ISSN No:-2456-2165

Monitoring of Concentration of PM_{10} and $PM_{2.5}$ in Indoor Air in the Laboratories of a Technical Institute

Aditya Singh Tomar[1]; Aditya Kumar Agarwal[2];
[1]Department of Civil Engineering, MITS, Gwalior (M.P.), India.
[2]Department of Civil Engineering, MITS, Gwalior, (M.P.), India.

Abstract:- This study consists of a comparison of the concentration of particulate matter in indoor air in the laboratories of a technical institute. For this, sampling is done with a portable indoor air sampler from July to October 2021. The total of 228 samples were collected for each particulate matter size i.e., $PM_{2.5}$ and PM_{10} in a total of five laboratories. In descriptive statistics, the highest level of concentration of PM was found in the chemical lab and the lowest value was interpreted in the research lab. Further, the comparison study states the means concentration level of both Particulate Matter of sizes <2.5 µm and <10 µm is higher than the prescribed value set by the WHO in all the monitored labs. The average concentration of both Particulate Matter was found higher than the prescribed limit set by WHO. Finally, it can be concluded that poor ventilation, presence of furniture, paints, oils, and electronics, etc., along with the additional influence of the outdoor air pollutants, location of laboratories, and outdoor construction activities, etc. are some of the prime reasons for the high concentration of indoor air particulate matter.

***Keywords**:- Indoor Air Quality, Descriptive Statistics, Academic Building, Particulate Matter.*

I. INTRODUCTION

Indoor air pollution is one of the leading causes of worldwide risk illnesses and a serious public health concern. In most cases, indoor air pollution is more dangerous than outside air pollution as enclosed rooms allow the potential contaminants to accumulate faster in comparison to open spaces [1]. Indoor air pollution has the potential to increase the likelihood of students and employees in educational institutions having long and short-term health concerns [2]. There has been a link established between air pollution levels in schools, colleges and the emergence of health concerns in children and adolescents [3]. The number of daily absences due to sickness has also been linked to air pollution and school building characteristics such as dampness and ventilation systems [4, 5].

Indoor particulate matter (PM) is primarily generated by two sources: first, indoor sources such as cooking, cigarette smoke, combustion equipment (e.g., stoves and heaters), cleaning, and dusting; and second, outdoor air infiltration [6]. Dust generated on floors and other interior surfaces as a result of human activities contains a lot of PM waste (from tracked-in dirt, textiles, skin and hair, household furniture, and so on). Dust can be resurrected by agitation (cleaning) or turbulence (HVAC systems, people movement). After being deposited on interior surfaces, ambient particles that have entered indoor microenvironments can be resuspended [7, 8]. Because most people spend 85 percent of their time inside and just 5 to 6% of their time in automobiles, indoor air quality is a key risk factor for human exposure to environmental pollutants. [9]. Indoor air quality is an important aspect of health and well-being in buildings, where most people spend a substantial amount of time. [10]. These above-mentioned factors have lately piqued the interest of scientists and government agencies [3].

Many statistical pieces of research have shown a correlation between ambient aerosol concentrations and severe health impacts [11]. Particulate matter especially $PM_{2.5}$, a fine respirable particle is linked to fatalities from heart disease and, in particular, lung cancer [12]. Several recent studies have revealed that each 10 µg/m3 increase in fine particle concentration is associated with a 4%, 6%, and 8% increase in the risk of all-cause, cardiovascular, and lung cancer mortality, respectively [13]. Employees' health is harmed by particulate matter that collects in their respiratory systems before entering their circulatory systems, depending on the size of the particle [14, 15]. The World Health Organization (WHO) reported in its World Cancer Reports issued in 2014 and 2019 that particulate matter can cause lung cancer regardless of its content [15, 16].

In the current research, indoor pollutants specifically $PM_{2.5}$ and PM_{10} were monitored in the main building of an engineering institute and analyzed statistically. For achieving this purpose, IAQ monitoring in the labs of different department of the main academic was conducted because the students, researchers, scholars, professors, and other staff are exposed to pollutants of indoor air in the school/university building as laboratory Incharge spend around 30-40 hours per week in the laboratory while student spent around 8 hours per week [17]. Such long exposure to indoor air pollutants affects the health along with the performance of students in an adverse way [18]. As a result, it is important to regularly monitor the indoor air quality (IAQ) for ensuring the health of the occupant of the specific building.

II. METHODOLOGY

A. *Site Details*

Indoor particulate matter monitoring was carried out in various laboratories from different engineering departments in the main academic building at Madhav Institute of Technology and Science, Gwalior (MITS, Gwalior) (26.231415948816732 N, 78.20534303234608 E) (as shown in Fig. 1).

In this study, five different laboratories were selected from different engineering departments for evaluating particulate matters across the main academic building of the institute. Figure 1 depicts the monitoring locations in the academic building. These were chosen based on a comprehensive time invested by students, professors, and teaching staff to investigate possible exposure to the institute's various learning environments. The details of the laboratories are provided in Table 1. Furthermore, these laboratories were selected based on the functioning inside the labs. L1 is furnished with a ceiling fan, and a window air conditioner (AC) while L2 is fitted with ceiling fans, and wall-mounted air conditioners (ACs). L3, L4, and L5 are provided with ceiling fans and have natural ventilation.

Fig. 1: Arial view of Study Area

Table 1: Details of Laboratories

S. No.	Laboratories	Department
L1	Waste Water Lab	Civil Engineering
L2	Research Lab	Computer Science Engineering
L3	IC Engine Lab	Mechanical Engineering
L4	Control Lab	Electronics Engineering
L5	Chemical Lab	Chemical Engineering

B. *Data Collection and Monitoring Device*

IAQ monitoring was carried out in the laboratories for non-consecutive weeks from July 2021 to October 2021. A total of 228 samples were collected for each parameter throughout the sampling period. The measurements were obtained every 30 minutes throughout the working hours of 10:00 a.m. to 5:00 p.m. The portable sample equipment for IAQ monitoring is based on Laser-Scattering Technology, which is used to determine the concentration of various particulates (e.g., $PM_{2.5}$, PM_{10}) [19]. Furthermore, It stood at a height of roughly 1 metre above the ground. , similar to a seated person's breathing zone, and sufficient distance was kept from the walls or any other barrier in the monitoring device's vicinity.

C. *Data Preparation and Statistical Analysis*

For statistical analysis, all data gathered during monitoring in each laboratory was carefully organized and arranged (in tabular form) in an MS-Excel file. To begin, a descriptive statistic for each pollutant was calculated for each lab category. Following that, the indoor air quality status of each lab was compared with guidelines mentioned by international agencies. IBM SPSS version 23 was used to conduct all statistical tests in this study, and data visualization was done with Python.

III. RESULTS AND DISCUSSIONS

Indoor air pollutant data that was arranged in the spreadsheet of MS-excel was used for further analysis. Figure 2 (a-b) depicts the trends in PM2.5 and PM10 concentrations in indoor air, in which it is seen that particle size and concentration of particulate matter (PM2.5 and PM10) and interpreted that L1 and L3 show high variation in the concentration level.

ISSN No:-2456-2165

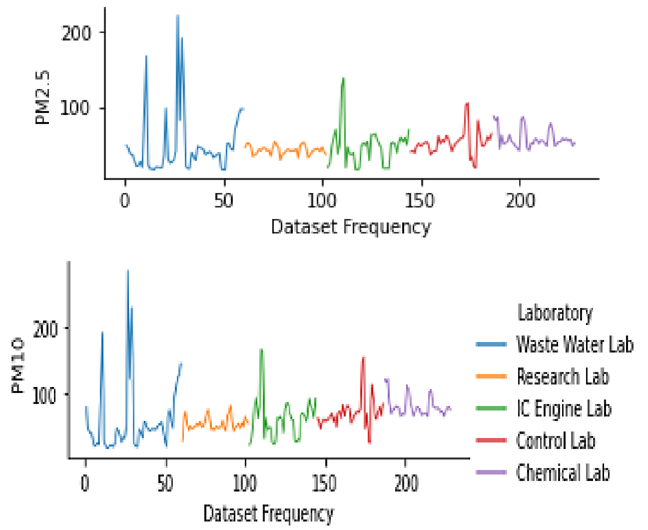

Fig. 2: Trends of indoor air pollutant in different laboratories (a) $PM_{2.5}$ (in µg/m^3) (b) PM_{10} (in µg/m^3).

A. *Descriptive Analysis*

The average $PM_{2.5}$ (in µg/m^3) concentration in L1, L2, L3, L4, and L5 was found to be 47.88, 41.83, 46.73, 51.31, and 57.45, respectively, whereas the average PM_{10} (in µg/m^3) concentration in various labs was found to be 61.94, 56.42, 65.00, 72.12, and 82.38 in L1, L2, L3, L4, and L5 respectively. L5 (Chemical Lab) had the highest level of $PM_{2.5}$ concentration, followed by L4, L1, L3, and L2. PM_{10} levels were also observed to be greater in Lab 5 (Chemical Lab) followed by L4, L3, L1, and L2. In L5, there are higher concentrations of both the Particulate Matter components of particulate matter. It may be due to the lab being situated in a downwind direction and it possesses natural open ventilation in it [20, 21]. Therefore, the outdoor particulate load may enhance the level of $PM_{2.5}$ and PM_{10} concentration in the labs. Further, L5 is attributed to the Chemical lab in which hammer mill and jaw crusher are frequently used along with the use of many chemicals for experiments or research works. Hence, there may be a chance of a combination of particles and some chemicals which further elevate the level of particulate matter concentration. It may also be possible that particulate matter which has a high residence time in the air remains in suspension which may be the reason for the exceedance value of both Particulate Matter.

Table 2: Indoor concentration of $PM_{2.5}$ and PM_{10}

Laboratories	Pollutants	Means	SD	Median	Min	Max
Waste Water Lab	$PM_{2.5}$	47.88	42.22	36.10	15.30	222.00
	PM_{10}	61.94	51.79	47.75	20.50	283.00
Research Lab	$PM_{2.5}$	41.83	5.91	41.95	28.30	53.50
	PM_{10}	56.42	9.95	53.30	31.20	83.30
IC Engine Lab	$PM_{2.5}$	46.73	25.41	48.75	15.80	138.00
	PM_{10}	65.00	30.46	64.90	25.70	166.00
Control Lab	$PM_{2.5}$	51.31	16.74	50.20	17.80	105.00
	PM_{10}	72.12	23.32	67.85	28.70	155.00
Chemical Lab	$PM_{2.5}$	57.45	12.91	53.20	40.90	87.00
	PM_{10}	82.38	15.20	78.80	67.30	123.00

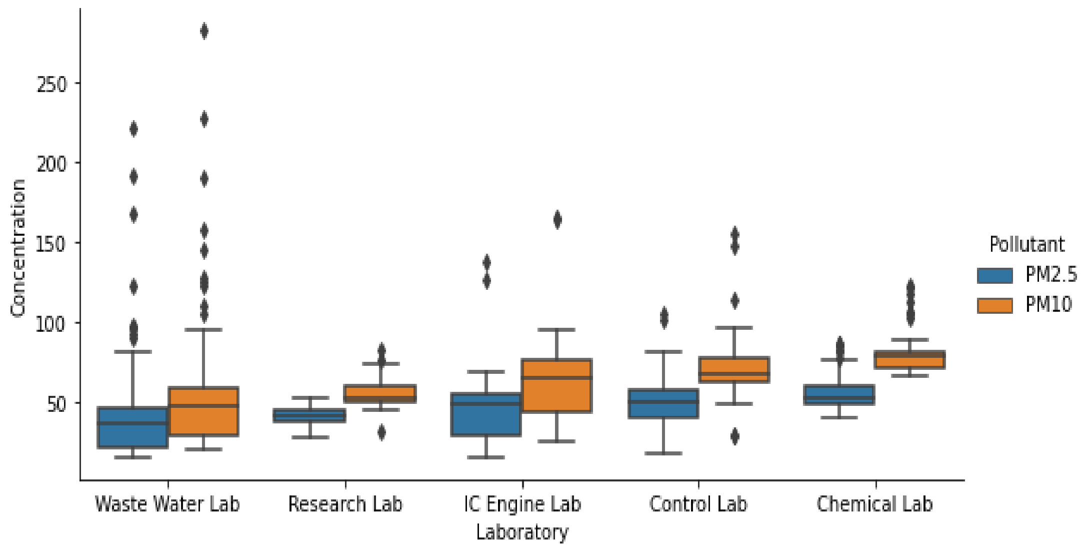

Fig. 3: Box whisker plot of particulate matter of different sizes in different laboratories.

Further, there was an effort to evaluate the air quality status in the laboratories by comparing the mean particulate matter concentration level with the guidelines provided by WHO for $PM_{2.5}$ and PM_{10}. According to WHO guidelines prescribed limit of PM (size <2.5µm) is 25 µg/m^3 and for PM (size <10µm) is 50 µg/m^3 [22]. It had been found out that the mean concentration level of both particulate matters in all the laboratories is higher than the limits prescribed by WHO as shown in fig. 4. It can be interpreted that the average concentration value of PM (size <2.5µm) in all the monitored labs is way higher than the threshold limit set by WHO. However, in the case of PM_{10} the mean concentration level is on the borderline in the research lab while the chemical lab possesses maximum difference from the threshold value set by WHO. High concentration of both the particulate matter may be due to the various phenomenon such as infiltration of outdoor air as the main academic building is situated near the high traffic road, resuspension of dust, presence of various chemicals and heavy machines in the laboratories.

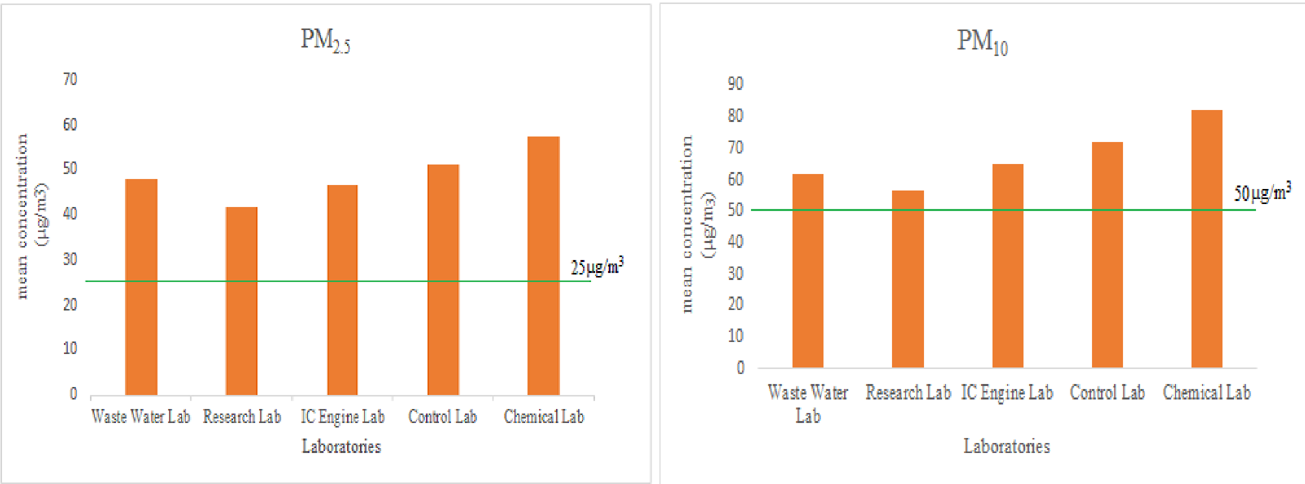

Fig. 4: Comparison of the mean concentration of $PM_{2.5}$ and PM_{10} with the guidelines set by WHO.

IV. CONCLUSION

In this study, the attempt was done to analyze the indoor air pollutant by comparing the mean concentration value of PM (sizes <2.5µm and <10 µm) by the threshold limit as prescribed by WHO to evaluate the indoor environment of the laboratories in the technical institute. It is observed that some outlier concentration was present in each pollutant due to the presence of various activities such as maintenance work, cleaning activities, etc. Subsequently, descriptive analysis of collected data clearly states that the mean concentration of PM sizes <2.5µm and <10 µm are found highest in L5 (Chemical lab) and lowest in L2 (Research lab). It is was also found that the concentration level of particulate matter in all of the monitored labs in the main academic building is higher than the limits set by the WHO. At last, it is observed that the elevated concentrations of the indoor air pollutant within each laboratory are due to poor ventilation, presence of furniture, paints, oils, computers, and printers, etc., the influence of outdoor air pollutants, location of laboratories, and outdoor construction activities, etc. Future attempts can be made to study detailed statistical analysis and inferential statistical analysis along with the spatial variability of the various IAQ parameters in various laboratories of the institution.

REFERENCES

[1]. Sekar A, Mohan P, Varghese GK, Varma MKR (2020) Exposure to particulate matter in classrooms and laboratories of a university building

[2]. Lee SC, Chang M (2000) Indoor and outdoor air quality investigation at schools in Hong Kong. Chemosphere 41:109–113. https://doi.org/10.1016/S0045-6535(99)00396-3

[3]. Yang J, Nam I, Yun H, et al (2015) Characteristics of indoor air quality at urban elementary schools in Seoul, Korea: Assessment of effect of surrounding environments. Atmos Pollut Res 6:1113–1122. https://doi.org/10.1016/j.apr.2015.06.009

[4]. Park H, Lee B, Ha EH, et al (2002) Association of air pollution with school absenteeism due to illness. Arch Pediatr Adolesc Med 156:1235–1239. https://doi.org/10.1001/archpedi.156.12.1235

[5]. Mendell MJ, Heath GA (2005) Erratum: Do indoor pollutants and thermal conditions in schools influence student performance? A critical review of the literature (Indoor Air 15:1 (27-52)). Indoor Air 15:67. https://doi.org/10.1111/j.1600-0668.2005.00329.x

[6]. Wallace L (1996) Indoor Particles: A Review. J Air Waste Manag Assoc 46:98–126. https://doi.org/10.1080/10473289.1996.10467451

[7]. Gemenetzis P, Moussas P, Arditsoglou A, Samara C (2006) Mass concentration and elemental composition of indoor PM2.5 and PM10 in University rooms in Thessaloniki, northern Greece. Atmos Environ 40:3195–3206. https://doi.org/10.1016/j.atmosenv.2006.01.049

[8]. USEPA (2004) Air Quality Criteria for Particulate Matter. Air Qual Criteria Part Matter I:900

[9]. Klepeis NE, Nelson WC, Ott WR, et al (2001) The National Human Activity Pattern Survey (NHAPS): A resource for assessing exposure to environmental pollutants. J Expo Anal Environ Epidemiol 11:231–252. https://doi.org/10.1038/sj.jea.7500165

[10]. Branco PTBS, Alvim-Ferraz MCM, Martins FG, Sousa SIV (2014) Indoor air quality in urban nurseries at Porto city: Particulate matter assessment. Atmos Environ 84:133–143. https://doi.org/10.1016/j.atmosenv.2013.11.035

[11]. Chen SJ, Lin TC, Tsai JH, et al (2013) Characteristics of indoor aerosols in college laboratories. Aerosol Air Qual Res 13:649–661. https://doi.org/10.4209/aaqr.2012.07.0176

[12]. Berico M, Luciani A, Formignani M (1997) Atmospheric aerosol in an urban area - Measurements of TSP and PM10 standards and pulmonary deposition assessments. Atmos Environ 31:3659–3665. https://doi.org/10.1016/S1352-2310(97)00204-5

[13]. Pope III CA, Burnett RT, Thun MJ, et al (2002) Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution. J Am Med Assoc 287:1132–1141

[14]. Sahu D, Kannan GM, Vijayaraghavan R (2014) Carbon black particle exhibits size dependent toxicity in human monocytes. Int J Inflam 2014:. https://doi.org/10.1155/2014/827019

[15]. Arsal Yıldırım S, Pekey B, Pekey H (2020) Assessment of occupational exposure to fine particulate matter in dental prosthesis laboratories in Kocaeli, Turkey. Environ Monit Assess 192:. https://doi.org/10.1007/s10661-020-08620-8

[16]. McGuire S (2016) World Cancer Report 2014. Geneva, Switzerland: World Health Organization, International Agency for Research on Cancer, WHO Press, 2015. Adv Nutr 7:418–419. https://doi.org/10.3945/an.116.012211

[17]. Sahu V, Gurjar BR (2020) Spatial and seasonal variation of air quality in different microenvironments of a technical university in India. Build Environ 185:107310. https://doi.org/10.1016/j.buildenv.2020.107310

[18]. Turner PD (1997) Indoor Air Quality Guidelines for Pennsylvania Schools. Paper 12

[19]. Wang K, Chen F er, Au W, et al (2019) Evaluating the feasibility of a personal particle exposure monitor in outdoor and indoor microenvironments in Shanghai, China. Int J Environ Health Res 29:209–220. https://doi.org/10.1080/09603123.2018.1533531

[20]. Idris SA ‘Ainaa,’ Hanafiah MM, Ismail M, et al (2020) Laboratory air quality and microbiological contamination in a university building. Arab J Geosci 13:. https://doi.org/10.1007/s12517-020-05564-8

[21]. Ścibor M, Bokwa A, Balcerzak B (2020) Impact of wind speed and apartment ventilation on indoor concentrations of PM10 and PM2.5 in Kraków, Poland. Air Qual. Atmos. Heal. 13:553–562

[22]. Ahmed Abdul–Wahab SA, En SCF, Elkamel A, et al (2015) A review of standards and guidelines set by international bodies for the parameters of indoor air quality. Atmos Pollut Res 6:751–767. https://doi.org/10.5094/APR.2015.084