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A study on monitoring of indoor air pollutants and their health effects

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ABSTRACT
Indoor air pollution is the degradation of indoor air quality by harmful chemicals and other materials and it is considered to be 10 times more severe than the outdoor air pollution. Poor indoor air quality is the second largest killer with 1.3 million deaths in India each year. Delhi, the capital of India is ranked first in the air pollution in terms of Particulate Matter according to Greenpeace report in 2019. A study involving measurement of different indoor air pollutants such as PM_1, $PM_{2.5}$ and PM_{10} has been presented in this study and furthermore the health effects associated with these pollutants have also been analysed. A Handy Sampler based on 32-BIT ARM processor was used to carry out this study. The monitored values were recorded at some pre selected locations of South Delhi . It was observed that most of the monitored data of particulate fractions (PM_1, $PM_{2.5}$ and PM_{10}) exceeded the NAAQS limits. The study therefore is one of the first attempts at monitoring indoor air quality of this region.

Keywords- Particulate Matter, Indoor Air Quality, Monitoring, Heath effects

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I. INTRODUCTION

Indoor air pollution is the degradation of indoor air quality by harmful chemicals and other materials; it can be up to 10 times worse than outdoor air pollution. The fine particles released from the gas flames, vegetables, oils and other indoor activities release harmful $PM_{2.5}$ particulates in the air, which lasts for about an hour in the surrounding.

According to WHO, majority of the people in India are under a constant threat of severe respiratory ailment due to poor indoor air quality. Around 2 million people die because of long term exposure to indoor air pollutants [1]. The city of Delhi having its indoor air pollutant sources like cooking, unventilated heating appliances, dusting and pets often subjects its residents to poor or hazardous indoor air quality which ultimately leads to severe health issues especially in children. Statistics suggest that in developing countries, health impacts of indoor air pollution far outweigh those of the outdoor air pollution. Some of the popular global studies have been reported in this research. A study conducted by Lanthier et al. [2] provided an examination of the independent contribution of residential dampness or mold (i.e., visible mold, mold odor, dampness, or water leaks) to asthma, allergic rhinitis, and respiratory infections among students at the Université de Sherbrooke (Quebec, QC, Canada), similarly the work of Szulc et al.[3] evaluated the microbiological contamination at a plant biomass processing thermal power station located in Poland. Among the factors that affect the prediction of human exposure to indoor air pollution, the pattern of human behavior and their activity play a decisive role. In another major work, Odeh and Hussein [4] reported about the human activity pattern of 285 subjects (17–63 years old) residents in Amman (Jordan) in order to use the outcomes in future human exposure researches.

It has also been observed by the authors while carrying out this study that environmental tobacco smoke (ETS) is a major contributor to indoor air pollution and public health. In comparison to the large body research on toxicological substances of ETS and concentrations of indoor ETS-dependent PM, minimal atterntion has been paid on the correlation between the odor concentration and the chemical composition of ETS. The odor concentrations of field ETS, second-hand smoke (SHS), and third-hand smoke (THS) in prepared samples were evaluated by Noguchi et al. [5] using the triangle-odor-bag method, while the chemical compositions of the same samples were determined by proton transfer mass spectrometry. The study concluded that the main contributing components to the odor of the field ETS samples (acetaldehyde, acetonitrile, acetic acid, and other unknown components with a mass-to-charge ratio were different from those found in SHS and THS samples. The present paper has the following objectives a) Monitoring the concentration PM_1, $PM_{2.5}$ and PM_{10} in dwellings located in residential and commercial areas of South Delhi. b)Comparing and analsysing the monitored data. c) Assessing the health implications associated with the poor indoor quality.

II. METHODOLOGY

1. Study Area

For our study, South Delhi region was adopted which boasts a population of 2.8 million. The region is bounded by the Yamuna River to the east, the districts of New Delhi to the north, Faridabad District of Haryana state to the southeast, Gurugram District of Haryana to the southwest, and South West Delhi to the west. This part of the capital city comprises of a mixed population urban villages, unauthorized and upscale colonies which are now severely congested. Rapid urbanization of this region has led to an increase in both indoor and outdoor air pollution which is resulting in severe health and respiratory issues [6]. The monitoring sites opted for the studies were selected largely on the basis of factors affecting the economic development of those localities such as per capita income, education and extent of poverty.

2. Sampling

The indoor air quality monitoring exercise was performed using a handy air sampler (SMILEDRIVE Portable air Quality Monitor) as shown in fig.1. The air pollution monitor has been equipped with a high performance three core 32-bit ARM processor. Based on laser scattering technology the meter can easily detect indoor concentration of particulate matter, VOC and HCHO. Test range for formaldehyde is 0-1.999 mg/m^3, for PM_1, $PM_{2.5}$, PM_{10} it is 0-999 $\mu g/m^3$ and for TVOCs it is 0-9.999 mg/m^3

Fig.1 Portable Pollution Meter

The instrument was installed considering an important factor for defining a sampling strategy i.e. the effect of air flow velocity on sampling results. Since the air flow is reduced near surfaces, meeting it was recommended that samplers should be placed at least 1 m from the wall and at least 1.5 m height from the floor. The sampling duration lasted for 10 hours at all the selected locations and the readings for PM_1, $PM_{2.5}$ and PM_{10} were recorded at every 10 minute interval. The monitoring exercise was executed as per the draft CPCB guidelines for indoor air quality monitoring [7].

A wide range of buildings such as educational institutions, hospitals, residential complexes, libraries and other commercial establishments were selected for our study. A total of 250 residential, commercial and industrial units were surveyed in the region of South Delhi. It was observed that around 30% of the adults were exposed to second hand smoke (tobacco smoke) at indoor work places. Around 22% of the children between 13-15 years were found exposed to tobacco smoke at homes.

At each location, at least three sampling locations were selected for example monitoring in a school required an extensive sampling and at every floor three random rooms occupied during the working hours were monitored. Factors affecting indoor air quality were registered and reported (sources of combustion indoor and outdoor, cooking, etc). Outdoor environment including distance to a busy road, industrial sources of emissions, etc., were described. The working hours during which the building occupants were present and the time of breaks were also recorded. A record of some other pertinent factors such as temperature and relative humidity was also maintained which most often influence the meter readings and produce sampling errors.

3. Data Analysis

After the collection of data, the analysis of data collected has been done by using the SPSS statistical program. The data for all the monitored pollutant parameters was processed and a couple of statistical measures were computed for further analysis. Mean, Standard deviation, range were computed for the observed data as shown in table 1. Furthermore, the comparative analysis has been done between the particulate matter (PM_1, $PM_{2.5}$ and PM_{10}) averages of every selected location, and the standards provided by National Building Code (2016).

Table -1. General statistics of the monitored data at all the five selected locations

Study location	No. of houses	Mean ±Std. Dev. $PM_{2.5}$	Mean ±Std. Dev. PM_{10}	Mean ±Std. Dev. PM_1	Range $PM_{2.5}$ μg/m^3	Range PM_{10} μg/m^3	Range PM_1 μg/m^3
Jamia Nagar	50	66.6±17.4	97.8±10	34.8±5.7	70	40	18
New Friends colony	50	39.3±5.3	93.4±9.8	31.4±3.8	19	40	11
East of Kailash	50	85.1±17.1	82.6±18.28	32.7±8.9	72	75	40
Okhla Industrial area	50	84.7±11.7	115.4±21.3	45.4±8.0	37	62	26
Nehru place	50	70.6±16.6	101.4±13.2	58.8±10.2	49	52	39

4. Health effects

High levels of pollutants are known to cause a range of health issues such as respiratory ailments, cardiovascular diseases, adverse pregnancy outcomes and even death. Our research is more or less focused on the adverse effects due to $PM_{2.5}$. Fine particulate matter (PM2.5) present a severe health risk, having an aerodynamic diameter of <2.5 microns these particles can get deep into the lungs and into the bloodstream [8][9]. $PM_{2.5}$ can also affect lung function and worsen medical conditions such as asthma and heart diseases [10][11]. Long-term exposure to $PM_{2.5}$ has been associated with an increased rate of chronic bronchitis, reduced lung function and increased mortality from lung cancer and heart diseases. In this study, an attempt has been made to draw out a relationship between the average indoor $PM_{2.5}$ concentration and associated respiratory illnesses. A student t-test was performed with the help of SPPS software (Version 23) in order to verify the association between high $PM_{2.5}$ concentrations and reported respiratory diseases in each of the monitored locations.

III. RESULTS AND DISCUSSION

The monitored data for PM at each site was processed and graphically presented for further analysis. The values showed a common trend in all locations and marginally exceeded in the case of Okhla Industrial area (Figure 2-Figure 6). In figure 2, the monitored values for PM_1, $PM_{2.5}$ and PM_{10} have been plotted for all 50 locations in East of

Kailash. The average PM_1, $PM_{2.5}$ and M_{10} μg/m^3 respectively. In comparison to the standard value of 60 μg/m^3 set by National building code (2016) the $PM_{2.5}$ and PM_{10} values tend to exceed the standards while the mean PM_1 concentration was observed within the permissible limits.

oncentration at this location were observed as 33 μg/m^3, 85.8 μg/m^3 and 81.92 μg/m^3 respectively. In comparison to the standard value of 60 μg/m^3 set by National building code (2016) the $PM_{2.5}$ and PM_{10} values tend to exceed the standards while the average PM1 concentration was found to be within the permissible limits.

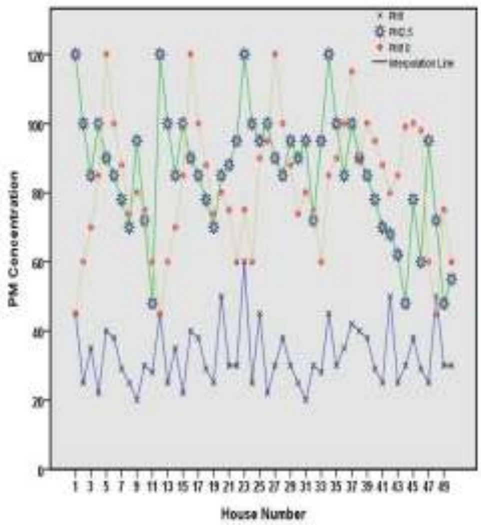

Fig.2. Monitored PM_1, $PM_{2.5}$ and PM_{10} conc. at E East of kailash

Similarly, In figure 3, the monitored values for PM_1, $PM_{2.5}$ and PM_{10} have been plotted for all 50 locations in Jamia Nagar. The average PM_1, $PM_{2.5}$ and PM_{10} concentration at this location were observed as 34.9 μg/m^3, 67.28 μg/m^3 and 98.32

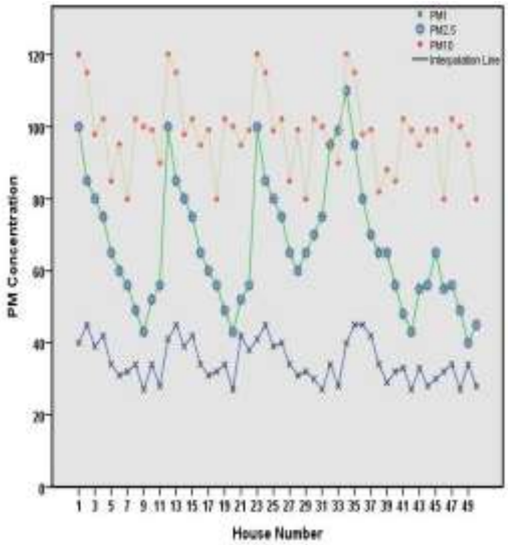

Fig**. 3.** Monitored PM_1, $PM_{2.5}$ and PM_{10} concentration at JamiaNagar

In figure 4, the monitored values for PM_1, $PM_{2.5}$ and PM_{10} have been shown for all 50 locations in Nehru place. The mean concentrations for PM_1, $PM_{2.5}$ and PM_{10} at this location were observed as 58.44 µg/m^3, 70.88 µg/m^3 and 102.26 µg/m^3 respectively. When comparing to the standard value of 60 µg/m^3 set by National building code (2016) the $PM_{2.5}$ and PM_{10} values tend to exceed the standards while the observed average PM_1 concentration was found to be within the permissible limits.

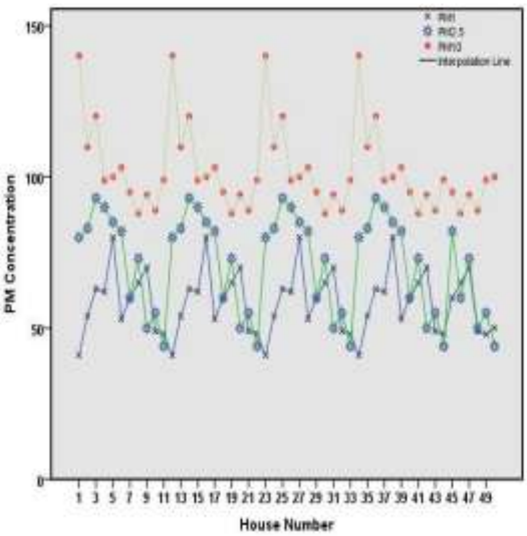

Fig. 4. Monitored PM_1, $PM_{2.5}$ and PM_{10} concentration at Nehru Place

Figure 5 shows the monitored values for PM_1, $PM_{2.5}$ and PM_{10} at all 50 locations in New Friends colony. The mean concentrations for PM_1, $PM_{2.5}$ and PM_{10} at this location were observed as 31.36 µg/m^3, 39.38 µg/m^3 and 93.18 µg/m^3 respectively. In comparison to the standard value of 60 µg/m^3 set by National building code (2016) the average PM_{10} values tend to exceed the standards while the average PM_1 and $PM_{2.5}$ concentration were observed within the permissible limits.

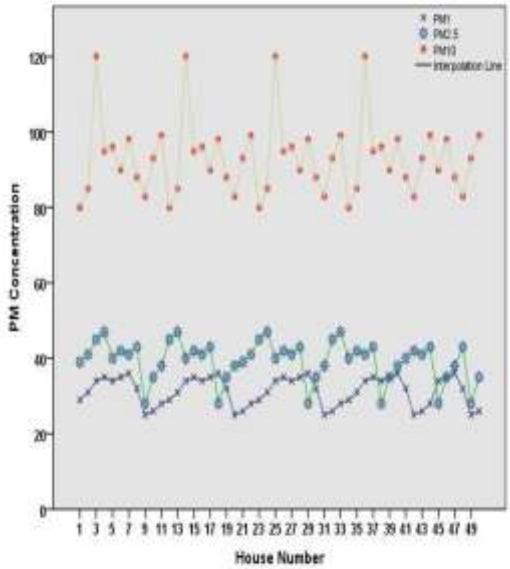

Fig. 5. Monitored PM_1, $PM_{2.5}$ and PM_{10} concentration at New Friends colony

Figure 6 shows the monitored values for PM_1, $PM_{2.5}$ and PM_{10} at all 50 locations in okha industrial area. The mean concentrations for PM_1, $PM_{2.5}$ and PM_{10} this location were observed as 45.4 µg/m^3, 84.72 µg/m^3 and 114.86 µg/m^3 respectively. In comparison to the standard value of 60 µg/m^3 set by National building code (2016) the average PM_{10} and $PM_{2.5}$ values tend to exceed the standards while the average PM_1 concentration was observed within the permissible limits.

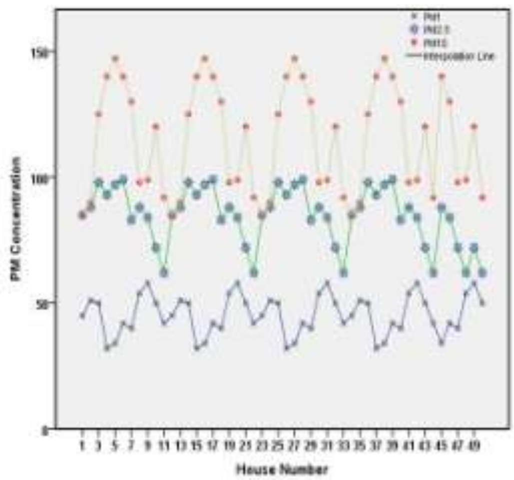

Fig. 6. Monitored PM_1, $PM_{2.5}$ and PM_{10} concentration at Okhla Industrial Area

Further analysis of the data was done using another statistical measure known as the student t-test at 5% significance level. The technique was implemented to draw out a relationship between indoor $PM_{2.5}$ levels and respiratory diseases. For this part of the study, the target pollutant so considered was $PM_{2.5}$ as it has a close quantitative relationship with increased mortality and morbidity. The results for the t-test have been presented in table 2.

Table-2 Association between Indoor $PM_{2.5}$ and Respiratory diseases.

Location	Respiratory diseases in Participants		DOF	t value	P value
East of Kailash	Found	25	48	10.03	0
	Not found	25	46.9		
Jamia Nagar	Found	26	48	-12.58	0
	Not found	24	36.7		
Nehru place	Found	21	48	-10.44	0
	Not found	29	36.8		
NewFriends colony	Found	24	48	-8.922	0
	Not found	26	43.9		
Okhla Industrial area	Found	32	48	-5.625	0
	Not found	18	33.3		

It can be observed from the t-test results shown in table 2 that the p value for all the locations was less than 0.05 which also proves the statistical significance of the results. Therefore, the results so obtained confirm that there is indeed a strong correlation between high indoor $PM_{2.5}$ levels and respiratory illnesses.

IV. CONCLUSION

The problem of indoor air pollution lacks extensive data and research in India. In this study, we report a research study where we monitored and compared the Indoor particulate matter concentration for certain localities in the South Delhi region. Moreover, a statistical hypothesis test (student t-test) was applied to study the relationship between the particulate matter concentration and respiratory illnesses associated with their long term exposure. In order to apprehend this study of indoor air quality, further longitudinal researches are required in this field. At the same time, substantial measures against indoor air pollution, education and awareness, policy formation, infrastructure and energy reforms and dedicated approach to promote public health is the only need of the hour.

REFERENCES

[1]. World Health Organization. The world health report 2002: reducing risks, promoting healthy life. World Health Organization, 2002.

[2]. Lanthier-Veilleux, Mathieu, Geneviève Baron, and Mélissa Généreux. "Respiratory diseases in university students associated with exposure to residential dampness or mold." International journal of environmental research and public health 13.11 (2016): 1154.

[3]. Owsianiak, Mikołaj, et al. "Biodegradation and surfactant-mediated biodegradation of diesel fuel by 218 microbial consortia are not correlated to cell surface hydrophobicity." Applied microbiology and biotechnology 84.3 (2009): 545-553.

[4]. Odeh, Issam, and Tareq Hussein. "Activity pattern of urban adult students in an Eastern Mediterranean Society." International journal of environmental research and public health 13.10 (2016): 960.

[5]. Noguchi, Masaharu, et al. "Production cross sections of tritium in high energy nuclear reactions with 12 GeV protons." International Journal of Radiation Applications and Instrumentation. Part A. Applied Radiation and Isotopes 42.6 (1991): 577-582.

[6]. Masood, Adil, and Kafeel Ahmad. "Air Pollution Dispersion Modeling for Diesel Generators at Jamia University Campus, New Delhi, India." International Journal of Engineering Applied Sciences and Technology 2 (2017): 82-87.

[7]. Central Pollution Control Board (CPCB), Indoor air pollution, monitoring guidelines, (2014): 1-18

[8]. Zhang, Renjian, et al. "Chemical characterization and source apportionment of PM 2.5 in Beijing: seasonal perspective." Atmospheric Chemistry and Physics 13.14 (2013): 7053-7074.

[9]. Sylla, Fatou K., et al. "Near-Road Exposure to Air Pollution and Allergic Rhinitis: A Cross-Sectional Study among Vendors in Dakar, Senegal." Occupational Diseases and Environmental Medicine 5.4 (2017): 106-120.
[10]. Mauad, Thais, et al. "Chronic exposure to ambient levels of urban particles affects mouse lung development." American journal of respiratory and critical care medicine 178.7 (2008): 721-728.
[11]. James Gauderman, W., et al. "Association between air pollution and lung function growth in southern California children." American journal of respiratory and critical care medicine 162.4 (2000): 1383-1390.

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