

Influence of Ventilation on Particulate Matter Concentration in Indoor Environment

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Abstract — The study of indoor air pollution has found its importance in recent days. The Particulate Matter is one of the main constituents of indoor air pollution. As humans spend a majority of the time indoor and especially in the indoor, it is important to know the indoor air pollution especially due to Particulate Matter in a residential house. The sources of release of the Particulate Matter in a residence can be mainly due to anthropogenic activities. The present study has been conducted in a residential house in Bengaluru, India to check the indoor air pollution due to Particulate Matter using ABT DM-02 Dust Monitor device. The Particulate Matter concentrations recorded were PM 2.5, PM 1.0, PM 10.0 and Air Quality Index based on PM2.5. The study area was subjected to two conditions namely ventilated and non-ventilated in order to understand the importance of ventilation in mitigating the impact of indoor air pollution on human health. From the results of the study, it can be inferred that the Particulate Matter is found to be low in ventilated condition of the study area. It was also found that temperature and relative humidity did not affect the Air Quality Index or the particulate matter concentration in the study area during the course of study.

Keywords— *Particulate Matter; Relative Humidity; Indoor Air Pollution; Air Quality Monitoring; Ventilation*

1. INTRODUCTION

The earth's atmosphere consists various gases in different quantities. Any unwanted change in the physical, chemical or biological characteristics of the gases in the atmosphere, over a period of time, is called as Air Pollution. The changes can be natural or anthropogenic. Over the years, many studies and research have been conducted to understand the causes, effects and control of Air Pollution. Introduction of chemicals, particulates, or biological materials into the atmosphere through natural or anthropogenic sources, which can result in damage to the health, comfort of living organisms and damages the property, can be called as Air Pollution. The pollutants can be solid particles, liquid droplets or gaseous in nature and can be classified as Primary and Secondary Pollutants based on their production and their effect to the atmosphere. In spite of known records of natural

causes of Air Pollution, the anthropogenic sources can be considered as the main contributor of the problem.

Humans spend most of the times indoor and the air pollution indoor is a major concern to the health of the inmates [1]. Indoor air quality is being studied by many universities across the globe. Pollutants responsible for Indoor Air Pollution are Particulate matter, Carbon monoxide, Polycyclic aromatic hydrocarbons, nitrogen oxides, sulphur oxides etc. Other causes of air pollution are use of formaldehyde in construction and poor ventilation.

The IAQ document published by United States Environmental Protection Agency states that Exposure to high level of inhalable particulate matter can affect the lungs and heart of human beings. Small particles enter deep into the lungs and then into blood streams. Some of the problems associated with particulate matter are coronary artery disease, congestive heart failure, asthma, chronic obstructive pulmonary disease. [2]

2. LITERATURE REVIEW

Indoor Air Pollution analysis and study has been conducted by several researchers around the world. The significance of the particulate matter and the cause of variation in the concentration of the particulate matter and in particular the ultrafine particulate matter has been studied in different parts of the world on the basis of environment and epidemiology. Nuno Canha et al. [3] in the study conducted in the classrooms of Lisbon, Portugal emphasised the importance of ventilation in the indoor environment in order to curb the ill effects due to the particulate matter and chalk powder re-suspension due to student activities in the non-ventilated condition.

The investigation conducted in the libraries of the southern part of Shenyang region of China by HuiXing Lia et al. [4] indicated that the particulate matter in the indoor condition is equal to the outdoor air condition and the indoor pollution is lesser when the pollution is less outdoors. In addition to this, the same study also revealed the decrease in PM2.5 concentration with increase in ventilation.

Similar study conducted in Finland by Sanna Lappalainen et al. [5] for an extended period of five years listed the sources of pollutants that increase the Particulate Matter content varying from 10 to 1 micron and in turn leading to cardiovascular diseases and lung cancer. Studies have also been conducted using indigenous portable devices to record the particulate matter concentration in the Universities building as the chalk and dust from teaching activities can be a health hazard Eva Kridlova et al. [6] This has also aided in emergence of a new indicator termed Indoor Environmental Quality (IEQ) measuring the level of comfort one feels in a confined location. A prominent research by Anil K.Mathur et al. [7] statistically proved the Respirable Particulate Matter are of great importance in causing poor indoor air quality. The study was conducted in 100 kitchens in residences of Jodhpur and Kota, India. The Multiple Linear Regression Model developed stated 80% of concentration of RPM is influenced by ventilation. Effect of the PM_{2.5} aggregating PM-induced allergic sensitization, influence of cooking and smoking on PM concentration in residences, change of PM emission with change in technology (T Ward et al.) [8] and increase of Particulate Matter due to use of Wood Fuel (R Mauricio et al.) [9] have all shown the importance of the study of particulate matter induced indoor air pollution and the influence of ventilation on concentration of Particulate Matter. The current study was to identify the particulate matter concentration in the given the study area using the ABT- DM 02 dust monitor equipment under different conditions, viz., Ventilated and Non-ventilated.

3. MATERIAL AND METHODOLOGY

A. Materials

The experimental study of Particulate matter was conducted by using the dust monitor manufactured in India. The instrument Aero Biotech Dust Monitor, Model: ABT-DM02 is a dust monitor based on laser scattering technology. ABT-DM02 can measure mass concentration of particles at three different sizes i.e., PM_{1.0}, PM_{2.5} and PM₁₀. It also measures TSPM (total suspended particulate matter) and provides data measurement in $\mu\text{g}/\text{m}^3$. The laser scattering technique provides ABT-DM02 the capability to measure particles upto 0.3 micron size. This means that the TSPM data accounts for all particles of size 0.3 micron and larger. With a tested response time of less than 5 seconds, ABT-DM02 finds application in both commercial and household use. ABT-DM02 has a large screen size of 3" and an additional feature of temperature and humidity monitoring. It can measure Air Quality Index (AQI) which can correlate to the pollution index range set by Government of India.

B. Methodology

The experimental study in this project involves to collect the data on Particulate Matter of various ranges in indoor air environment of a residential house. The study was conducted to test the Particulate matter of PM₁, PM_{2.5} and PM₁₀ using the instrument obtained from the Engineering Physics Laboratory of Department of Physics, BMS College of Engineering. The instrument was used to measure and record several other parameters such as Relative Humidity, Temperature, Total Solid Particulate Matter, Air Quality Index and Air Quality Condition (as prescribed by the Central Pollution Control Board) as shown in Table 3.1

TABLE I. INDIAN AIR QUALITY INDEX BY CPCB

AQI Range	AQI Category
0 – 50	Good
51 – 100	Satisfactory
101 – 200	Moderate
201 – 300	Poor
301 – 400	Very Poor
401 – 500	Severe

Aligned with the objectives of the research, the experimental analysis of PM was tested in various locations of a residential house. The study was taken up at a limited location as the Pandemic of Covid19 was widespread and lockdown was imposed throughout the nation. In the residential house situated in suburban location of city of Bengaluru, Karnataka, India, various internal location and various conditions were selected for the noting down of the readings. Another important condition in which the test was conducted is in Ventilated and Non-Ventilated Conditions. The test was conducted in different months of the year under varied temperature. The time of study was usually for minimum 5 to 6 hours per day at an interval of 30 minutes between each reading.

4 RESULT AND DISCUSSION

The particulate matter was recorded in the identified location in the residential house as the predetermined time interval of 30 minutes. The readings were later subjected to statistical analysis by plotting the Time Variation Graph, Time v/s Air Quality Index, Effect of Temperature on various concentration of Particulate Matter, Effect of Relative Humidity on different concentration of Particulate Matter. The mean, median and mode was also identified for various conditions, for various parameters.

The recorded data as shown in the Table II show significant variation in the concentration of the Particulate Matter in the selected location studied in the Ventilated and Non-Ventilated conditions.

TABLE II. TIME VARIATION OF PARAMETERS

Time	PM 2.5 in $\mu\text{g}/\text{cub.m}$		PM 10.0 in $\mu\text{g}/\text{cub.m}$		PM 1.0 in $\mu\text{g}/\text{cub.m}$	
	Non ventilated condition	Ventilated condition	Non ventilated condition	Ventilated condition	Non ventilated condition	Ventilated condition
11:00	16	15	18	14	10	11
11:30	13	16	15	17	9	11
12:00	12	8	15	9	9	5
12:30	12	25	14	35	6	14
13:00	13	11	14	14	8	7
13:30	11	9	13	9	8	6
14:00	34	8	36	11	21	4
14:30	21	8	20	12	14	5
15:00	16	9	20	15	11	6
15:30	16	5	17	6	11	3
16:00	13	6	11	7	8	4
16:30	13	6	14	7	8	3
17:00	15	10	17	13	10	6

The variation of the concentration of particulate matter has found to be significantly higher under the non-ventilated condition when compared to that with ventilated. The increase in the particulate matter can be observed in the mid day due to cooking activities in the households.

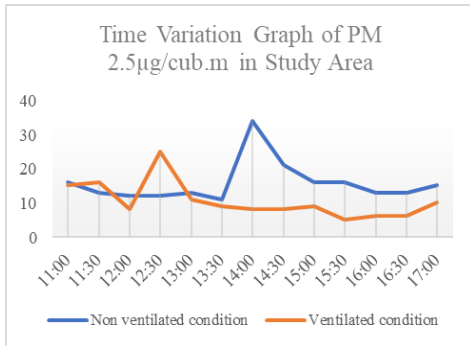


Fig. 1. Time Variation Graph of PM 2.5 $\mu\text{g}/\text{cub.m}$ in Study Area.

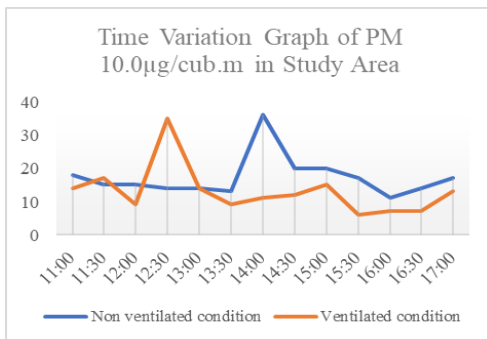


Fig. 2. Time Variation Graph of PM 10.0 $\mu\text{g}/\text{cub.m}$ in Study Area.

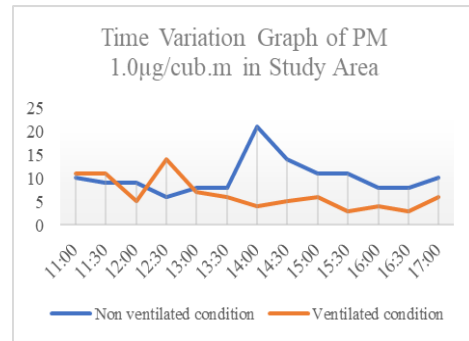


Fig. 3. Time Variation Graph of PM 1.0 $\mu\text{g}/\text{cub.m}$ in Study Area

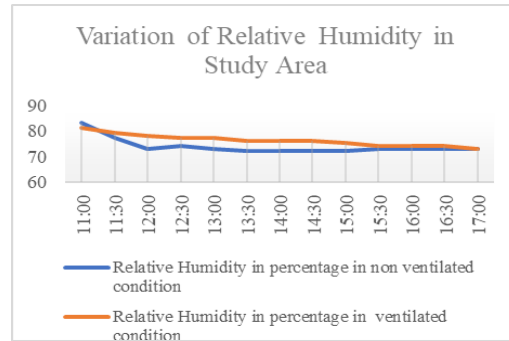


Fig. 4. Time Variation Graph of Relative Humidity in Study Area.

The increase in the particulate matter in the mid day in majorly contributed by the cooking activities. Activities such as frying, grinding or boiling can lead to increase.

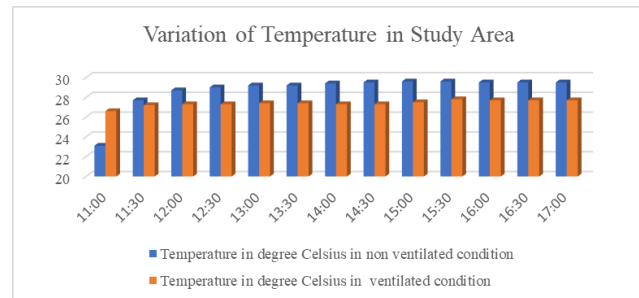


Fig. 5. Variation of Temperature in Study Area

The temperature was found to increase in the environment without proper ventilation.

5. CONCLUSION

The study hence substantiates that the ventilation plays a significant role in maintaining the Indoor Air Quality. The reduction of PM_{2.5} by 33.6%, PM_{10.0} by 24.5% and PM_{1.0} by 36.09% in the study area signifies that the indoor air can be influenced by the ventilation and for a household to have a healthy environment, it must be provided with well planned ventilation. The Relative humidity and temperature in the

study area was also found to be comparatively better in the ventilated condition. But it is important to note that the Indoor air quality in the ventilated condition is influenced by the external environment and can the concentration of particulate matter can increase due to infiltration of air from external environment. Proper and well-planned ventilation to the residential houses with provision for control of external influences can impact Indoor Air quality positively and hence ensure of good health to the inmates.

6. REFERENCES

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