ENVIS NEWSLETTER

Acid Rain and Atmospheric Pollution

Indian Institute of Tropical Meteorology, Pune

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Editors Desk:

In our previous newsletter issue (Vol 6, Issue 3) we had provided some knowledge on understanding the basics of air pollution science. The issue covered the details regarding the formation of the most important toxic pollutant "OZONE" and its effect on our atmosphere. Simple and interesting experiment on ground level ozone testing was also provided for the voracious readers. In continuation with the previous issue we would now like to attract the attention of our readers on the most important everyday issue related to our health.

In the current issue we would like to enlighten our readers on the effects that tropospheric Ozone and general air pollution cause on our health. Further we appreciate the views of the reader/user groups about this newsletter, so that we can enrich it further. We also encourage and invite relevant articles, news, events on pollution related topic for publication in newsletter in future.

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CONTENTS

ENVIS TEAM

Programme Officer

Aparna Deshpande

Technical Support

Shradha Kale

Anil Pandey

Atmospheric Ozone: A Brief Overview

Ozone is exceedingly rare in our atmosphere, averaging about 3 molecules of ozone for every ten million air molecules. Nonetheless, atmospheric ozone plays vital roles and is crucial for sustaining life on Earth. Ozone is mainly found in two regions of the Earth's atmosphere. Most ozone (about 85-90%) resides in a layer between approximately 15 and 50 kilometers above the Earth's surface, in the region of the atmosphere called the stratosphere. This stratospheric ozone is commonly known as the "ozone layer." The remaining ozone is in the lower region of the atmosphere, the troposphere, which extends from the Earth's surface up to about 15 kilometers. While the ozone in these two regions is chemically identical (both consist of three oxygen atoms and have the chemical formula "O_3"), the ozone molecules have very different effects on humans and other living things depending upon their location, where it resides. Depending on where it resides, it can protect or harm life on Earth. Stratospheric ozone (ozone at the altitude about 15 km from the Earth) acts as a shield to protect Earth's surface from the sun's harmful ultraviolet (UV) radiation. In the air we breathe, ozone is a harmful pollutant that causes damage to lung tissue and plants. In this way, we can say that ozone may be 'good' or 'bad' depending on where it resides. *The good ozone (stratospheric ozone) is decreasing in our protective shield and the bad ozone is increasing in the air we breathe.* Thus, ozone is playing a dual role in the atmosphere. Therefore, an upsetting in the ozone balance can have serious consequences for sustaining life on Earth. With these dual aspects of ozone come two separate environmental issues, controlled by different forces in the atmosphere. In the troposphere, there is concern about increases in ozone. Low lying ozone is a key component of smog, a familiar problem in the atmosphere of many cities around the world.

In view with the topic of this issue the present article is focused on particularly “bad ozone” which is increasing in the air we breathe, that can affect the health of humans, animals and plants. Traditional air pollutants, for example, carbon monoxide, nitrogen dioxide, sulfur dioxide, etc are emitted from their respective sources. These emitted pollutants are called primary air pollutants. No doubt, these pollutants are harmful to human health. Often the most deleterious air pollutants are not those emitted directly by sources but those formed in the atmosphere by chemical reactions, such as ozone and organic nitrates. In the analysis of air pollution it is

therefore essential that the chemical processes taking place in the atmosphere be understood. Secondary air pollutants such as bad ozone (hereafter ozone), organic nitrate, formaldehyde, hydrocarbon, proxy acetylnitrate, etc are formed in the air by chemical reactions among primary air pollutants that are emitted directly into the urban as well as rural environments. Most of the secondary air pollutants are carcinogenic, which are responsible for cancer. These pollutants are also called photochemical air pollutants. Urban environment consist of thousands of such chemical compounds, at present very few are identified and a very few are being monitored at very few locations on the Earth. Primary pollutants are mostly caused by anthropogenic activities associated with energy production and utilization. *As a pollutant, ozone is undesirable on the Earth surface.*

Ozone is a secondary air pollutant, its formation take place through the chemical mechanism by its precursors like nitrogen oxides, carbon monoxide, hydrocarbon and methane. Nitrogen oxides consist of nitric oxide and nitrogen dioxide. Ozone formation is a nonlinear and complex oxidation processes. *Ozone is produced, as a by-product of atmospheric oxidation processes.* The ozone formation efficiency is more in moderately polluted environment than in unpolluted and polluted environment. The complete explanation of these chemical processes is beyond the scope of this article. The nonlinear processes means, increasing or decreasing ozone precursors concentration, may or may not increase or decrease ozone concentration. It depends on chemical and atmospheric dynamic processes. For example, ozone increases with increasing nitrogen oxides concentration up to certain limit (~10 ppb), then after that ozone decreases as nitrogen oxides increases in the environment. In such an environment decrease in nitrogen oxides concentration will result in increase of ozone concentration. Due to this nonlinear behaviour of chemical mechanism of ozone formation, US and European countries are unable to control ozone within World Health Organization (WHO) permissible limit in their environment even after spending billions of dollars. This type of environment is termed as a 'hydrocarbon-limited' by atmospheric chemist, here hydrocarbons means chemical compounds mainly formed by carbon and hydrogen atoms. Other type of environment is that 'nitrogen oxides-limited' environment. In other words, hydrocarbon limited environment means more polluted and nitrogen oxides-limited environment means less polluted. In India at present, we are experiencing nitrogen oxides-limited

environment. The population pressure is increasing and hence the energy demand is also increasing as the region is developing very fast. *Due to the increasing human activities, Indian region is changing to moderately polluted environment, where ozone forming potential is very high.* Indian region may also change to 'hydrocarbon-limited' environment in near future. Once the environment become hydrocarbon-limited, it is very difficult to control ozone below WHO prescribed permissible limit. The present WHO permissible limit of ozone in environment is 80 ppb hourly average (1 ppb = one ozone molecule per billion of air molecules). Now Indian region is 'nitrogen oxides-limited', hence it is easier to control ozone in environment below permissible limit by taking efficient suitable precautionary measures to control transport sector by reducing nitrogen oxides.

Pune environs at present are experiencing ozone concentration of 20 to 80 ppb depending upon time and season. During the late 19'h century it was approximately 10 ppb. *It is increasing at the rate of ~1 to 2% per year.* This means that after 36 years, ozone will become double of present value. Ozone shows maximum concentration around noon and minimum concentration at sun rise. In summer it is maximum while in rainy season is minimum. The diurnal and seasonal variation of ozone concentration is due to the variation in atmospheric dynamic processes, precursors concentration and in reaction rate of ozone formation and destruction. The ozone concentration is more during clear sky day and minimum during cloudy and rainy day. Ozone formation processes takes place in the presence of sunlight only and peak of ozone formation attains around noon. There after, ozone starts reducing till the next sunrise. In Los Angeles windows of school are closed due to the high ozone concentration during noon as developing lungs of children are more susceptible. Ozone warning is issued in Japan if its concentration is exceeding 120 ppb. Mexico city is the unique example of a topographical influence where ozone concentration reach up to 500 ppb. In Taipei, Taiwan, ozone problem became serious as concentration exceeds often 120 ppb. In short, all over the world, almost all mega cities are facing more or less the ozone problem in environment. In future, it will become more serious if we consider business as usual scenario. Over oceanic region ozone concentration is 10 to 30 ppb due to the low concentration of nitrogen oxides which are a limiting and critical precursors of ozone formation and destruction. Table shows the comparison between the present-day (year 2000) and

pre-industrial time atmosphere. Increase in surface ozone showed highest followed by methane, carbon dioxide and nitrous oxide. Dissociation of nitrous oxide to nitric oxide provides major loss to stratospheric ozone.

Table: A summary of key chemical species affected by human activities.

Chemical Species	Present-Day atmosphere Average (maximum)	Pre-industrial atmosphere	(%) increase
Carbon dioxide	368	280	31
Methane	1714	700	144
Nitrous oxide	311	275	13
Pune,ozone	*40 (90)*	10	400
Delhi, ozone	50 (110)	10	500

The pre-industrial time atmosphere is defined as the average over several centuries before 1850. Carbon dioxide yearly average concentration is in ppm (parts per million of air molecules) and other species yearly average concentration in ppb.

Impact of Bad Ozone:

Ozone is a highly oxidizing agent. It reacts with almost all compounds and living species. Small amounts of ozone about 40 ppb at ground level can cause chest pain, coughing, nausea, throat irritation and congestion in healthy people. It may also worsen bronchitis, heart disease, emphysema and asthma. The study shows that in mega cities death rate is related to increasing ozone concentration. *Also increasing asthmatic, heart and cancer patient in urban cities are related to increasing ozone in environment. Ozone* is phytotoxic to plant species. It can produce acute folier injuries, reduced crops yield and bio-mass production. Ozone disturbs the photosynthesis process, resulting in reduction in crop growth and ultimately reduced crops yield. Earlier and recent international CHINAMAP research project (1999) show that wheat production decreases by 10% or more if ozone concentration is more than 60 ppb in the ambient environment. The results of this experiment are really upsetting. *It indicates that in near future, it will be difficult to meet food demand of growing population of country like China and India.* Increasing ozone in environment is one of the major causes of rapid deforestation. Ozone is highly oxidizing agent and it reacts with all substances. The result is that it reduces the life span of reacting substances. For example, it reacts with rubber, oil paint, concrete building, art material, caves and archeological monuments. *Life span of these materials will be reduced if ozone is enhanced in the environment.* In western countries, they have to replace the vehicle tyre very frequently because of high ozone concentration. This leads to increase economic loss. Ozone is a greenhouse gas;

therefore it helps to warm the Earth's surface. It global warming potential is 2000 times more than that of carbon dioxide. *It indicate that enhancement of ozone can have large climatic consequences in future.* In conclusion, Indian region has high ozone forming potential as this region is getting moderately polluted. Hence, we can visualize a hazy future if ozone increases on Earth surface is not controlled.

Ground Level Ozone and Its Effect on Health

Ozone is great, high up in the atmosphere as it reflects heat and other radiates. But closer to earth, ozone is an air pollutant that can be harmful to humans. When ground level ozone is created, it hangs around in the layer of air near the ground and hence referred to as "Ground Level Ozone". This is typically a band of air from 0 to 10 miles high; where it affects and reacts with everything it comes in contact with.

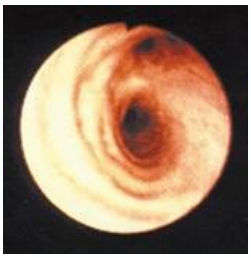
Inhaling ground-level ozone can result in a number of health effects that are observed in broad segments of the population. Some of these effects include:

- **Induction of respiratory symptoms :**

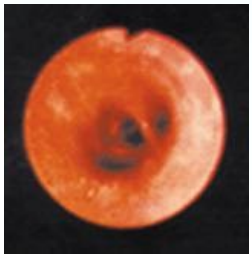
Ozone can irritate your respiratory system, causing you to start coughing, feel an irritation in your throat and/or experience an uncomfortable sensation in your chest.

- **Decrements in lung function:**

Ozone can reduce lung function and make it more difficult for you to breathe as deeply and vigorously as you normally would. When this happens, you may notice that breathing starts to feel uncomfortable. If you are exercising or working outdoors, you may notice that you are taking more rapid and shallow breaths than normal.



Healthy Lung Air way



Inflamed Lung Air way

Ozone may cause permanent lung damage. Repeated short-term ozone damage to children's developing lungs may lead to reduced lung function in adulthood. In adults, ozone exposure may accelerate the natural decline in lung function that occurs as part of the normal aging process.

- **Inflammation of airways:**

Ozone can inflame and damage cells that line your lungs. Within a few days, the damaged cells are replaced and

the old cells are shed-much in the way your skin peels after sunburn.

- **Respiratory symptoms can include:**
  - Coughing
  - Throat irritation
  - Pain, burning, or discomfort in the chest when taking a deep breath.
  - Chest tightness, wheezing, or shortness of breath

Ozone can aggravate asthma. When ozone levels are high, more people with asthma have attacks that require a doctor's attention or the use of additional medication. One reason this happens is that ozone makes people more sensitive to allergens, which are the most common triggers for asthma attacks. Also, asthmatics are more severely affected by the reduced lung function and irritation that ozone causes in the respiratory system.

Ozone may aggravate chronic lung diseases such as emphysema and bronchitis and reduce the immune system's ability to fight off bacterial infections in the respiratory system.

Exposure to Ozone:

Exposure occurs when people inhale ambient air containing ozone. The rate of exposure for a given individual is related to the concentration of ozone in the surrounding air and the amount of air the individual is breathing per minute (minute ventilation).

Although ozone concentrations in the outside (ambient) air are generally similar across many locations in a particular airshed, a number of factors can affect ozone concentration in "microenvironments" within the larger airshed (e.g., inside a residence, inside a vehicle, along a roadway). Ozone concentrations indoors typically vary between 20% to 80% of outdoor levels depending upon whether windows are open or closed, air conditioning is used, or other factors. People with the least exposure in a particular location are those resting in an air-conditioned building with little air turnover. People with the greatest exposure are those heavily exercising outdoors for long periods of time when ozone concentrations are high. This is because heavily exercising people tend to breathe more rapidly and deeply (increased tidal volume). In addition, when people breathe more deeply, ozone uptake may shift from the upper airways to deeper areas of the respiratory tract, increasing the possibility of adverse health effects.

Ozone sensitivity in relation with different groups

Active children are the group at highest risk from ozone exposure because they often spend a large part of the summer playing outdoors. Children are also more

likely to have asthma, which may be aggravated by ozone exposure.

Active adults of all ages who exercise or work vigorously outdoors have a higher level of exposure to ozone than people who are less active.

People with asthma or other respiratory diseases that make the lungs more vulnerable to the effects of ozone will generally experience health effects earlier and at lower ozone levels than less sensitive individuals.

People with unusual susceptibility to ozone: Some healthy people may also experience health effects at more moderate levels of outdoor exertion or at lower ozone levels than the average person.

In general, as concentrations of ground-level ozone increase, more and more people experience health effects, the effects become more serious, and more people are admitted to the hospital for respiratory problems. Therefore when ozone levels are very high, everyone should be concerned about ozone exposure.

Do you Know????

- UV is a type of light emitted by the sun or certain kinds of artificial light. As the ozone layer thins, the amount of UV reaching the earth's surface increases.
- Exposure to UV is the main cause of skin cancer. There are two types of UV rays. UVB rays (280-315 nm) are responsible for delayed tanning and sunburning. UVA rays (315-400 nm) cause immediate tanning, premature aging and wrinkling of the skin, eye damage and a decrease in immune system response. UVA is prevalent in tanning parlors.
- One can get a sunburn on a cloudy day. Up to 80% of the sun's rays can penetrate light cloud, mist and fog.
- Children inhale more pollution per kilogram of body weight than adults.

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