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OZONE LAYER DEPLETION –A SAFETY LAYER CONVERTED INTO DANGEROUS ZONE

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ABSTRACT

There are many situations where human activities have significant effects on the environment. Ozone layer damage is one of them. The objective of this paper is to review the origin, causes, mechanisms and bio effects of ozone layer depletion as well as the protective measures of this vanishing layer. Ozone layer depletion, is simply the wearing out (reduction) of the amount of ozone in the stratosphere. Unlike pollution, which has many types and causes, Ozone depletion has been pinned down to one major human activity. Industries that manufacture things like insulating foams, solvents, soaps, cooling things like Air Conditioners, Refrigerators and 'Take-Away' containers use something called chlorofluorocarbons (CFCs). These substances are heavier than air, but over time, (2-5years) they are carried high into the stratosphere by wind action.

Keywords: Chloro Flouro Carbons, ODS, Ozone Layer,

I. INTRODUCTION

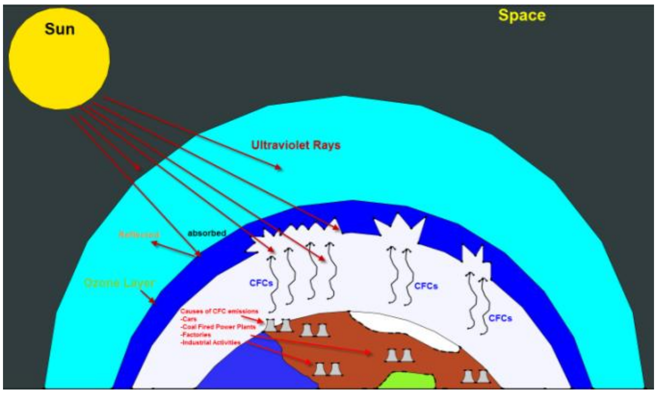
The ozone layer is a belt of naturally occurring ozone gas that sits 9.3 to 18.6 miles (15 to 30 kilometers) above Earth and serves as a shield from the harmful ultraviolet B radiation emitted by the sun. Ozone is a highly reactive molecule that contains three oxygen atoms. It is constantly being formed and broken down in the high atmosphere, 6.2 to 31 miles (10 to 50 kilometers) above Earth, in the region called the stratosphere. Today, there is widespread concern that the ozone layer is deteriorating due to the release of pollution containing the chemicals chlorine and bromine. Such deterioration allows large amounts of ultraviolet B rays to reach Earth, which can cause skin cancer and cataracts in humans and harm animals as well.

Extra ultraviolet B radiation reaching Earth also inhibits the reproductive cycle of phytoplankton, single-celled organisms such as algae that make up the bottom rung of the food chain. Biologists fear that reductions in phytoplankton populations will in turn lower the populations of other animals. Researchers also have documented changes in the reproductive rates of young fish, shrimp, and crabs as well as frogs and salamanders exposed to excess ultraviolet B.

1.1 Causes of Ozone Depletion:

Scientific evidence indicates that stratospheric ozone is being destroyed by a group of manufactured chemicals, containing chlorine and/or bromine. These chemicals are called "ozone-depleting substances" (ODS).

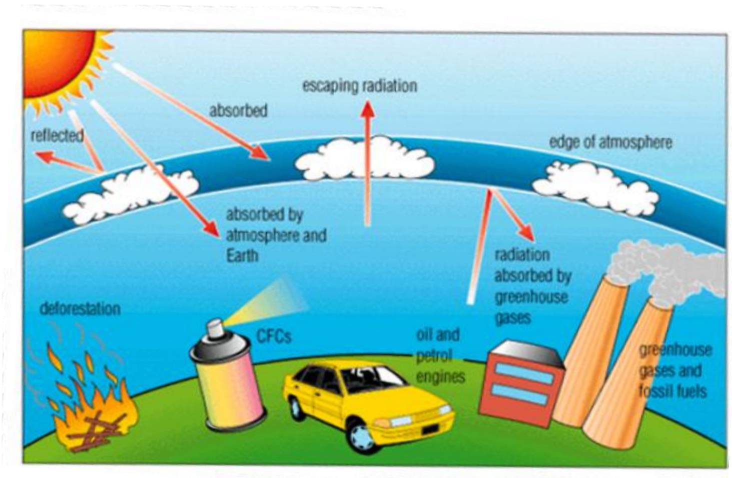
ODS are very stable, nontoxic and environmentally safe in the lower atmosphere, which is why they became so popular in the first place. However, their very stability allows them to float up, intact, to the stratosphere. Once there, they are broken apart by the intense ultraviolet light, releasing chlorine and bromine. Chlorine and bromine demolish ozone at an alarming rate, by stripping an atom from the ozone molecule. A single molecule of chlorine can break apart thousands of molecules of ozone.



What's more, ODS have a long lifetime in our atmosphere — up to several centuries. This means most of the ODS we've released over the last 80 years are still making their way to the stratosphere, where they will add to the ozone destruction.

The main ODS are chlorofluorocarbons (CFCs), hydrochlorofluorcarbons (HCFCs), carbon tetrachloride and methyl chloroform. Halons (brominated fluorocarbons) also play a large role. Their application is quite limited: they're used in specialized fire extinguishers. But the problem with halons is they can destroy up to 10 times as much ozone as CFCs can. For this reason, halons are the most serious ozone-depleting group of chemicals emitted in British Columbia.

Hydrofluorocarbons (HFCs) are being developed to replace CFCs and HCFCs, for uses such as vehicle air conditioning. HFCs do not deplete ozone, but they are strong greenhouse gases. CFCs are even more powerful contributors to global climate change, though, so HFCs are still the better option until even safer substitutes are discovered.



1.2 Ozone Layer Depletion

1.2.1 Ozone Oxygen Cycle

Three forms of oxygen (allotropes) are involved in ozone-oxygen cycles.

a) Oxygen atom or atomic oxygen (O)

b) Oxygen molecules - O_2 or diatomic oxygen

c) Ozone gas - O_3

O_3 is formed in stratosphere when O_2 molecules photo dissociate after absorbing an u.v. light (photon) whose wavelength is shorter than 240nm. (Nano- billionth of unit)

$$O_2 + \frac{u.v.\ radiation}{240nm} 20\ or\ 0 + 0 \quad \text{(This produces 2 oxygen atoms)}$$
$$(Shorter\ than)$$

This atomic oxygen then combines with another O_2 molecule to produce O_3 molecules.

$$O + O_2 \rightarrow O_3\ (Ozone)$$

Ozone O_3 molecule absorbs u.v. light whose wavelength in between 24004310nm. And splits in to "O" atom and O_2 molecule.

$$O_3 \frac{u.v.\ radiation}{240\ \&\ 310nm} O + O_2 (molecule)$$
$$(between)$$

This oxygen atom then joins up with another O_2 molecule and O_3 (ozone) is formed. (regenerated).

Note – this is a continuous process which terminates when an oxygen atom recombines with O_3 molecule instead of O_2 molecule to form $2\,O_2$ molecule.

1.2.2 Ozone-layer depletion (process) or mechanisms

The overall amounts of O_3 in stratosphere is determined by a balance between photochemical production and recombination. $O_3(ozone)$ can be destroyed by a no. of free radicals. Such as –

Nitric oxide radical(No)	Natural and anthropogenic
Hydroxyl radicals(OH)	Natural and anthropogenic
Atomic chlorine (Cl)	Sources but human activities
Atomic Bromine (Br)	has dramatically increased the levels of Cl and Br.

These elements are found in certain stable organic compounds, especially chlorofluorocarbons $(cFe's)$ trands home Freon and bromofluorocarbons known as Halons.

1) $CFC - 11(CFCl_3) - 1.0 - O_3$ depleting Potential- As coolant in refrigerator & air conditioning.

2) $CFC - 12(CF_2Cl_2) - .9 - 1 - 9$ - Refrigeration, foam, food freezing, heat detectors etc.

3) Halon $(1301)(C.Br.F_3) - 10.0 - 13.2$ - Fir fighting

4) Halon $(1211)(C\,Cl.Br.F_2)2.2 - 3.0$ - India stopped production of both.

$CFC's$ reach stratosphere without being destroyed in the troposphere due to their low reactivity.

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Once they reach in the stratosphere, the Cl and Br atoms are liberated from the parent compound by the action of u.v. light can destroy ozone molecules.

$$CFCl_3 + hD \rightarrow CFCl_2 + Cl$$

(h' is plank's constant & D' is frequency of EMR)

Free Cl and Br atoms can destroy O_3 molecules through a variety of catalytic reactions.

Free chlorine (Cl) atom reacts with O_3 molecule which splits in to 'O' atom O_2 molecule.

The result is that free Cl combines with this 'O' atom and destroy O_3.

$$Cl + O_3 \rightarrow Cl_0 + O_2 \rightarrow \text{molecule}$$

Chlorine monoxide

$$Clo + O_3 \rightarrow Cl + 2O_2$$

$$Cl + O_3 \rightarrow Clo + O_2$$

$$Clo + O_3 \rightarrow Cl + 2O_2 \ldots\ldots\ldots\ldots\ldots\text{so on.}$$

A single Cl atom would keep on destroying O_3 for up to two years.

Dr. F. Sherwood Rowland predicted that each Cl atom can destroy, 1,00,000 ozone molecules by such cyclic process.

1.2.3 Depletion of ozone layer (ozone hole) over Antarctic region

Ozone hole was first noticed by a research group from British Antretic survey scientist Joseph Forman, Brian Gardiner and Janathan Shanklin.

Satellite measurement showing massive depletion of ozone (40% loss in the spring time) around the south pole.

The polar regions are more prone to ozone depletion because of the formation of polar vortex (a huge air mass, trapped for a long time due to blowing of wing in a circular patter at polar region), which collects dust particles, $CFC's$ and other components.

Polar regions get a much larger variations in sunlight than anywhere else and during 3 months of winter spend most of time in dark without solar radiation and temp reach close around – 80^{0}C cause cloud formation are known as polar stratospheric clouds.

These polar stratospheric clouds are composed of the ice crystals.

The $CFC's$ brought from lower levels/regions get attached to the tiny ice crystals.

When the sun rises after a long night (Antarctica spring) sun light triggers a massive demotion of ozone by C/o.

The vast demotion of ozone at that level in the stratosphere makes the ozone layer very then.

This is called "ozone hole"

"The ozone hole is defined geographically as the area wherein the total ozone amount is less than 220 dobson unit."

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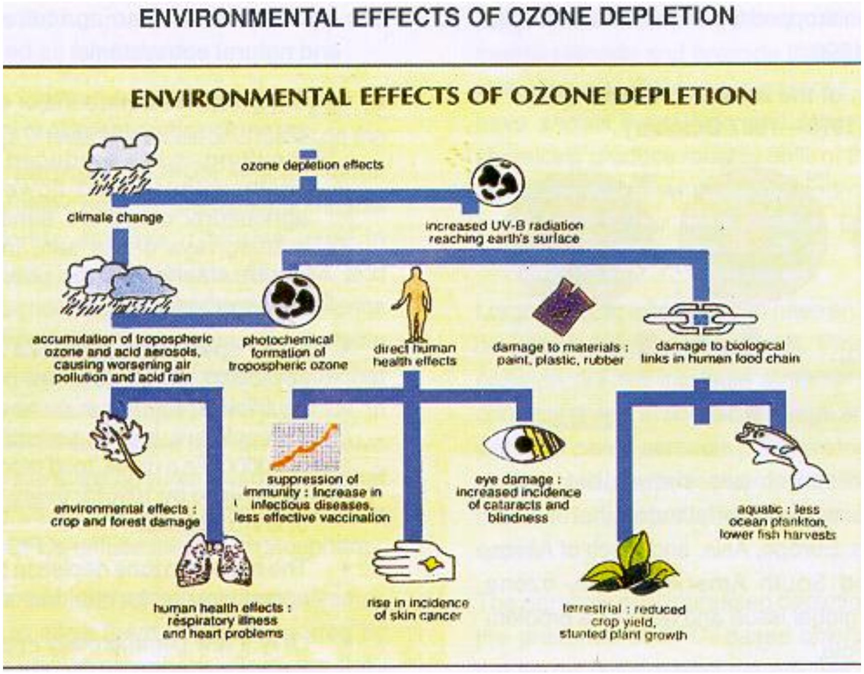
1.2.4 Control Ozone depletion

1.2.4.1 Limit private vehicle driving

A very easy way to control ozone depletion would be to limit or reduce the amount of driving as vehicular emissions eventually result in smog which is a culprit in the deterioration of the ozone layer. Car pooling, taking public transport, walking, using a bicycle would limit the usage of individual transportation. It would be a great option to switch to cars/vehicles that have a hybrid or electric zero-emission engine.



1.2.4.2 Use eco-friendly household cleaning products

Usage of eco-friendly and natural cleaning products for household chores is a great way to prevent ozone depletion. This is because many of these cleaning agents contain toxic chemicals that interfere with the ozone layer. A lot of supermarkets and health stores sell cleaning products that are toxic-free and made out of natural ingredients.

1.2.4.3 Avoid using pesticides

Pesticides may be an easy solution for getting rid of weed, but are harmful for the ozone layer. The best solution for this would be to try using natural remedies, rather than heading out for pesticides. You can perhaps try to weed manually or mow your garden consistently so as to avoid weed-growth.

1.2.4.4 Developing stringent regulations for rocket launches

The world is progressing in scientific discoveries by leaps and bounds. A lot of rocket launches are happening the world over without consideration of the fact that it can damage the ozone layer if it is not regulated soon. A study shows that the harm caused by rocket launches would outpace the harm caused due to CFCs. At present, the global rocket launches do not contribute hugely to ozone layer depletion, but over the course of time, due to the advancement of the space industry, it will become a major contributor to ozone depletion. All types of rocket engines result in combustion by products that are ozone-destroying compounds that are expelled directly in the middle and upper stratosphere layer – near the ozone layer.

1.2.4.5 Banning the use of dangerous nitrous oxide

Due to the worldwide alarm caused by a study in the late 70s about the alarming rate at which the ozone was being depleted, nations around the globe got together and formed the Montreal Protocol in the year 1989 with a strong aim to stop the usage of CFCs. However, the protocol did not include nitrous oxide which is the most fatal chemical that can destroy the ozone layer and is still in use. Governments across the world should take a strong stand for banning the use of this harmful compound to save the ozone layer.

1.3 Montreal Protocol

The Montreal Protocol on substances that deplete the ozone layer is a landmark international agreement that was designed to reduce the production and consumption of ozone depleting compounds $(CFC's)$ carbon tetrachloride, methyl chloroform etc.

This protocol was signed on 16 September 1987 and came in to force on 1 January 1989.

In 1995 the United Nations named September 15 the International day for the protection of the ozone layer. The Montreal Protocol includes a unique adjustment provision that enables the Parties to the Protocol to respond quickly to new scientific information and agree to accelerate the reductions required on chemicals already covered by the Protocol. These adjustments are then automatically applicable to all countries that ratified the Protocol. Since its initial adoption, the Montreal Protocol has been adjusted six times. Specifically, the Second, Fourth, Seventh, Ninth, Eleventh and Nineteenth Meetings of the Parties to the Montreal Protocol adopted, in accordance with the procedure laid down in paragraph 9 ofArticle 2 of the Montreal Protocol, certain adjustments and reductions of production and consumption of the controlled substances listed in the Annexes of the Protocol. These adjustments entered into force, for all the Parties, on 7 March 1991, 23 September 1993, 5 August 1996, 4 June 1998, 28 July 2000 and 14 May 2008, respectively.

The Parties to the Montreal Protocol have amended the Protocol to enable, among other things, the control of new chemicals and the creation of a financial mechanism to enable developing countries to comply. Specifically, the Second, Fourth, Ninth and Eleventh Meetings of the Parties to the Montreal Protocol adopted, in accordance with the procedure laid down in paragraph 4 of Article 9 of the Vienna Convention, four Amendments to the Protocol – the London Amendment (1990), the Copenhagen Amendment (1992), the Montreal Amendment (1997) and the Beijing Amendment (1999). Unlike adjustments to the Protocol, amendments must be ratified by countries before their requirements are applicable to those countries. The London, Copenhagen, Montreal and Beijing Amendments entered into force on 10 August 1992, 14 June 1994 10 November 1999 and 25 February 2002 respectively, only for those Parties which ratified the particular amendments.

In addition to adjustments and amendments to the Montreal Protocol, the Parties to the Protocol meet annually and take a variety of decisions aimed at enabling effective implementation of this important legal instrument. Through the 22nd Meeting of the Parties to the Montreal Protocol, the Parties have taken over 720 decisions. The decisions adopted by the Parties are included in the reports of the Meetings of the Parties and, along with other documents considered during the meetings, can be accessed under the meetings' links.

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