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A detailed study of loss of ozone layer: Causes and it's impact

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Abstract

Ozone (O3) is a stratospheric layer that plays as support system for human being survival. It is an essential factor for many global, biological and environmental phenomena. The ultra-violet (UV) rays emitted from sun are captured by ozone and thereby provide a stable ontological structure in the biosphere. Various anthropogenic activities such as emissions of CFCs, HCFCs and other organo-halogens lead to the depletion of ozone. The ozone depletion resulted in secondary production of an ozone layer near the ground (terrestrial ozone layer), which is responsible for adverse effects on plants, humans and environment with increased number of bronchial diseases in humans. The mutations caused by UV rays result in variation in morphogenic traits of plants which ultimately decreases crop productivity. However, UV radiation is required in optimum intensity for both plants and animals. This review takes into an account the wide ranging effects of ozone depletion with a majority of them being detrimental to the plant system.

Keywords: ozone depletion, ultra-violet radiation, chlorofluorocarbons, plants, ecosystem

Introduction

The ozone layer is a layer in Earth's atmosphere which contains relatively high concentrations of ozone (O3). This layer absorbs 93-99% of the sun's high frequency ultraviolet light, which is potentially damaging to life on earth. Over 91% of the ozone in Earth's atmosphere is present here. It is mainly located in the lower portion of the stratosphere from approximately 10 km to 50 km above Earth, though the thickness varies seasonally and geographically. The ozone layer was discovered in 1913 by the French physicists Charles Fabry and Henri Buisson. Its properties were explored in detail by the British meteorologist G. M. B. Dobson, who developed a simple spectrophotometer (the Dobson meter) that could be used to measure stratospheric ozone from the ground. Between 1928 and 1958 Dobson established a worldwide network of ozone monitoring stations which continues to operate today. The "Dobson unit", a convenient measure of the total amount of ozone in a column overhead, is named in his honor.

Memorable points

- Ozone is a highly reactive oxygen molecule containing oxygen.
- The ozone layer is a portion of the stratosphere with a slightly higher concentration of ozone molecules. It forms a protective shield that filters out harmful ultraviolet radiatation.
- Ozone layer occupies the inner 2/3rd of the stratosphere, 15- 45 km above the earth surface. Natural Process:

Without ozone, life on Earth would not have evolved in the way it has. The first stage of single cell organism development requires an oxygen-free environment. This type of environment existed on earth over 3000 million years ago. As the primitive forms of plant life multiplied and evolved, they began to release minute amounts of oxygen through the photosynthesis reaction (which converts carbon dioxide into oxygen).

The buildup of oxygen in the atmosphere led to the formation of the ozone layer in the upper atmosphere or stratosphere. This layer filters out incoming radiation in the "cell-damaging" ultraviolet (UV) part of the spectrum. Thus with the development of the ozone layer came the formation of more advanced life forms. Ozone is a form of oxygen. The oxygen we breathe is in the form of oxygen molecules (O2) - two atoms of oxygen bound together. Normal oxygen which we breathe is colourless and odourless. Ozone, on the other hand, consists of three atoms of oxygen bound together (O3). Most of the atmosphere's ozone occurs in the region called the stratosphere. Ozone is colourless and has a very harsh odour. Ozone is much less common than normal oxygen. Out of 10 million air molecules, about 2 million are normal oxygen, but only 3 are ozone. Most ozone is produced naturally in the upper atmosphere or stratosphere. While ozone can be found through the entire atmosphere, the greatest concentration occurs at altitudes between 19 and 30 km above the Earth's surface. This band of ozone-rich air is known as the "ozone layer". Ozone also occurs in very small amounts in the lowest few kilometres of the atmosphere, a region known as the troposphere. It is produced at ground level through a reaction between sunlight and volatile organic compounds (VOCs) and nitrogen oxides (NOx), some of which are produced by human activities such as driving cars. Ground-level ozone is a component of urban smog and can be harmful to human health. Even though both types of ozone contain the same molecules, their presence in different parts of the atmosphere has very different consequences.

Stratospheric ozone blocks harmful solar radiation - all life on Earth has adapted to this filtered solar radiation. Ground-level ozone, in contrast, is simply a pollutant. It will absorb some incoming solar radiation, but it cannot make up for ozone losses in the stratosphere.

Ozone Hole

In some of the popular news media, as well as in many books, the term "ozone hole" has and often still is used far too loosely. Frequently, the term is employed to describe any episode of ozone depletion, no matter how minor. Unfortunately, this sloppy language trivializes the problem and blurs the important scientific distinction between the massive ozone losses in Polar Regions and the much smaller, but nonetheless significant, ozone losses in other parts of the world. Technically, the term "ozone hole" should be applied to regions where stratospheric ozone depletion is so severe that levels fall below 200 Dobson Units (D.U.), the traditional measure of stratospheric ozone. Normal ozone concentration is about 300 to 350 D.U. Such ozone loss now occurs every springtime above Antarctica, and to a lesser extent the Arctic, where special meteorological conditions and very low air temperatures accelerate and enhance the destruction of ozone loss by man-made ozone depleting chemicals (ODCs).

The Ozone Hole 2009

Situation at 2009 November the 2009 ozone hole is now waning, with much of the continent experiencing a stratospheric spring warming. The residual vortex is over the Weddell Sea and Antarctic Peninsula and here minimum values are around 160 DU and depletion exceeds 50%. Ozone values outside the polar vortex have dropped to near 400 DU, and inside the vortex ozone values are increasing as the atmosphere warms [7]. The temperature of the ozone layer over Antarctica is now rising, though a small area is still cold enough for polar stratospheric clouds (PSCs) to exist. During the early winter, the polar vortex was often rather more elliptical than it was in 2008, and this lead to some early depletion in circumpolar regions as stratospheric clouds became exposed to sunlight. It reverted to a more circular circulation as winter progressed and this led to another relatively slow start to the growth of the ozone hole (as measured by NASA/SBUV2), with the "hole" not beginning until mid-August. The vortex became more elliptical again in late August, with South Georgia being affected by the fringes of the ozone hole between September 2 and 6. The hole grew to reach an area of around 24 million square kilometers by mid-September, but had declined to 12 million square kilometres by mid-November. It is now a little larger than the average for the past decade. The tip of South America and South Georgia were affected by the fringes of the ozone hole from September 24 to September 30 and again from October 3 to October 7.

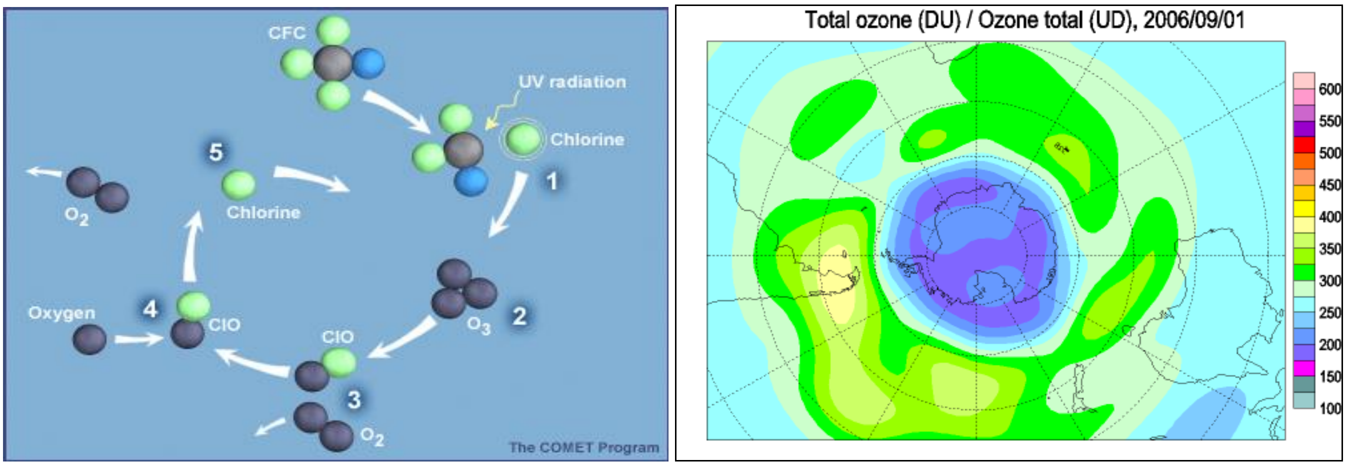


Fig 1

Stratospheric Ozone Depletion-

When ultraviolet radiation strikes ozone molecules, it causes them to split:

$UV + O_3 \rightarrow O + O_2$

The products, however quickly reunite, re- forming ozone and giving off heat

$O + O_2 \rightarrow O_3 + heat$

Thus, the ozone layer is a renewable form of protection that convert harmful UV radiation into heat.

Key Concepts

The ozone layer is a portion of the stratosphere with a slightly higher concentration of ozone molecule. It forms a protective shield that filters out harmful ultraviolet radiation.

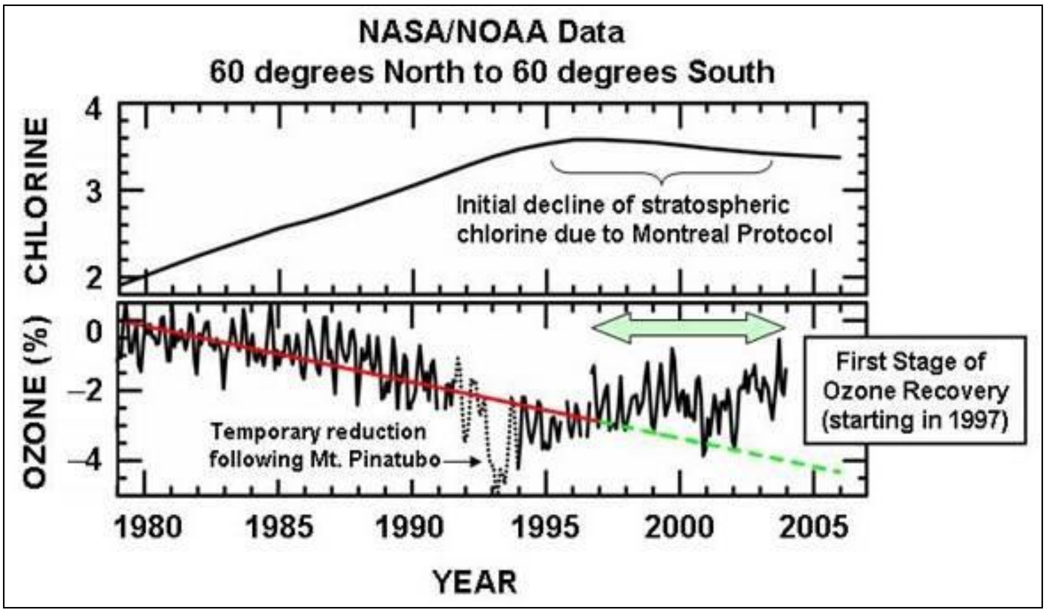


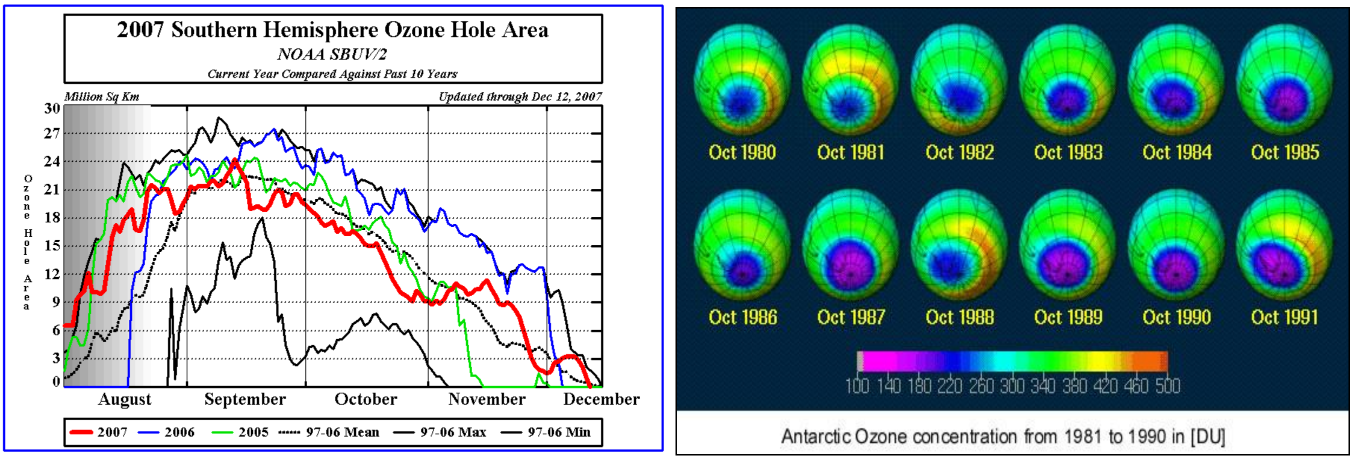
Fig 2

The Antarctic Ozone Depletion

Every spring, up to 95% of stratospheric ozone is destroyed at a height of 12 – 24 km above the earth' surface – the heart of polar ozone layer. There is strong scientific evidence that man- made chlorine and bromine compounds are to blame for these losses.

The seeds of ozone destruction above Antarctic are sown in the winter when a vortex of extremely cold air blows around the pole. No sunlight enters the vortex in the Antarctic winter night and no air form warmer latitudes moves into the vortex. The extreme cold primes the vortex for ozone destruction by allowing clouds of nitric acid add water ice to form in the lower polar stratosphere.

Reactions between particles in these polar stratospheric clouds and stable chlorine and bromine compounds play a major role in large- scale ozone depletion above Antarctic.



Antarctic Ozone concentration from 1981 to 1990 in [DU]

Fig 3

Mid Latitude Ozone layer Depletion

In mid- December 1987, the deepest Antarctic ozone hole in stratospheric ozone above southern Australia and New Zealand which lasted for the rest of the month. It is expected that mid- latitude ozone depletions will be as large during the 1990s as they were during the 1980s reaching six% in summer and about 10% in winter by the year 2000. Sulphuric acid particles may also trigger reactions causing rapid destruction of stratospheric ozone. This could be particularly important after a volcanic eruption.

Arctic Ozone layer Depletion-

In northern mid- latitudes, the ozone layer in the 38- 43 km slice of stratosphere thinned by 5- 13% between 1979 and 1986. Arctic ozone hole will form, through it is unlikely to be as deep or long lived as its Antarctic counterpart. Polar stratospheric clouds have been sighted in the Arctic, although there are 10-100 times more of them above Antarctica. Above the Arctic, the vortex wanders over lower latitudes as well, allowing warmer air to raise temperature within the vortex.

Observations of Arctic stratosphere chemistry show changes similar to those observed in Antarctic and indicate greater efficiency at destroying ozone than previously realized concentration of chlorine monoxide. 3-6 times greater than photochemical models predicted for that latitude and time of year.

While ozone depletion over Antarctica happens over largely unpopulated regions, a depleted ozone layer above the Arctic could seriously affect the populations of Europe, Canada, Greenland and Siberia.

Ozone Depletion: The History of a Scientific Discovery

In 1974 the chemists Rowland and Molina announced that CFCs, previously considered safe, could react with and remove ozone molecule from the stratosphere. Their initial projections indicated that CFCs could eventually destroy 20-30% of ozone layer. Their work on CFCs and ozone depletion eventually won Nobel prize.

In May 1985, for example, British scientist reported a large decrease in the ozone layer above Antarctica. In 1986 and 1987, intense study of ozone hole strongly suggested that it was caused in large part by CFCs. In 1988, researchers discovered that a similar hole was forming over the Arctic. In March of 1998, atmospheric scientist published a report claiming that ozone concentration had declined 1.7 to 3% over the northern hemisphere since 1969.

Key Concept

Studies of the ozone layer show substantial declines over the globe, with the highest level of depletion in southern hemisphere and Antarctica.

Ozone depletion over India

With so much worry about the rapid ozone depletion taking place in various parts of the earth, Indian scientists are closely monitoring the ozone layer over India for possible depletion trends. Opinions are many and varied. According to S K Srivastava, head of the National Ozone Centre in New Delhi, there is no trend to show total ozone depletion over India. V.Thaphyal and S M Kulshresta of the Indian Meteorological Department also point out that for the period 1956 to 1986 "ozone measurements exhibit year to year variability, but do not show any increasing or decreasing trend over India." However, former director of the National Ozone Centre, K Chatterji, now with Development Alternatives, warns that there is no case for complacency. He asserts that his calculations exhibit an ozone depletion trend in the upper, layers of the stratosphere over New Delhi and Pune from 1980 to 1983 in the month of October when the Antarctic ozone hole is at its maximum. Since India already receives high doses of ultraviolet (UV-B) radiation, and is at the threshold go to speak, effects of ozone layer depletion could he far more disastrous in India. A P Mitra, former director general of the Council of Scientific and Industrial Research, clarifies that while there is no trend in the total ozone value, there is some evidence of ozone depletion at higher altitudes - at about 30 to 40 km - even over the tropics. He argues, however, that there is insufficient data and that the depletion may be due to solar cycles and other natural phenomena. However, the effects of CFCs and belong cannot be ruled out. Total column ozone data has been recorded over India for a long time. A network of stations using Dobson spectrophotometers to mea- sure total ozone, some six times a day, covers Srinagar, New Delhi, Varanasi, Ahmedabad, Pone and Kodaikanal. Ozone profiles are also regularly recorded using balloons. Ozone levels are the lowest during November and December and the highest in summer. Across the country, variations do exist. In Kodaikanal, the total ozone is 240 to 280 Dobson units (DU), in New Delhi 270 to 320 DU and in Srinagar 290 to 360 DU. One Dobson unit is the equivalent of 0.01 mm of compressed gas at a pressure of 760 rare mercury and 0°C.B N Srivastava of the National Physical Laboratory, who been working on incident UV- radiation levels, says that during summer, at noon, the UV-B radiation with a wavelength of 290 nanometer (nm) is equivalent to levels attained in the Antarctica during the ozone hole period. He warns that even a slight depletion of the ozone layer over India may lead to large percentage changes in UV-B radiation over the country. According to eminent skin specialists in New Delhi, the incidence of skin cancer in India is low, but they admit that the surveys conducted to identify any trends are inadequate. Controlled studies to observe the effects of changing UV- B radiation concentrations on crops are on, they said. However no field surveys have been done in the country as yet.

Causes of Stratospheric Ozone Depletion

Nitric oxide, chlorine atom and hydroxyl ions, chlorine atoms and hydroxyl ions are well known fact that the atmospheric ozone immediately covering the surface of the atmospheric ozone immediately covering the surface of the planet there is a rise in temperatures. In between two zones lies a narrow region called the troposphere, which has almost uniform temperature. However, some exchange does occur between the two. In addition to these prospectivness, many kinds of pollutants are injected straight into the stratosphere by man made agencies or activities, and natural events.

A. Anthropogenic

1. Use of nitrogenous fertilizers in excess

Nitrogenous oxides are produced by the microbial action on nitrogenous fertilizer and this readily escape into the atmosphere .it is estimated that tropospheric load of nitrous oxide is 1.7×10^{18} gms whereas stratospheric content is about 8.0×10^{15}gms.sun convert the nitrous oxide to nitric oxide which is an important ozone destroying constituent of the stratosphere.

2. Combustion of fossil fuel

Huge quantity of oxides of carbon nitrogen and sulphur hydrocarbons and fine particulate material is introduced daily into the troposphere some portion of which goes high enough to reach the stratosphere. Methane is one of the most important constituents which reach high enough to pollute the stratosphere.

3. Use of chloroflurocarbons in excess

Chloroflourocarbons sare inert highly stable colourless odourless chemicals which can be easily liquefied these gases under the influence of high energy radiatations break up to yield chlorine atom.

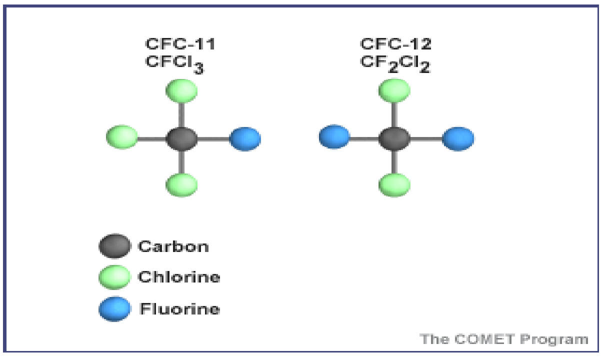


Fig 4

4. Use of Supersonic Transports, Rockets and Space Shutters

The jet engines of the supersonic aircraft flying at high altitudes release nitrogen oxide (NO_x) which catalytical destroys ozone molecules.

5. Conduction of Nuclear Tests

Surface nuclear explosions produce huge quantities of various gases, dust, soot and debris with enormous force which carries much of material straight into the stratosphere. Much of thismaterials damages the ozone layer.

B. Natural Sources of Pollutants

1. Volcanic Eruptions

There are several records of volcanic eruptions since 1500 A.D. Krakota in 1882 and a more recent one of almost equal magnitude was that of Mt. Agurg in 1963. Elchihon in Mexico, Mount Pinatubo in Philippines are quite recent examples of addition of enormous quantities of waste gases and other pollutants. Rogelio Madura (1992) has reported that Mt. Erebus on Antarctica alone ejects about 1000 tons of chlorine a day

2. Solar Flares

Scientists have observed occurrence of violent eruptions from the sun. This occurrence of solar flares on August 4, 1972 alone has been estimated to have caused about 1396 reduction in of ozone content.

Cosmic ray theory for ozone hole

University of Waterloo scientist says that an observed cyclic hole in the ozone layer provides proof of a new ozone depletion theory involving cosmic rays, a theory outlined in his new study, just published in Physical Review Letters. Qing-Bin Lu, a professor of physics and astronomy and an ozone depletion expert, said it was generally accepted for more than two decades that the Earth's ozone layer is depleted by chlorine atoms produced by the sun's ultraviolet light-induced destruction of chlorofluorocarbons (CFCs) in the atmosphere. But mounting evidence supports a new theory that says cosmic rays, rather than the sun's UV light, play the dominant role in breaking down ozone-depleting molecules and then ozone. Cosmic rays are energy particles originating in space. Ozone is a gas mostly concentrated in the ozone layer, a region located in the stratosphere several miles above the Earth's surface. It absorbs almost all of the sun's high-frequency ultraviolet light, which is potentially damaging to life and causes such diseases as skin cancer and cataracts.

The Antarctic ozone hole is larger than the size of North America. In his study, Lu analyzes reliable cosmic ray and ozone data in the period of 1980-2007, which cover two full 11-year solar cycles. The data unambiguously show the time correlations between cosmic ray intensity and global ozone depletion, as well as between cosmic ray intensity and the ozone hole over the South Pole. The Schwabe solar cycle or Schwabe-Wolf cycle is the eleven-year cycle of solar activity of the sun. It was named after Samuel Heinrich Schwabe (October 25, 1789 April 11, 1875) a German astronomer remembered for his work on sunspots. At periods of highest activity, known as solar maximum or solar max, sunspots appear. Periods of lowest activity are known as solar minimum. The last solar maximum was in 2001. The solar cycle is not strictly 11 years; it has been as short as 9 years and as long as 14 years in recent years.

This finding not only provides a fingerprint for the dominant role of the cosmic-ray mechanism in causing the ozone hole, but also contradicts the widely-accepted photochemical theory," Lu said. "These observations cannot be explained by that photochemical model. Instead, they force one to conclude that the cosmic ray mechanism plays the dominant role in causing the hole. His study quantitatively predicted that the mean total ozone in the October hole over Antarctica would be depleted to around 187 Dobson units (DU). The latest NASA OMI satellite data sets, released on March 13, show that the mean total ozone in the ozone hole in October 2008 was 197 DU, within five per cent of Lu's prediction. "The total ozone values in the ozone hole in November and December nearly reached the minimum values in the months on record," Lu said. "The 2008 ozone hole shrank quite slowly and persisted until the end of December, making it one of the longest lasting ozone holes on record." He added that in earlier studies he and former colleagues found a strong spatial correlation between cosmic ray intensity and ozone depletion, based on the data from several sources, including NASA satellites. "Lab measurements demonstrated a mechanism by which cosmic rays can cause drastic reactions of ozone-depleting halogens inside polar clouds." Cosmic rays are concentrated over the North and South Poles due to Earth's magnetic field, and have the highest electron-production rate at the height of 15 to 18 km above the ground -- where the ozone layer has been most depleted. Lu says that years ago atmospheric scientists expressed doubts about the cosmic ray mechanism, but now observed data shows which theory is the correct one. For instance, the most recent scientific assessments of ozone depletion by the World Meteorological Organization and the United Nations Environment Program using photochemical models predicted that global ozone will recover (or increase) by one to 2.5 per cent between 2000 and 2020 and that the Antarctic springtime ozone hole will shrink by five to 10 per cent between 2000 and 2020. In sharp contrast, the cosmic ray theory predicted one of the severest ozone losses over the South Pole in 2008-2009 and another large hole around 2019-2020.

Effect of Ozone layer Depletion on Society

1. Ultraviolet Radiation

Ultraviolet radiation is divided into three types according to wavelength. UV-A radiation emitted at wavelength 315 – 400 nm is unaffected by ozone reduction and is relatively harmless. UV- B radiation, emitted at 200- 315 nm is affected by decrease in atmospheric ozone. It is UV- B radiation that causes most of the damage of plants and animals. UV-C which is lethal – is emitted at wavelength of 200- 280 nm. UV-C is completely absorbed by atmospheric ozone and oxygen. Even with severe ozone reduction, UV-C would still be absorbed by the remaining ozone oxygen. Even with severe ozone reduction, UV-C would still be absorbed by the remaining ozone.

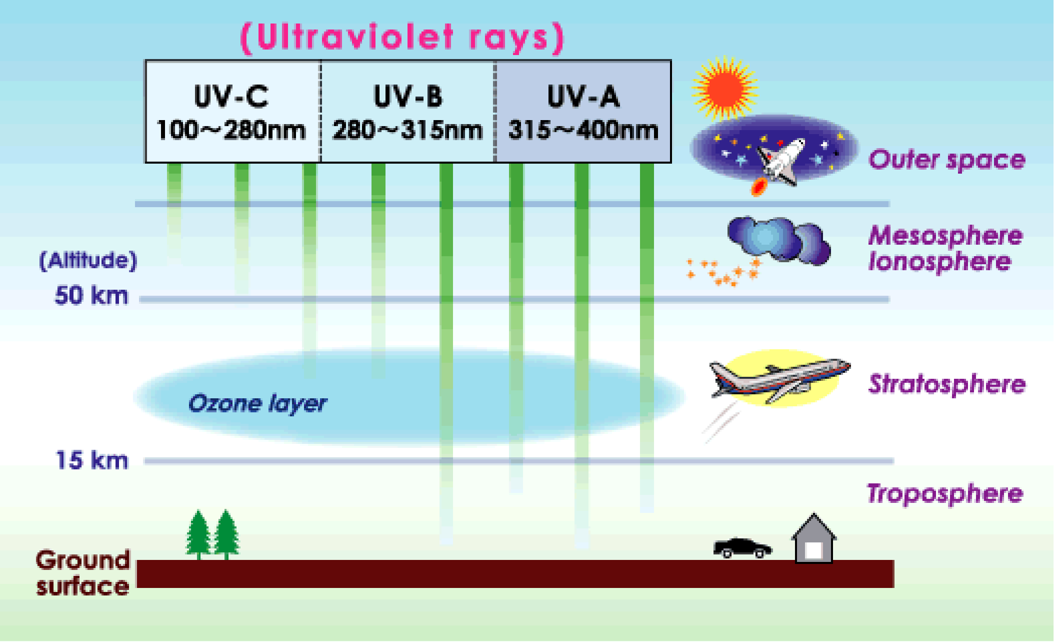


Fig 5

2. Immune System and vaccination

Ultraviolet radiation suppresses allergic reactions of the skin and profoundly affects the immune system – particularly in skin cells where it is often the body's first line of defence against infection. A vaccine injected into the skin triggers an immune response as the injected antigen stimulates the production of lymphocytes in the skin. In UV- treated skin however the activity of this antibody – producing cells is suppressed and there is an increase in numbers of another type of cell, which normally prevents the body from rejecting essential substance such as its own proteins. When skin has been over – exposed to ultraviolet radiation, these T- cells prevent the body from recognizing the vaccine being injected as foreign tissue; consequently the body fails to produce the antigens required for defence.

At the very fast, these include all disease that have a stage involving the skin: measles and other viral diseases that cause a rash to develop such as chicken pox and herpes, parasitic diseases introduced through the skin such as malaria and leishmaniasis: bacterial disease such as tuberculosis and leprosy and fungal infectious such as candidiasis. Vaccination programmes designed to deal with insect – borne diseases could be compromised if vaccines were given to people who had been exposed to high amount of UV- B.

3. Skin Cancer

The combination of increased exposure to UV- B radiation, and the capacity of UV- B to suppress the skin's immune defences, will mean much higher rates of skin cancer. A convincing and clear – cut relationship has been established between UV- B radiation and potentially non – melanoma skin cancer. In addition, because UV-B suppresses the skin's immune response, the body's immune system is less likely to reject a growing tumor.

It has been calculated that 5% decrease in ozone would mean a 14% increase in basal cell carcinoma – the most common type of non – melanoma skin cancer- and a 25% increase in squamous cell carcinoma – the common type of non – melanoma skin cancer that is most frequently fatal. In U.S.A. a 5% decrease in ozone could mean an additional 56,000 people developing squamous cell carcinomas each year. For cutaneous malignant melanoma (another type of skin cancer) the U.S. Environmental Protection Agency concluded that every 1% decrease in stratospheric ozone could mean an extra 2% of the world's population developing this type of cancer dying as a result.

4. Increasing Eye Damage

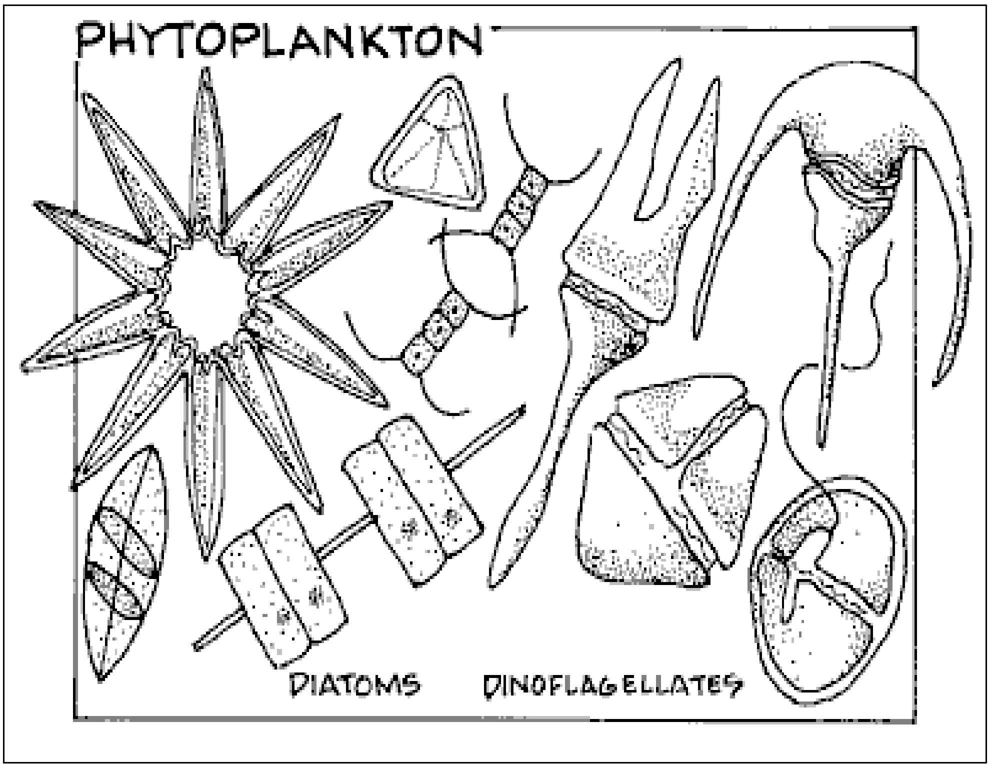
UV- B radiation can damage the cornea, the lens and – to a lesser extent – the retina. The eye first responds to damaging UV- B radiation by developing photokeratitis in which the fronts of the eye, eyelids and the skin surrounding the eyes redden. In 1985, the World Health Organization estimated that cataracts were responsible for 17 million cases of blindness: more than half the global total. A 1% reduction of the ozone layer in 1985, there would have been an extra 100,000- 150,000 cases of cataract- induced blindness.

Intraocular melanoma: A cancer affecting the eyes. People living in lower latitudes are about three times more likely to develop this type of tumour, with blue – eyed individuals at greatest risk.

1. Impact on the Oceans

Ozone layer Depletion seems likely to distrupt ocean life and seriously affect the marine food web. Phytoplanktons are the variety of plankton. Each year, they produce more than one -half of the Earth's biomass. Their annual biomass production has been calculated as 6 x 10^{14} kg a mass equivalent to that of a coal train longer than the distance from the earth to Moon and back. Slightly increased does of UV- B radiation reduce the amount of food phytoplankton.

Zooplankton, which feed off phytoplankton and form the second stage of the marine food web, are also affected by increased UV-B radiation, it would take less than 5- days in summer for half the zooplankton in the top meter of these waters to die from the increased radiation. UV-B also damage juvenile fish, shrimp and crab larva and other small animals in the oceans. A 16% reduction in ozone would kill 50%, 82% and 100% of andhovy larva aged 2,4 and 12 days, respectively.



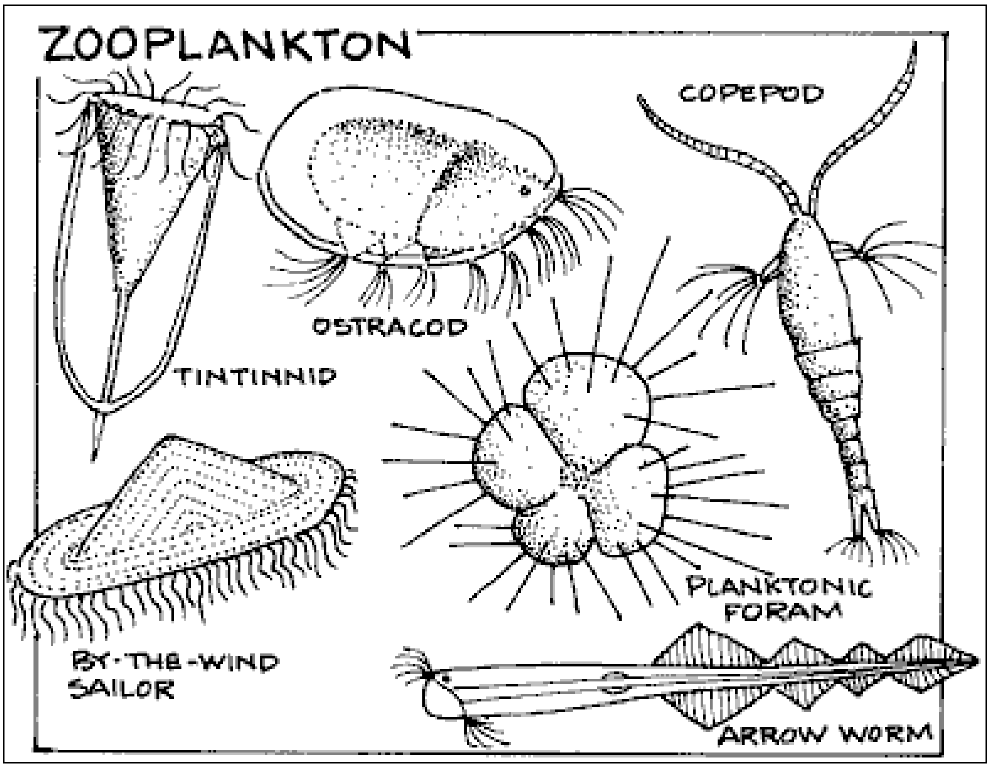


Fig 6

2. Impact on Land Plants

Tiny organism such as cynobacteria, play essential role in providing nitrogenous material for ecosystem by fixing atmospheric nitrogen dissolved in water- something that higher plants cannot do. Significant reductions in yield- of up to 25% for a 25% ozone depletion- have been found in several soybean cultivars. In a trial of 10 crop species, half the species showed yield reductions of between 5% and 90%. Wheat yields dropped by 5%, potato yields by 21% and squash by 90%. Rice, peanut and corn were not affected.

3. Increased Air Pollution

Ozone is a toxic gas, and its presence in the lower atmosphere contributes to air pollution. If stratospheric ozone diminishes, the extra UV- B reaching the troposphere will cause increased chemical reactivity and therefore greater pollution – in both urban and rural areas where nitrogen oxide levels are high enough to contribute to ozone production. UV-B stimulates the formation of very reactive radical- molecules that react rapidly with other chemicals, forming new substances. The hydroxyl radical (OX^-), for example, initiates the reactions that produce virtually every trace gas found near the Earth's surface.

In urban areas, a 10% depletion of the ozone layer is likely to results in 10- 25 % increase in tropospheric ozone. In rural areas in the mid – latitudes, a 20% reduction in stratospheric ozone is likely to cause a 10% increase in troposphere ozone. More UV-B radiation seems likely to cause global increases in atmosphere hydrogen peroxide. This is the principal chemical that oxidizes sulphur dioxide to form sulphuric acid in cloud water, making it an important part of acid rain formation.

The rate and number of chemical reactions caused by increased UV-B radiation could generate higher concentrations of solid particles in the atmosphere(aerosols).As these particles reach the lower stratosphere, they could provide a surface for the kind of large-scale destruction of ozone presently observed only above Antarctica and the Arctic.

4. Damage to materials

Plastics used outdoors will have much shorter lifetimes with even marginal increases in short-wavelength ultraviolet radiation. Polyvinyl chloride (PVC) sidings, window and door frames, pipes, gutters and trimes used in buildings are likely to degrade faster along with cable coverings, polycarbonate and acrylic glazing and coatings and unsaturated reinforced polyester outdoor panels, water tanks and pipes.

Polyurethane and polypropylene car bumpers and coatings with not last as long; nor will the high-performance composites used in aircraft construction. Nylon, polyethylene and polypropylene fishing nets, ropes and sacks used at sea will deteriorate faster as will vessel hulls made of unsaturated reinforced polyester. Faster degradation will also affect the much film and plastic used in greenhouses. In addition ,outdoor plastics such as stadium seats, tyers and hoses, polymer-based coatings.

Importance of Ozone Shield-

- The evolution of terrestrial life was inhibited.
- DNA efficiency absorbs UV light, which seriously disrupts DNA replication, causing reproductive failure and death.
- Relatively small increase in UV radiation can cause mutation during the replication process that may result in the production of cancerous cells.
- A major concern is the potential damage caused by UV light to plant, which could reduce primary productivity, therefore affect whole system.

Ozone Layer Recovery

The ozone depletion caused by human-produced chlorine and bromine compounds is expected to gradually disappear by about the middle of the 21st century as these compounds are slowly removed from the stratosphere by natural processes. This environmental achievement is due to the landmark international agreement to control the production and use of ozone-depleting substances. Full compliance would be required to achieve this expected recovery. Without the Montreal Protocol and its Amendments, continuing use of chlorofluorocarbons (CFCs) and other ozone-depleting substances would have increased the stratospheric abundances of chlorine and bromine tenfold by the mid-2050s compared with the 1980 amounts [9]. Such high chlorine and bromine abundances would have caused very large ozone losses, which would have been far larger than the depletion observed at present. In contrast, under the current international agreements that are now reducing the human-caused emissions of ozone-depleting gases, the net troposphere concentrations of chlorine- and bromine-containing compounds started to decrease in 1995. Because 3 to 6 years are required for the mixing from the troposphere to the stratosphere, the stratospheric abundances of chlorine are starting to reach a constant level and will slowly decline thereafter. With full compliance, the international agreements will eventually eliminate most of the emissions of the major ozone-depleting gases. All other things being constant, the ozone layer would be expected to return to a normal state during the middle of the next century. This slow recovery, as compared with the relatively rapid onset of the ozone depletion due to CFC and bromine-containing halons emissions, is related primarily to the time required for natural processes to eliminate the CFCs and halons from the atmosphere. Most of the CFCs and halons have atmospheric residence times of about 50 to several hundred years.

Ozone-Friendly Technology

1. Refrigeration and Air conditioning

CFSs used as cooling fluids in freezers, refrigerators, air conditioners and heat pumps make up 25 per cent of global CFC consumption. While developing countries are expected to make 30 per cent more domestic refrigerators each year. Although emissions reductions of about 45 per cent by 1994 and 50-60 per cent by 1997-98 appear feasible, completely replacing the CFCs in refrigerators with ozone-friendly substitutes is expected to take 15-20 years. Alternative refrigerants that use HCFCs hydrofluorocarbons (HCFCs) or blends of these chemicals are available now but existing equipment will have to be upgraded and replaced slowly. Some industrial refrigeration systems can switch over to alternative cooling fluids, but in most cases CFCs will be reduced by conserving and recycling existing stocks. Mobile air-conditioning units currently use CFC 12 exclusively, and it is estimated that 28 per cent of global CFC 12 production is used this way. The most viable candidate to replace CFC 12 is HFC 134a which, while not depleting ozone.

2. Foam Production

Foam production accounts for a further 25-30 per cent of global CFC consumption. Current technology, many foam manufacturers have few other options without HCFCc .Non-CFC substitutes already compete in all sectors of the foam market, with the possible exception of applications insulation, and without CFCs or HCFCs foam products could not challenge these alternatives.

3. Solvents

CFC 113, which is used as a solvent for cleaning electronic circuit boards, precision instruments, metals and clothing, represents about 16 per cent of global CFC use, of which the electronics industry accounts for about 80%. Phasing out CFC 113 depends only partly on HCFCs because many other options are available including product and process substitutes water cleaning hydrocarbon and solvent free cleaning processes.

4. Aerosol, Sterilisation and Other Uses

In 1986,CFC used in aerosol accounted for 27 percent of global CFC use.The most common substitutes are the highly flammable hydrocarbons propane , butane and pentane .Non-Flammable HCFC 22 are also possibilities but they are still very expensive .CFC's were used in medical production in 1986 – including 3000-4000 tonnes in inhalant drugs such as asthma medication .Approximately 20000-250000 tonnes of CFC12 in sterilants could be substantially curtailed by substituting existing alternatives such as steam sterilisation and formaldehyde Liquid nitrogen , along with several commercially viable techniques is an available alternative to using CFC12 for freezing delicate foods . There are already substitutes available for 90-95 percent of the use of methyl chloroforms and for most use of carbon tetrachloride.

5. Fire Fighting

Halocarbons while damaging ozone at 10 times the rate of rate of CFCs, are exceptionally effective for fire fighting because they do not conduct electricity, dissipate quickly, leave residue and do not harm human . Halon 1301, with its capacity to flood an enclosed area and extinguish a fire without harming people or property ,poses a particular dilemma.

6. Banning CFC's and other Ozone Depleting Chemicals: A Global Success Story

In the 1970 fear caused by early projection of ozone depletion moved several nations, including the United States, Sweden, Finland, Norway and Canada, to cut back on CFC emissions. In 1978, for example, the United States banned CFC use in spray cans. In 1987, the United Nations sponsored negotiations aimed at reducing global CFC production. In September of that year, 24 nations signed a treaty called the Montreal Protocol, which would cut production of 5 CFCs in hall by 1990 and freeze production of halons at 1986 levels.

This agreement paved the way for a gradual decline in CFC production in the industrial nations, but critics argued that it had too many loopholes. Like so many other population control strategies, it would only slow the rate of destruction, not stop it. In March of 1988, DuPont, a major producer of CFCs called for a total worldwide ban on CFC production-when only two weeks earlier it had said that it would not support a ban. In London, where in June 1990 they reached a new agreement. This treaty was signed by 93 nations and called for complete elimination of CCFs and halons by year 2000, if substitutes were available by then. The signatories also agreed to phase out other ozone depletion chemicals.

In 1992, a team of 40 scientists announced record – high concentrations of chlorine monoxide in air above New England and Canada. If chlorine levels contribute to climb, chances are good that the Arctic ozone hole will begin to appear with great regularity, exposing Canada and the parts of United States, Europe and Asia to dangerous level of UV radiation. In 1992, the nation of the world met in Copenbagen to sign another agreement calling for acceleration of the phase out of CFCs, CCl_4 and another ozone depleting chemicals within 4-9 years. Although progress has been impressive, police are finding that CFCs are being illegally imported into the United States in massive quantities.

Key Concepts: As scientific evidence on ozone depletion accumulated, the nations of the world tightened restriction on production of ozone depleting chemicals. Three international treaties have already been signed to eliminate the production of ozone- depleting compounds, and progress towards meeting these goals has been very impressive.

Table 1: Estimated End of Use Dates Worldwide for Controlled CFCs

	Sector	Date
Refrigerstion		1989–2015
	Domestic	1995–1999
	Commercial/ Retail	1989- 1999
	Cold storage	1989-2005
	Comfort air condition	1991-2015
	Industrial	1989-2010
	Heat pump	1989-2005
	Mobile air conditioning	1994-2010
Flexible foams		1989-1993
Rigid foams solvents		1989-1995
	Electronic	1995-1997
	Metal cleaning	1993-1996
	Dry cleanin	1993-1995
Miscellaneous	Aerosols (non-medicals)	1990-1995
	Aerosols (medicals)	1995-2000
	Sterilisation	1990-1995

7. Recycling and Destroying CFCs and Halons

Government intervention will probably be necessary- in developing and developed nations alike – if existing CFCs and holons are to be recovered and recycled. Economic or regulatory incentives are inadeqqate, the market has not yet accepted recycled products purity and standards specifications still demand the use of new CFCs and halons, and government regulations restrict the collection and transportation of used CFCs. Recovering and recycling refrigerants, such as CFCs 12 is difficult. Recovery equipment is little advertised and expensive, and minimum quantities quaoted by CFC producers represent perhaps a whole year's use refrigerant for a single dealer.

To develop a suitable national and international recycling service will almost certainly require economic incentives or legislative action. In the meantime, conserving refrigerant by avoiding unnecessary leaks when manufacturing, repairing and testing equipment is essential – and has the added incentive of saving money. There is also a strong need for systematic observation of all chlorine and bromine containing chemicals that can contribute to the chlorine and bromine loading of the atmosphere and hence to ozone depletion and global warming.

8. Financial Benefits of Finding Substitutes

The financial benefits of reducing CFCs and halons use undoubtedly outweight the coasts of these reductions. Clearly there will also be significant health, agriculture and environmental advantages, but it is difficult – if not impossible – to put a price on the number of cases of cancer avoided, or the ecosystems left untouched by damaging UV-B radiation. The first 50% reduction in global CFCs use will require modest new capital investment. Estimates for remaining reductions vary widely and depend on future availability of CFC substitutes, their price, safety and energy efficiency, and the costs of re- engineering equipment and products. Substitution will lead to some savings. The hydrocarbons replacing CFCs in aerosols are cheaper to produce. Many CFC solvents in electronics can be eliminated simply through better, less wasteful housekeeping procedures. Some blends of refrigerant substitutes make refrigeration system more energy efficient, which would benefit ant country planning increased refrigerator use, especially if this use had to be supported by expanding the electrical power supply infrastructure. The Economic Assessment Panel established under the Montreal Protocol has warned that a rapid phase out of some CFCs over a period of much less than 10 years.

International Efforts to Protect Ozone Layer

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 focused in 1977. In 1985 in an article published in the prestigious science journal, “Nature” by Dr. Farman pointed out "the Antarctica Ozone hole". His findings were confirmed by Satellite observations and offered the first proof of severe ozone depletion and stirred the scientific community to take urgent remedial actions in an international convention held in Vienna on March 22, 1985. This resulted in an international agreement in 1987 on specific measures to be taken in the form of an international treaty known as the Montreal Protocol.

Montreal Protocol

In 1985 the Vienna Convention established mechanisms for international co-operation in research into the ozone layer and the effects of ozone depleting chemicals (ODCs). 1985 also marked the first discovery of the Antarctic ozone hole. On the basis of the Vienna Convention, the Montreal Protocol on Substances that Deplete the Ozone Layer was negotiated and signed by 24 countries and by the European Economic Community in September 1987. The Protocol called for the Parties to phase down the use of CFCs, halons and other man-made ODCs. The Montreal Protocol represented a landmark in the international environmentalist movement. For the first time whole countries were legally bound to reducing and eventually phasing out altogether the use of CFCs and other ODCs. Failure to comply was accompanied by stiff penalties. The original Protocol aimed to decrease the use of chemical compounds destructive to ozone in the stratosphere by 50% by the year 1999. The Protocol was supplemented by agreements made in London in 1990 and in Copenhagen in 1992, where the same countries promised to stop using CFCs and most of the other chemical compounds destructive to ozone by the end of 1995. Fortunately, it has been fairly easy to develop and introduce compounds and methods to replace CFC compounds. In order to deal with the special difficulties experienced by developing countries it was agreed that they would be given an extended period of grace, so long as their use of CFCs did not grow significantly. China and India, for example, are strongly increasing the use of air conditioning and cooling devices. Using CFC compounds in these devices would be cheaper than using replacement compounds harmless to ozone. An international fund was therefore established to help these countries introduce new and more environmentally friendly technologies and chemicals. The depletion of the ozone layer is a worldwide problem which does not respect the frontiers between different countries. It can only be affected through determined international co-operation.

Australian Chlorofluorocarbon Management Strategy It provides a framework for the responsible management and use of CFCs in Australia. The strategy recognizes some continuing need for these chemicals in pharmaceutical and laboratory uses, but commits to their gradual phasing out.

Environmental Protection (Ozone Protection) Policy 2000 This WA policy aims to minimize the discharge of ozone-depleting substances into the environment, and has been extended to cover use of alternative refrigerants (where relevant). This has been done to prevent current stocks of ozone-depleting substances from being released to the atmosphere by trade’s people that are not accredited, or with inadequate training and/or equipment working on systems that contain these substances.

United Nations Environment Programme

UNEP has published several assessments of the environmental effects of ozone depletion (United Nations Environment Programme, 1998; World Meteorological Organization, 2002).

Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 (and associated regulations and amendments)

Ozone protection and synthetic greenhouse gas management act, 1989 was implemented by the Commonwealth Government to meet its commitments under the Montreal Protocol.

Ultraviolet index forecast

The Bureau of Meteorology has developed a model to predict the amount of ultraviolet exposure and the times of day at which it will occur for 45 WA locations. It is designed to help people minimize their exposure to dangerous levels of ultraviolet radiation.

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