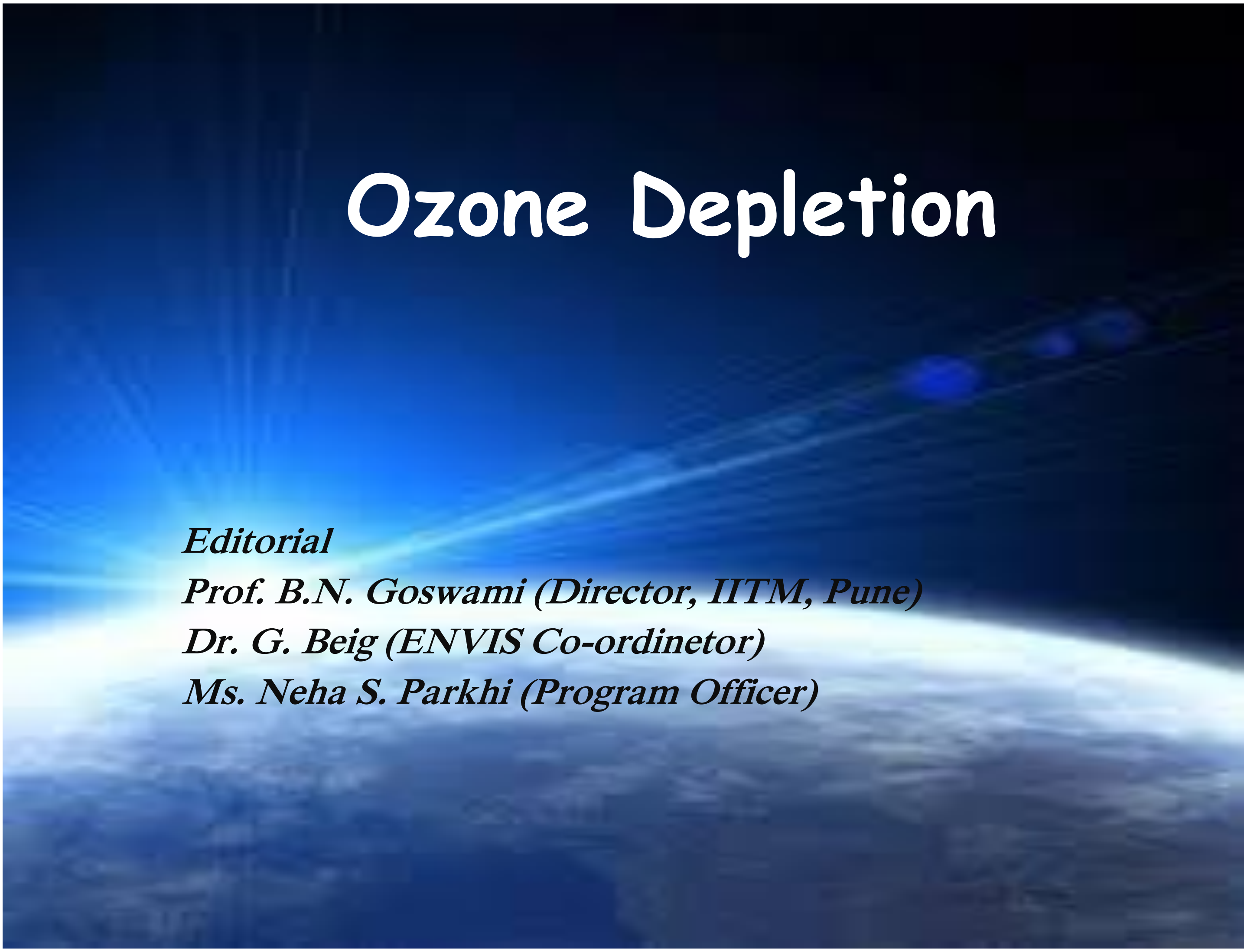
ENVIS- IITM NEWSLETTER

The Air Quality: A Global Challenge



Ozone Depletion

Editorial

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EDITORIAL

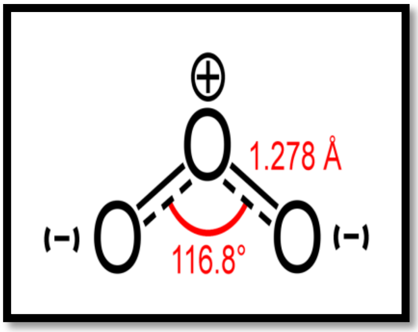
ENVIS-IITM centre deals with the very important and sensitive component of the environment "The Air we breathe" and related challenges. In our last series of newsletters under the heading "Air Pollution Chemistry" we have taken a brief knowledge of Earth system, interdependence of different components of environment, the atmosphere, air pollution, criteria air pollutants etc. Alteration in the natural composition of the air can harm not only the health of human being but also it affects the health of environment which will eventually end up with the imbalance in the functioning of Earth System resulting in to the local, regional and global challenges. ENVIS-IITM is introducing a new series "The Air Quality: A Global Challenge", where we will discuss about various local, regional and global impacts resulted due to the atmospheric pollution along with their causes and effects. In the first parts of the series we have covered the regional and global problems Acid rain and global warming along with its effects.

Present issue will deal with the problem of Ozone depletion, different mechanisms responsible for observed decrease in stratospheric ozone all over the globe and at the Earth's Polar Regions. We hope our attempt to convey complicated scientific information in simple language will help to create awareness amongst the common public which is the first step towards safeguarding our environment.

Inside the Issue

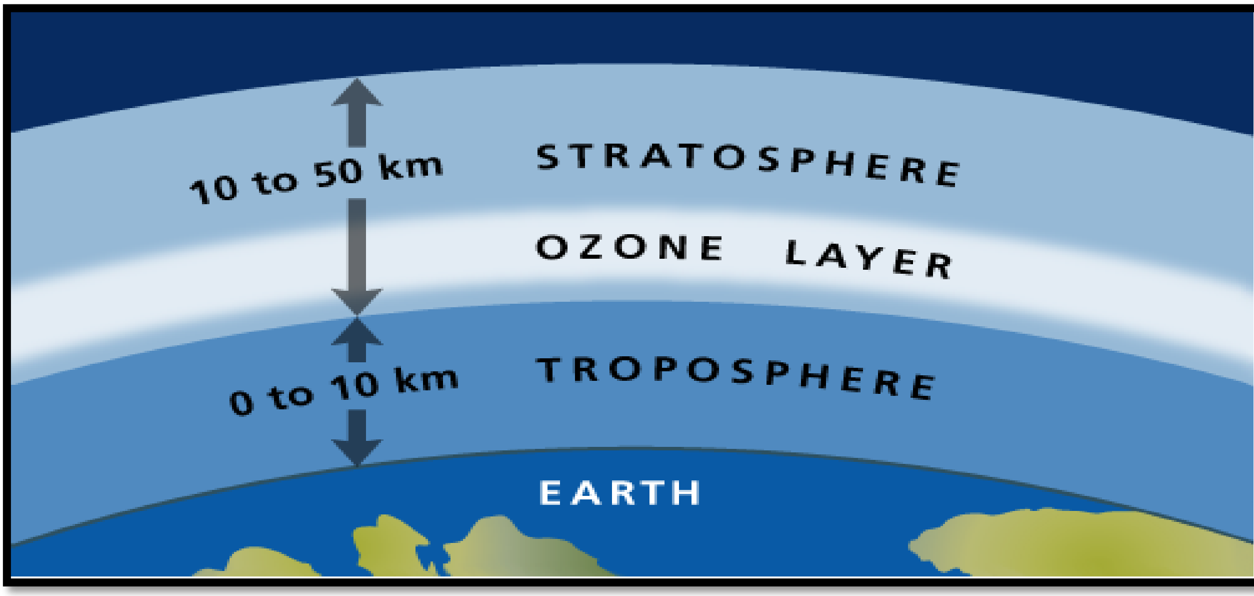
- *What is Ozone layer why it is important*
- *Ozone cycle*
- *Ozone Depletion*
- *Measure of Ozone depletion*
- **Is the Ozone Hole is a real Hole with No O_3 in Stratosphere?**
- *Effect of ozone depletion and Montreal protocol*

What is Ozone Layer

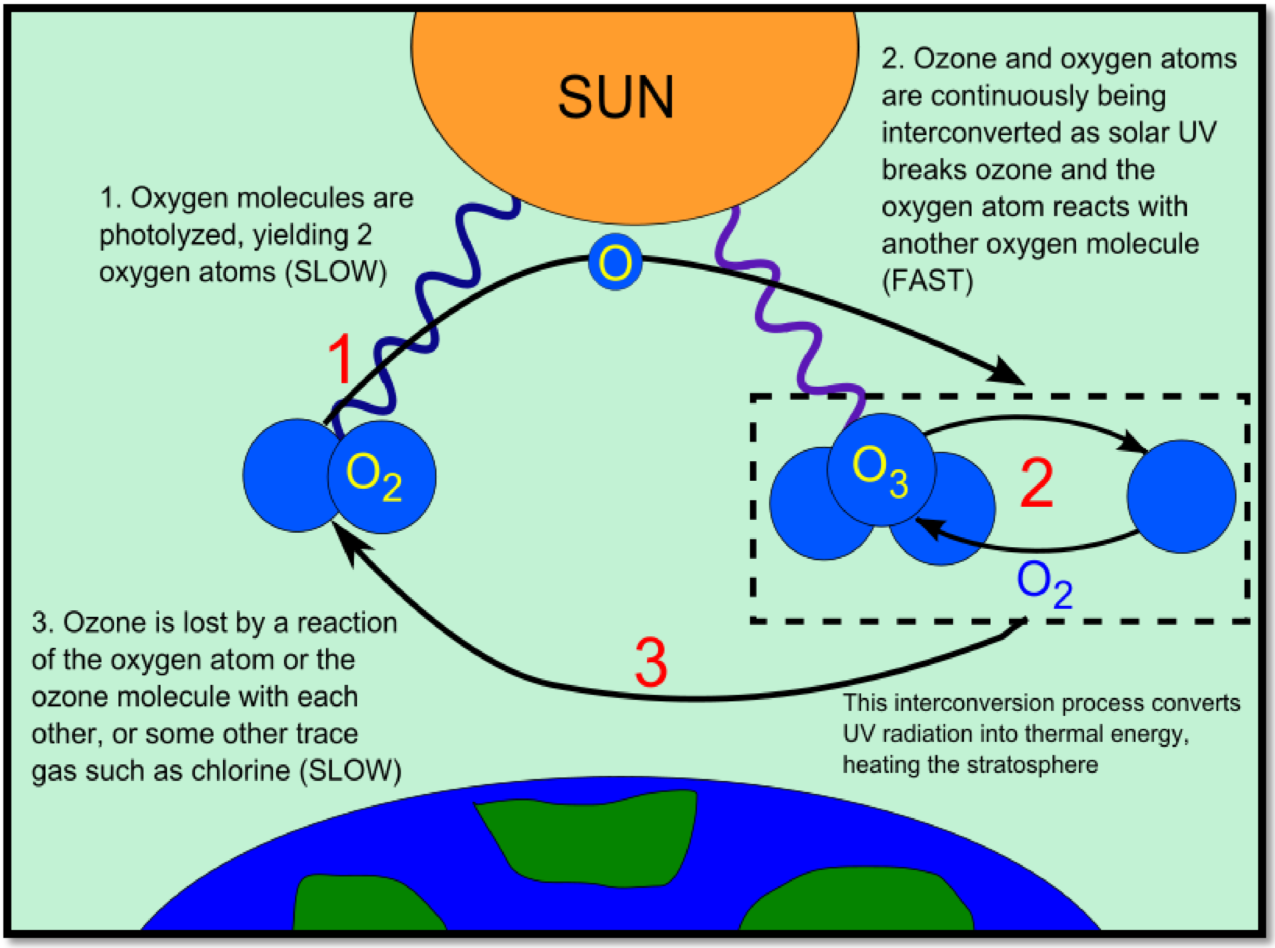


Ozone is a tri-atomic molecule, constituting of three oxygen atoms. **It is blue in color and has a strong odor.** ***It formed from di-oxygen by the action of Ultraviolet radiation and atmospheric electrical charges.***

Most of the atmospheric ozone is concentrated in a layer in the stratosphere, about 15-30 km above the Earth's surface. This region is known as "Ozone Layer". **Ozone layer absorbs biologically harmful ultraviolet (UV) radiation called "UVB" coming from the sun. And hence protect us from the harmful ill effects of UVB like skin cancer, cataracts etc.** The concentration of Ozone varies naturally with sunspots, the seasons and latitude. However, in the stratosphere ozone molecules are constantly formed and destroyed and hence its total amount remains relatively stable. It has been proved by the scientist that each natural reduction in the ozone levels has been followed by a recovery.



Ozone Cycle



Ozone cycle is a continuous process going on in to the Stratosphere. It involves three forms of Oxygen.

1. Oxygen atom (O : Oxygen atom)
2. Oxygen gas (O_2 :Di-atomic oxygen)
3. Ozone gas (O_3: Tri-atomic oxygen)

Ozone is formed in the stratosphere when oxygen molecules photodissociate after absorbing an ultraviolet photon whose wavelength is shorter than 240 nm.

O_2 + <u>photon</u> (radiation < 240 nm) → 2 O

The atomic oxygen radicals then combine with separate O2 molecules to create two O3 molecules.

$O + O_2 + M \rightarrow O_3 + M$

Where, "M" denotes the third body that carries off the excess energy of the reaction. These ozone molecules absorb UV light between 310 and 200 nm, following which ozone splits into a molecule of O_2 and an oxygen atom.

O_3 (radiation between 310-200nm) → O_2 + O

The latter reaction is catalyzed by the presence of certain free radicals, of which the most important are hydroxyl (OH), nitric oxide (NO) and atomic chlorine (Cl) and bromine (Br).

The oxygen atom then joins up with an oxygen molecule to regenerate ozone. Hence, the overall amount of ozone in the stratosphere is determined by a balance between photochemical production and recombination.

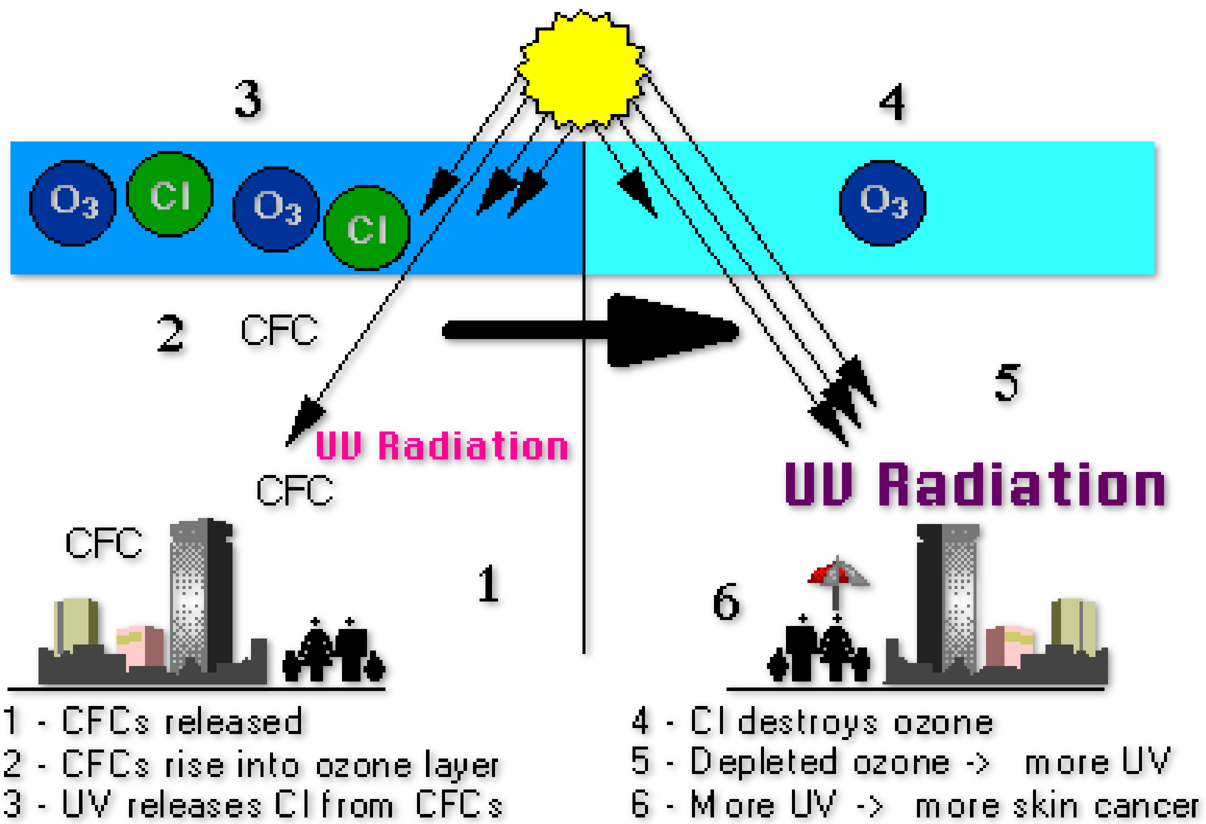
Ozone Depletion

In the recent period scientific evidences showed that the Ozone layer which we can call as a life protecting shield is being depleted well beyond the changes due to natural processes. The O3 can be destroyed by a number of Free radical catalysts. **The most important of which are the Hydroxyl radical (OH·), the nitric oxide radical (NO·), atomic chlorine ion (Cl·) and atomic bromine ion (Br·).**

These species have an unpaired electron and are thus extremely reactive. All these species have natural as well as manmade sources. It has been found that at present time, most of the OH· and NO· in the stratosphere is of natural origin, where as human activity has dramatically increased the levels of chlorine and bromine. These elements are found in certain stable organic compounds such as chlorofluorocarbons (CFCs), hydro chlorofluorocarbons (HCFCs), halons, methyl bromide, carbon tetrachloride, methyl chloroform etc. They are known as **Ozone Depleting Substances (ODS)**. ODS are stable, nonflammable, low toxic and inexpensive to produce, hence, over the 50 years these ODS were used by human extensively as solvent, industrial chemical, refrigerants, fire extinguishing agent, soil fumigant etc. All of these substances have a very long atmospheric life time and generally very stable in the troposphere. There are no natural processes that remove the above mentioned human made substances from the lower atmosphere. Over a time winds drive these substances into the stratosphere. These substances only degrade in the intense ultraviolet light in the stratosphere, hence, when they reach stratosphere exposure to strong UV radiation breaks them down and they releases atomic chlorine or bromine, which then deplete ozone.

Large increase in stratospheric chlorine and bromine has disturbed the balance between the photochemical production and recombination reactions occurring in the Ozone cycle. As a result of which they are removing ozone faster than natural ozone creation reactions can and hence ozone level fall.

1 chlorine atom can destroy over 100,000 ozone molecules before it is removed from the stratosphere.



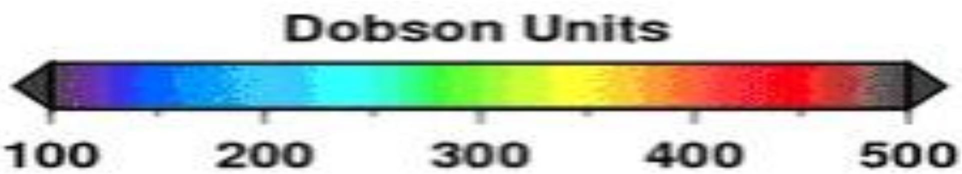
Depletion of the global ozone layer began gradually in the 1980s and reached a maximum of about 5% in the early 1990s. The depletion has lessened since then and now it is about 3.5% averaged over the globe. However, the average depletion exceeds the natural year o year variations of global total ozone. The ozone loss is very small near the equator and increases with latitude towards the poles. The larger polar depletion is observed in the late winter or early spring each year.

Antarctic Ozone Layer: Although ODS are present throughout the stratospheric ozone layer, the observed severe depletion of the Antarctic ozone layer known as Ozone hole is a result of the special atmospheric and chemical conditions that exist there and nowhere else on the globe. The very low winter temperature in the Antarctic stratosphere cause polar stratospheric clouds (PSCs) to form. Reactions that take place on polar stratospheric clouds (PSCs) play an important role in enhancing ozone depletion

Arctic Ozone Layer: Significant depletion of the Arctic ozone layer has been observed in the late winter and early spring period, 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 over Antarctic stratosphere does not occur in the Arctic.

Tibet Ozone Layer: In 2006 considerable ozone depletion was detected over Tibet. Again in 2011 Ozone hole appeared over the mountainous regions of Tibet, Xinjiang, Qinghai and the Hindu Kush, however, it is far less intense than that of Arctic and Antarctic

Measure of Ozone Hole



The Ozone hole is not measuered in terms of Ozone concentration, whereas, it is measured in terms of Reduction in total column ozone, above a point on the Earth's surface, which is expressed in Dobson units, abbreviated as "DU". The marked decrases in the column Ozone compared to early 1970s and before have been observed using instruments such as the Total Ozone Mapping Spectrometer (TOMS).

Is the Ozone Hole is a real Hole with No O_3 in Stratosphere?

There is a common misconception that the Ozone hole is a really a hole in the ozone layer in the stratosphere. When the ozone hole occurs, the ozone in the lower stratosphere is destroyed. The upper stratosphere is less affected, hence, amount of ozone over the continent decreases by 50% or even the more. But the ozone does not disappear through the layer, nor is there a uniform thinning of the ozone layer. The Hole is a Depression, not in the sense of a hole in the live protective shield.

Ozone depletion results in the increased surface UVB levels, which could lead to skin cancer, cataracts; it may results in increased tropospheric ozone which is considered as Bad ozone having adverse effects on human health because of its strong oxidant properties, it can also affect other forms of life including crops. Ozone depletion is also linked with the global warming hence climate change. IPCC concluded that observed ozone losses over the past two decades have caused a negative forcing of the surface-troposphere system. Moreover, ODS are Greenhouse Gases, the increased in their concentration have produced 0.34+-0.03W/m2 of radioactive forcing.

Observed and projected decreases in ozone have generated worldwide concern leading to adoption of the Montreal Protocol that bans the production of CFCs, halons, and other ozone-depleting substances.

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