International Journal of Pharmaceutical and Bio-Medical Science

ISSN(print): 2767-827X, ISSN(online): 2767-830X

Volume 03 Issue 03 March 2023

Page No: 98-101

DOI: https://doi.org/10.47191/ijpbms/v3-i3-02, Impact Factor: 6.858

Investigatory Studies on Pattern in Enhancement in Fine Particulate Matter in the Delhi During Winters

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ABSTRACT

Smog is a harmful mixture of fog, smoke, dust and air pollutants such as nitrogen oxides, volatile organic compounds etc. Ground ozone can cause distressing health effect. Smog is a complex atmospheric pollutant mixture consisting of ozone, a pollutant with adverse effects on human health, vegetation, and materials; other eye-irritant and phytotoxic pollutants (such as aldehydes and peroxyacetyl nitrates); nitrogen dioxide (cause of the "whiskey-brown" color in the Los-Angeles atmosphere); and fine particles that cause adverse health effects, reduce visibility, and cause the "brown cloud" phenomenon. Photochemical smog is produced by vehicular emission mainly. Here we are discussing chemistry of formation of PAN (Peroxyacetyl nitrate), its impact environment & human health.

KEYWORDS: Photochemical smog, ozone, PAN, Aerosols, fog, VOC's.

ARTICLE DETAILS

Published On:
02 March 2023

Available on:
https://ijpbms.com/

INTRODUCTION

In 1970, photochemical smog caused huge damage in Japan. This incidence was held in Tokyo on 18th July, 1970. Few students suddenly complained about a little difficulty in breathing, dizziness and eyes and throats irritation, and all were taken to the hospital by ambulance. After examination, the hygienic department of Tokyo Metropolis declared that this incident was caused by photochemical smog. After this incidence studies on the effects of photochemical smog upon the human body were initiated in Japan. In U.S, it is reported that the city of Los Angeles experienced the problem of air pollution due to photochemical smog as early as the late 1940's. According to Haagen - Smit report in 1950, polluted gases in the atmosphere, when the exhaust gas emitted by vehicles reacted with sunlight. The pollutant gas in atmosphere created several allergies in eye. We have carried out a series of experiments on the eye affected by photochemical air pollution, since the simple survey of the affection to the eye under environmental problems was presented in 1974. Subsequent researches on the affection to the eye were done to make both subjective and objective signs clear. At first, one experiment was made for research on the relationship to eye irritation by irritants in synthetic oxidant from 1975 to 1976. Examined irritants were formaldehyde, peroxy acetyl nitrate (PAN), peroxy benzyl nitrate (PBzN). Thresholds and grades of eye irritation was studied with each of a single irritant gas and compound irritant gases, because an air pollution was composed of various irritants.

Another epidemiological study was made throughout two summer seasons (1975-1976) in Tokyo. Those subjects studied were students of a senior high school. When photochemical oxidant was high, the value of lysozyme in tears decreased significantly and besides there was a tendency that the pH value of tears also decreased. Petroleum contains a wide variety of volatile organic compounds (VOCs). Due to their low boiling points, VOCs can be emitted to the atmosphere and immediately contaminate the air. The main anthropogenic VOC sources include vehicular exhaust, various industrial processes, fossil fuel combustion and solvent usage. Photochemical smog, characterized by high concentrations of O_3 and fine particles, is of great concern in many cities around the world. Although VOCs and NO_x have been confirmed as the key precursors of O_3, the development of an effective strategy for reducing O_3 pollution in metropolitans is still problematic due to the non-linear dependency of O_3 formation on NO_x and VOCs. VOCs as a group include many hundreds of species, and each one reacts at different rate and with a different reaction mechanism. Furthermore, they are also emitted into the atmosphere at different mass emission rates, depending on the local and

regional industries, land-use and biogenic sources. Hence, it is important to figure out which VOC species have the highest influence on the O_3 formation. Without this knowledge we will not be able to formulate proper O_3 reduction strategy, i.e. which target pollutants need to be controlled. PM2.5 refers to atmospheric Particulate Matter (PM) that have a diameter of less than 2.5 micrometers, which is about 3% the diameter of a human hair. Commonly written as PM2.5, particles in this category are so small that they can only be detected with an electron microscope. They are even smaller than their counterparts PM10, which are particles that are 10 micrometers or less, and are also called fine particles.

How is PM2.5 Harmful?

Researchers have found a close link between exposure to fine particles and premature death from heart and lung disease. Fine particles are also known to trigger chronic disease such as asthma, heart attack, bronchitis and other respiratory problems.

Exposure to PM2.5 may lead to plaque deposits in arteries, causing vascular inflammation and a hardening of the arteries which can eventually lead to heart attack and stroke. Scientists in the study estimated that for every 10 micrograms per cubic meter ($\mu g/m^3$) increase in fine particulate air pollution, there is an associated 4%, 6% and 8% increased risk of all-cause, cardiopulmonary and lung cancer mortality, respectively.

"$NO + O_3 \rightarrow NO_2 + O_2$"

"$NO_2 \rightarrow NO + O_2$"

"$O + O_2 \rightarrow O_3$"

(O) + Hydrocarbons $\rightarrow$ RCO° + $O_2 \rightarrow RCO_3$°

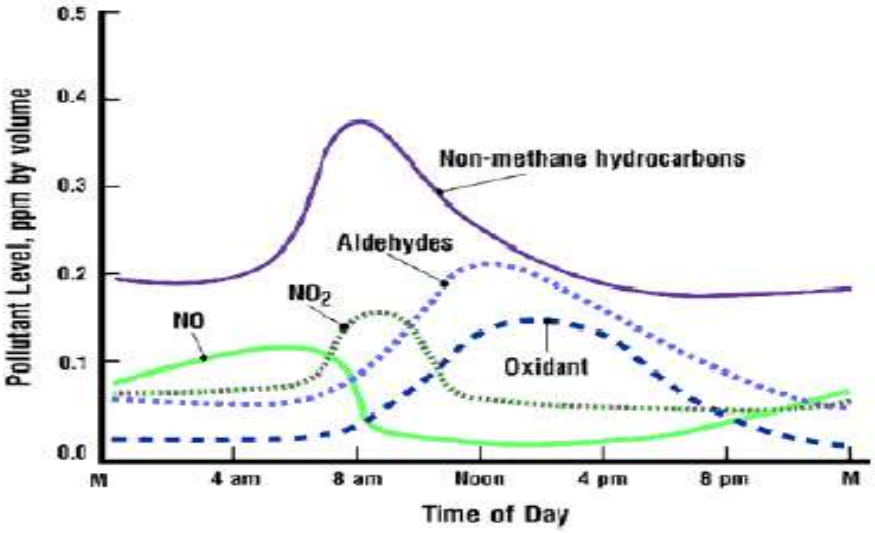
"RCO_3° + Hydrocarbons $\rightarrow CH_2 = O$, Ketones etc"

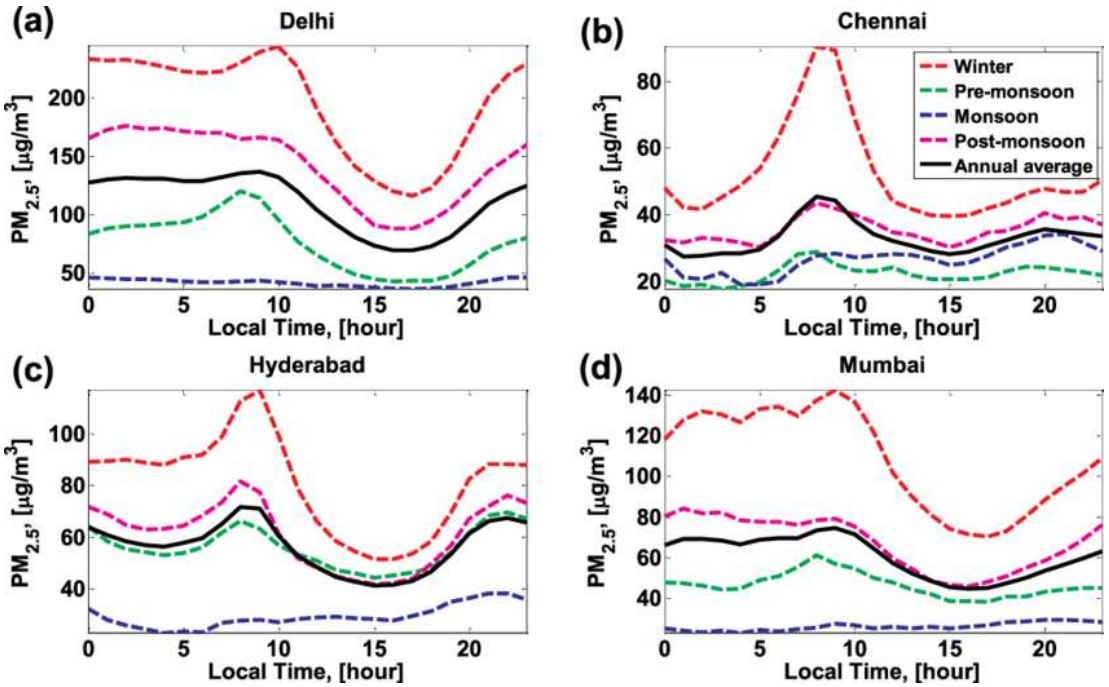
"RCO_3° + $O_2 \rightarrow RCO_2$° + O_3"

"RCO_3° + NO $\rightarrow RCO_2$° + NO_2"

"RCO_3° + $NO_2 \rightarrow RCO_3NO_2$ (PAN)"

The presence of excessive O_3 along with along with aldehydes, ketones, PAN constitute photochemical smog.





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Lack of active monitoring and reaction by authorities. Motor vehicle emissions are one of the **causes** of poor air quality. Other **causes** include wood-burning fires, fires on agricultural land, exhaust from diesel generators, dust from construction sites, burning garbage and illegal industrial activities in **Delhi**

Oxidation Reactions

"$CO + 0.5\ O_2 \rightarrow CO_2$"

"$C_2H_4 + 4.5O_2 \rightarrow 3CO_2 + 3H_2O$"

"$C_2H_4 + 5O_2 \rightarrow 3CO_2 + 4H_2O$"

"$H_2 + 0.5O_2 \rightarrow H_2O$"

NO Reduction Reactions

"$CO + NO \rightarrow CO_2 + 0.5N_2$"

"$C_2H_6 + 9NO \rightarrow 3CO_2 + 4.5N_2$"

"$H_2 + NO \rightarrow H_2O + 0.5N_2$"

Water Gas and Steam Reforming Reactions

"$CO + H_2O \leftrightarrow CO_2 + H_2$"

"$C_3H_6 + 3H_2O \leftrightarrow 3CO + 6H_2$"

Mechanism of Photochemical smog Formation

"$N_2 + O_2 \rightarrow 2NO$"

(In automobiles engines or power plants)

"$2NO + O_2 \rightarrow 2NO_2$"

"$NO + O_3 \rightarrow NO_2 + O_2$"

$NO_2 \rightarrow NO + O_2$

$O + O_2 \rightarrow O_3$

Both NO_2 and O_3 are strong oxidizing agents

"$3CH_4 + 2O_3 \rightarrow HCHO + 3H_2O$"

Hydrocarbons + O_3, O_2, O, NO, NO_2 → R — CO — O — NO_2 + HCHO + CH_2 =CH-CHO} Acrolein

Time of day	Event	Chemical Reactions
1030A.M : – 4:30P.M	As sunlight becomes very hot, NO_2 get dissociated and the conc. of O_3 increases	"$NO_2 \rightarrow NO + O_2$" "$O + O_2 \rightarrow O_3$"
	NO_2 can also react with VOCs from vehicles, refineries to produce toxic PANs	"NO_2 + VOCs → PANs"
	NO_2 react with H_2O vapor to produce nitric acid and nitric oxide	"$3N_2O + H_2O \rightarrow 2HNO_3 + NO$"
4:00P.M - Sunset	O_3 production is halted	

Effects on children

2.2 million children in Delhi have irreversible lung damage due to the poor quality of the air. In addition, research shows that pollution can lower children's immune system and increase the risks of cancer, epilepsy, diabetes and even adult-onset diseases like multiple sclerosis.

Effects on adults

Poor air quality is a cause of reduced lung capacity, headaches, sore throats, coughs, fatigue, lung cancer, and early death.

Health effects

The government of Delhi has declared a health advisory.

- Respiratory issues
- Congestion
- Eyes irritation
- Asthma
- Allergy

PROCEDURE

Collecting data from online resources.

1. Feeding the sensor data in a spreadsheet from 24 to 35 different locations for the purpose of studying the data and finding patterns.
2. Analyzing the air quality data for 90 days i.e. for months January, February and March 2021.
3. Organizing the databases of each area and region into spreadsheet.
4. Plotting the graph.
5. Drawing conclusions from the graph and data.

RESULT

DATA AND GRAPHS

Level of PM2.5 drops as we move from January to March level of PM2.5 is high in the month of JAN and FEB whereas it is significantly lower in the month of March. In winters PM2.5 Level rises due to increase in the level of moisture and fog in the atmosphere.

CONCLUSION

In Delhi this pollutant has risen between the duration of Jan-Feb due to the following reasons -

- Vehicle emission
- Burning of organic material such as wood, paper, coal etc.
- Temperature and Humidity, since this constituent is found in high concentration in the months of January and February due to the presence of smog and settlement of dust particles in the lower layer of atmosphere as they are heavy.

ACKNOWLEDGEMENT

Authors would like to express their sincere thanks to for his valuable inputs and suggestions for the paper.

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