held on 16th September 2007 at Montreal, for India's contribution to the project "Foam Sector Umbrella Project for conversion to CFC free technology".

- Ecological Refrigeration (ECOFRIG), Human and Institutional Development for Ecology Refrigeration (HIDECOR) and National CFC Consumption Phase-out Plan (NCCoPP) were conferred **"The Montreal Protocol Exemplary Project Recognition Award"** by the Montreal Protocol, Ozone Secretariat, UNEP, on the occasion of the 20th Anniversary of the Montreal Protocol held on 16th September, 2007 at Montreal.

- Two industries, M/s Kirloskar Copeland Ltd. and M/s Satya Deeptha Pharmaceuticals were Conferred **"The Montreal Protocol Exemplary Project Recognition Award"** by the Montreal Protocol, Ozone Secretariat, UNEP, on the occasion of the 20th Anniversary of the Montreal Protocol held on 16th September, 2007 at Montreal.

- **The Stratospheric Ozone Protection Award, 2008:** In recognition of exceptional contributions to global environmental protection, was conferred on Dr. A. Duraisamy, Director, Ozone Cell by the United States Environmental Protection Agency (USEPA), Washington DC for "Leadership in Ozone Layer Protection" at a special ceremony on 19th May, 2008 at the Kennedy Center for the Performing Arts in Washington DC, U.S.A.

- **Awarded Recognition** to the Ozone Cell, India by the Montreal Protocol, Ozone Secretariat, UNEP on the occasion of the 21st MOP to the Montreal Protocol held from 4th to 8th November, 2009 at Port Ghalib, Egypt, for its Ratification of the Vienna Convention on 18th March, 1991 and the Montreal Protocol on Substances that Deplete the Ozone Layer on 19th June, 1992 and its Efforts in Ozone Layer Protection.

- The 22nd MOP of the Montreal Protocol held from 8th November, 2010 to 12th November, 2010 at Bangkok **congratulated India for its outstanding achievements** for not seeking any CFCs for manufacturing of

MDIs under the EUN provisions of the Montreal Protocol for the year 2011 and beyond.

- The 22nd MOP of the Montreal Protocol held from 8th to 12th November 2010 at Bangkok, **appreciated the role of Indian delegation** for raising the issue of pre-blended polyols as a controlled substance and arriving at the decision to provide funding to the enterprises in A-5 Parties for conversion from pre-blended polyols with HCFC-141b to non-ODS technologies.

- **Certificate of Recognition** awarded to Dr. A. Duraisamy, Director, Ozone Cell by the Montreal Protocol, Ozone Secretariat, UNEP on 18th February, 2011, for his extraordinary efforts and leadership in phasing out CFCs in the MDI manufacturing Industry.

# 3. HOW CAN YOU HELP TO PROTECT THE OZONE LAYER?

**"Being Ozone friendly"** means taking individual action to reduce and eliminate impacts on the stratospheric ozone layer caused by the products that you buy, the appliances and equipment that your household or business uses, or the manufacturing process used by your company. Products made with, or containing ODSs such as CFCs, CTC, HCFCs, halons, methyl chloroform and methyl bromide can contribute to ozone layer depletion.

Actions that an individual can take to protect the ozone layer:

### Be an Ozone-friendly consumer

Buy products (aerosol spray cans, refrigerators, fire extinguishers, etc.) that are labelled "ozone friendly" or "CFC free". The product labels should indicate that they do not contain ODSs such as CFCs or halons. Ask for more information from the seller to ensure that the product is ozone friendly. Tell your neighbour that you are the proud owner of "ozone friendly" products.

### Be an ozone-friendly homeowner

Dispose of old refrigerators and appliances responsibly. CFC and HCFC refrigerants should be removed from an appliance before it is discarded. Portable halon fire extinguishers that are no longer needed should be returned to your fire protection authority for recycling. Consider purchasing new fire extinguishers that do not contain halon (e.g. dry powder) as recommended by your fire protection authority.

### Be an ozone-friendly farmer

If you use methyl bromide for soil fumigation, consider switching to effective and safe alternatives that are currently being used in many countries to replace this ozone damaging pesticide. Consider options such as integrated pest management that do not rely on costly chemical inputs. If you don't currently use methyl bromide, don't begin to use it now (you will have to get rid of it in the future).

### Be an ozone-friendly refrigeration servicing technician

Ensure that the refrigerant you recover from air conditioners, refrigerators or freezer during servicing is not "vented" or released to the atmosphere. Regularly check and fix leaks before they become a problem. Help start a refrigerant recovery and recycling programme in your area.

### Be an ozone-friendly office worker

Help your company identify which existing equipment (e.g. water coolers, air conditioners, cleaning solvents, fire extinguishers), and what products it buys (aerosol sprays, foam cushions/ mattresses) use ODSs, and develop a plan for replacing them with cost-effective alternatives. Become an environmental leader within your office.

### Be an ozone-friendly company

Replace ODSs used in your premises and in your manufacturing processes (contact your National Ozone Unit to see if you are eligible for financial and technical assistance from the MLF. If your products contain ODSs, change your product formulation to use alternative substances that do not destroy the ozone layer.

### Be an ozone-friendly teacher

Inform your students about the importance of protecting the environment and in particular, the ozone layer. Teach students about the damaging impact of ODSs on the atmosphere, health impacts and what steps are being taken internationally and nationally to solve this problem. Encourage your students to spread the message to their families.

### Be an ozone-friendly community organizer

Inform your family, neighbours and friends about the need to protect the ozone layer and help them get involved. Work with Non-Governmental Organizations (NGOs) to help start information campaigns and technical assistance projects to phase out ODSs in your city, town or village.

### Be an ozone-friendly citizen

Read and learn more about the effects of ozone depletion on people, animals and the environment, your national strategy and policies to implement the Montreal Protocol, and what the phase out of ozone depleting substances means to your country. Get in touch with your country's National Ozone Unit and learn how you can get involved on an individual level.

Website: **www.ozonecell.com**

# 4. OZONE IN OUR ATMOSPHERE

Twenty Questions and Answers about the Ozone Layer

### Q.1. : What is ozone and where is it in the atmosphere?

Ozone is a gas that is naturally present in our atmosphere. Each ozone molecule contains three atoms of oxygen and is denoted chemically as O3. Ozone is found primarily in two regions of the atmosphere. About 10% of atmospheric ozone is in the troposphere, the region closest to Earth (from the surface to about 10-16 kilometers (6-10 miles)). The remaining ozone (about 90%) resides in the stratosphere between the top of the troposphere and about 50 kilometers (31 miles) altitude. The large amount of ozone in the stratosphere is often referred to as the "ozone layer."

### Q.2. : How is ozone formed in the atmosphere?

Ozone is formed throughout the atmosphere in multistep chemical processes that require sunlight. In the stratosphere, the process begins with an oxygen molecule (O2 ) being broken apart by ultraviolet radiation from the Sun. In the lower atmosphere (troposphere), ozone is formed by a different set of chemical reactions that involve naturally occurring gases and those from pollution sources.

### Q.3. : Why do we care about atmospheric ozone?

Ozone in the stratosphere absorbs a large part of the Sun's biologically harmful ultraviolet radiation. Stratospheric ozone is considered "good" ozone because of this beneficial role. In contrast, ozone formed at Earth's surface in excess of natural amounts is considered "bad" ozone because it is harmful to humans, plants, and animals. Natural ozone near the surface and in the lower atmosphere plays an important beneficial role in chemically removing pollutants from the atmosphere.

### Q.4. : How is total ozone distributed over the globe?

The distribution of total ozone over the Earth varies with location on timescales that range from daily to seasonal. The variations are caused by large-scale movements of stratospheric air and the chemical production and destruction of ozone. Total ozone is generally lowest at the equator and highest in polar regions.

### Q.5. : How is ozone measured in the atmosphere?

The amount of ozone in the atmosphere is measured by instruments on the ground and carried aloft on balloons, aircraft, and satellites. Some instruments measure ozone locally by continuously drawing air samples into a small detection chamber. Other instruments measure ozone remotely over long distances by using ozone's unique optical absorption or emission properties.

## Q.6. : What are the principal steps in stratospheric ozone depletion caused by human activities?

The initial step in the depletion of stratospheric ozone by human activities is the emission, at Earth's surface, of gases containing chlorine and bromine. Most of these gases accumulate in the lower atmosphere because they are unreactive and do not dissolve readily in rain or snow. Natural air motions transport these accumulated gases to the stratosphere, where they are converted to more reactive gases. Some of these gases then participate in reactions that destroy ozone. Finally, when air returns to the lower atmosphere, these reactive chlorine and bromine gases are removed from Earth's atmosphere by rain and snow.

## Q.7. : What emissions from human activities lead to ozone depletion?

Certain industrial processes and consumer products result in the emission of ozone-depleting substances (ODSs) to the atmosphere. ODSs are manufactured halogen source gases that are controlled worldwide by the Montreal Protocol. These gases bring chlorine and bromine atoms to the stratosphere, where they destroy ozone in chemical reactions. Important examples are the chlorofluorocarbons (CFCs), once used in almost all refrigeration and air conditioning systems, and the halons, which were used in fire extinguishers. Current ODS abundances in the atmosphere are known directly from air sample measurements.

## Q.8. : What are the reactive halogen gases that destroy stratospheric ozone?

Emissions from human activities and natural processes represent a large source of chlorine- and bromine-containing gases that enter the stratosphere. When exposed to ultraviolet radiation from the Sun, these halogen source gases are converted to more reactive gases containing chlorine and bromine. Some reactive gases act as chemical reservoirs that convert to form the most reactive gases, namely chlorine monoxide (ClO) and bromine monoxide (BrO). The most reactive gases participate in catalytic reactions that efficiently destroy ozone. Most volcanoes emit some reactive halogen gases that readily dissolve in water and are usually washed out of the atmosphere before they can reach the stratosphere.

## Q.9. : What are the chlorine and bromine reactions that destroy stratospheric ozone?

Reactive gases containing chlorine and bromine destroy stratospheric ozone in "catalytic" cycles made up of two or more separate reactions. As a result, a single chlorine or bromine atom can destroy many thousands of ozone molecules before it leaves the stratosphere. In this way, a small amount of reactive chlorine or bromine has a large impact on the ozone layer. A special situation develops in polar regions in the late winter/early spring season where large enhancements in the abundance of the most reactive gas, chlorine monoxide, leads to severe ozone depletion.

## Q.10. : Why has an "ozone hole" appeared over Antarctica when ozone-depleting substances are present throughout the stratosphere?

Ozone-depleting substances are present

throughout the stratospheric ozone layer because they are transported great distances by atmospheric air motions. The severe depletion of the Antarctic ozone layer known as the "ozone hole" occurs because of the special atmospheric and chemical conditions that exist there and nowhere else on the globe. The very low winter temperatures in the Antarctic stratosphere cause polar stratospheric clouds (PSCs) to form. Special reactions that occur on PSCs, combined with the relative isolation of polar stratospheric air, allow chlorine and bromine reactions to produce the ozone hole in Antarctic springtime.

### Q.11. : How severe is the depletion of the Antarctic ozone layer?

Severe depletion of the Antarctic ozone layer was first reported in the mid-1980s. Antarctic ozone depletion is seasonal, occurring primarily in late winter and early spring (August-November). Peak depletion occurs in early October when ozone is often completely destroyed over a range of altitudes, thereby reducing total ozone by as much as two-thirds at some locations. This severe depletion creates the "ozone hole" apparent in images of Antarctic total ozone made using satellite observations. In most years the maximum area of the ozone hole far exceeds the size of the Antarctic continent.

### Q.12. : Is there depletion of the Arctic ozone layer?

Yes, significant depletion of the Arctic ozone layer now occurs in most years in the late winter/early spring period (January-March). However, the maximum depletion is less severe than that observed in the Antarctic and is more variable from year to year. A large and recurrent "ozone hole," as found in the Antarctic stratosphere, does not occur in the Arctic.

### Q.13. : How large is the depletion of the global ozone layer?

Depletion of the global ozone layer began gradually in the 1980s and reached a maximum of about 5% in the early 1990s. The depletion has lessened since then and now is about 3.5% averaged over the globe. The average depletion exceeds the natural year-to-year variations of global total ozone. The ozone loss is very small near the equator and increases with latitude toward the poles. The larger polar depletion is attributed to the late winter/early spring ozone destruction that occurs there each year.

### Q.14. : Do changes in the Sun and volcanic eruptions affect the ozone layer?

Yes, factors such as changes in solar radiation, as well as the formation of stratospheric particles after volcanic eruptions, do influence the ozone layer. However, neither factor can explain the average decreases observed in global total ozone over the last three decades. If large volcanic eruptions occur in the coming decades, ozone depletion will increase for several years afterwards.

### Q.15. : Are there controls on the production of ozone-depleting substances?

Yes, the production and consumption of ozone-depleting substances are controlled under a 1987 international agreement known as the "Montreal Protocol on Substances that Deplete the Ozone Layer" and by its subsequent Amendments and Adjustments. The Protocol, now ratified by all 196 United Nations members, establishes legally binding controls on national production and consumption of ozone-depleting substances (ODSs). Production and consumption of all principal ODSs by developed and developing nations will be almost completely phased out before the middle of the 21st century.

### Q.16. : Has the Montreal Protocol been successful in reducing ozone-depleting substances in the atmosphere?

Yes, as a result of the Montreal Protocol, the overall abundance of ozone-depleting substances (ODSs) in the atmosphere has been decreasing for about a decade. If the nations of the world continue to comply with the provisions of the Montreal Protocol, the decrease will continue throughout the 21st century. Those gases that are still increasing in the atmosphere, such as halon-1301 and HCFC-22, will begin to decrease in the coming decades if compliance with the Protocol continues. Only after midcentury will the effective abundance of ODSs fall to values that were present before the Antarctic ozone hole was observed in the early 1980s.

### Q.17. : Does depletion of the ozone layer increase ground-level ultraviolet radiation?

Yes, ultraviolet radiation at Earth's surface increases as the amount of overhead total ozone decreases, because ozone absorbs ultraviolet radiation from the Sun. Measurements by ground-based instruments and estimates made using satellite data provide evidence that surface ultraviolet radiation has increased in large geographic regions in response to ozone depletion.

### Q.18. : Is depletion of the ozone layer the principal cause of climate change?

No, ozone depletion itself is not the principal cause of climate change. Changes in ozone and climate are directly linked because ozone absorbs solar radiation and is also a greenhouse gas. Stratospheric ozone depletion and increases in global tropospheric ozone that have occurred in recent decades have opposing contributions to climate change. The ozone-depletion contribution, while leading to surface cooling, is small compared with the contribution from all other greenhouse gas increases, which leads to surface warming. The total forcing from these other greenhouse gases is the principal cause of observed and projected climate change. Ozone depletion and climate change are indirectly linked because both ozone-depleting substances and their substitutes are greenhouse gases.

### Q.19. : Have reductions of ozone-depleting substances under the Montreal Protocol also protected Earth's climate?

Yes. All ozone-depleting substances are also greenhouse gases that contribute to climate forcing when they accumulate in the atmosphere. Montreal Protocol controls have led to a substantial reduction in the emissions of ozone-depleting substances (ODSs) over the last two decades. These reductions have provided the added benefit of reducing the human contribution to climate change while protecting the ozone layer. Without Montreal Protocol controls, the climate forcing contribution from annual ODS emissions could now be 10-fold larger than its present value, which would be a significant fraction of the climate forcing from current carbon dioxide ($CO_2$) emissions.

## Q.20 : How is ozone expected to change in the coming decades?

Substantial recovery of the ozone layer from the effects of ozone-depleting substances (ODSs) is expected near the middle of the 21st century, assuming global compliance with the Montreal Protocol. Recovery will occur as ODSs and reactive halo-gen gases in the stratosphere decrease in the coming decades. In addition to responding to ODSs, future ozone amounts will increasingly be influenced by expected changes in climate. The resulting changes in stratospheric ozone will depend strongly on the geographic region. During the long recovery period, large volcanic eruptions could temporarily reduce global ozone amounts for several years.


*"International Ozone Day-2010" held on 16th September, 2010 at New Delhi*


*Shri Jairam Ramesh, Hon'ble Minister of State for Environment & Forests (Independent Charge) addressing the participants during the "International Ozone Day-2010" function on 16th September, 2010*


"INDO-US Workshop on HFCS" held on 18th February, 2011 at New Delhi


Shri Jairam Ramesh, Hon'ble Minister of State for Environment & Forests (Independent Charge) addressing the participants during the "INDO-US Workshop on HFCS" on 18th February, 2011


*First meeting of "India-US Task Force on Hydrofluorocarbons" held on 22nd June, 2011 at New Delhi*


*Children participating in skit competition organized by the Ozone Cell on 29th August, 2011 at New Delhi on the occasion of the International Ozone Day for the year, 2011*


***Display of posters made by participants of children competition organized by the Ozone Cell on 29th August, 2011 at New Delhi on the occasion of the International Ozone Day for the year, 2011***


***Display of paintings made by participants of children competition organized by the Ozone Cell on 29th August, 2011 at New Delhi on the occasion of the International Ozone Day for the year, 2011***


***Display of slogans made by participants of children competition organized by the Ozone Cell on 29th August, 2011 at New Delhi on the occasion of the International Ozone Day for the year, 2011***

***Display of models made by participants of children competition organized by the Ozone Cell on 29th August, 2011 at New Delhi on the occasion of the International Ozone Day for the year, 2011***

# PAINTING COMPETITION

**1st Prize**
Arjun Sehgal, Delhi Public School, New Delhi

**2nd Prize**
Akshay Verma, M.G. Public School, Muzaffar Nagar

**3rd Prize**
Rajiv Kumar, Evergreen Public School, Delhi

SAVE OUR OZONE LAYER

## WHOM TO CONTACT TO LEARN MORE ABOUT OZONE

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