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Comparative Assessment of Indoor and Outdoor Air Quality in the Close Vicinity of Canteens

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Abstract

Clean and pure air is an essential parameter for a safe and inhabitable environment. People have the tendency to spend most of their time at indoors or at confined places. This makes it important to maintain the indoor air quality to prevent any inconvenience. The canteens in a university are the places where students visit more often for food and refreshments. The cooking fumes from canteen are of particular concern as they affect the health of human beings. The objective of present study is to monitor and compare indoor and outdoor air quality on selected parameters (PM2.5 & PM10) of three major canteens located inside the campus of Jamia Millia Islamia (JMI). Concentrations of PM2.5 and PM10 have been monitored continuously for three consecutive days (two working and 1 non-working) for each site (six sites). The data have been collected for 8 hours at ten minutes interval. The air qualities for indoor and outdoor sites have been monitored at the same time with two separate devices. The collected data have been analyzed to understand temporal variation and compare indoor and outdoor air quality. The sites monitored are much polluted with high concentration of particulate matter (PM10 and PM2.5) exceeding the standard given by the CPCB. The Indoor/Outdoor ratio is also high.

Keywords: PM2.5, PM10, Indoor Air Quality, Outdoor Air Quality, Temporal variation

1. Introduction

The fumes generated in the process of cooking in the canteens at institutional areas negatively affect the air quality of sensitive places such as educational institute. Poor air quality is a serious problem for public health. Poor air quality in a university may be due to poor management of waste materials, lack of proper ventilation, irregular maintenance and cleaning. Canteen in a university is a place visited by many students and low quality of air may reduce their efficiency and also cause to several health problems. Health of those residing at places with high concentrations of particulate matter and dust particles is negatively affected ***(WHO, 2004;***

WHO, 2006). Poor Air Quality can be very harmful to small children, elderly people, teenagers and people with chronic health issues***(Cincinelli and Martellini, 2017)***. To avoid negative effects of poor air quality at indoors of institutional area factors affecting indoor air quality have been studied ***(Yang, 2017; Kraus and Nováková, 2019; Erlandson et al., 2019)***. Study has been done to draw a parallel contrast between particulate matter concentration at indoor and outdoor in a university of Iran ***(Mohammadyan et al., 2017)***.The canteens present at universities often have dining and cooking area very close to each other. Study has been conducted to examine concentration of particulate matter concentration inside a canteen in a public university located in Marmara region, Turkey ***(Gülgün DEDE and Cemile DEDE, 2021)***. The cooking fumes may be a major source generating particulate matter at indoors ***(Gysel et al. 2018)***. These fumes causes discomfort and negative health impact on people occupying the space ***(Neghab et al, 2017).*** Assessment has been made to understand the impact of emission from eateries into the outdoor environment ***(El Sharkawy and Ibrahim, 2022)***. Since indoor air quality is combination of indoor factors and outdoor air ***(Leung, 2015)***. Therefore, ***Alves et al. (2019)***have conducted a comprehensive air sampling campaign, both indoors and outdoors have been continuously monitored for pollutant like Carbonyls and VOC at university cafeteria, León (Spain). ***Zhao et al. (2010)***has studied concentration of Particulate matter at the cafeteria of three different university cafeterias and suggested the possible strategies to tackle the indoor air quality (IAQ) problem due to cooking. ***Zhang et al. (2017)***has monitored concentration of cooking particles generated at university canteen with open and closed cooking and it was observed that it effects the particle concentration significantly. Several other studies have also been done to assess the IAQ at eateries with different cooking styles ***(Dai et al., 2018; Elsharkawy and Javed, 2018; Sofuoglu et al., 2015; Taner et al., 2013; Wilson et al., 2011)***. ***Hsu and Huang (2013)*** have studied about the airflow, humidity and temperature along with the concentration of CO2 and total suspended particles at a student canteen at Chia-Nan University, Taiwan and assess the efficiency of disinfection treatments.

The aim of this study is to monitor the air quality of university canteens. Three major canteens at a central university in Delhi have been selected. All the canteens have both indoor and outdoor dining spaces. Indoor and outdoor concentrations of PM2.5 and PM10 of the three canteens have been compared. The I/O ratio graph for PM 2.5 and PM10 is also plotted to show the influence of outdoor and indoor air on each other.

2. Methodology

2.1 Monitoring Location and Time Period

In the present study indoor and outdoor seating area of canteen present inside the campus of Jamia Millia Islamia have been selected.All the sites have been monitored during spring season between the months of

February to April; each location has been monitored for 3 consecutive days (1 non-working; 2 working) from 9 am morning to 5 pm evening at 10 minutes interval. Table 1 shows monitoring location and time period.

Table1 Monitoring Locations and Time period

S.no.	Monitoring Locations	Latitude	Longitude	Monitoring Date
1	Site 1 FET (Faculty of Engineering and Technology) Canteen	28.559692°	77.278471°	16th February to 18th
2	Site 2 Central Canteen	28.562165°	77.280296°	12th March to 14th March
3	Site 3 Castro Café	28.558966°	77.283633°	9th March to 11th March

Figure 1 shows the location of canteens inside the campus. It can be observed that the FET Canteen is near the Faculty of Engineering and Technology, Central Canteen is present inside the main campus and Castro Café is farthest from the road.

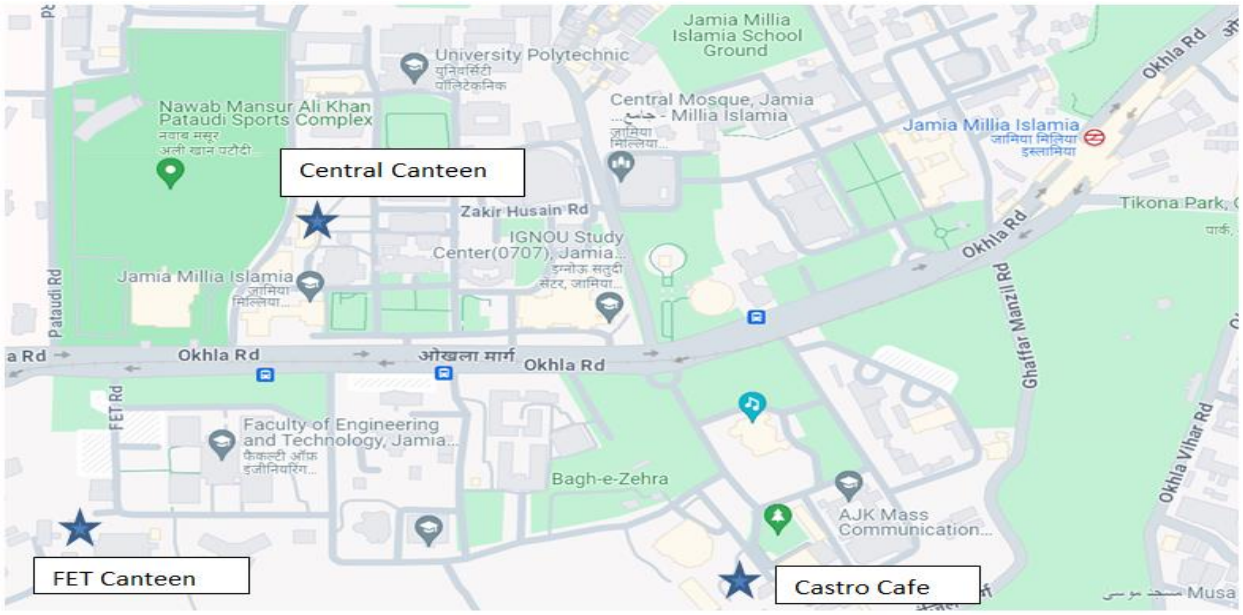

Figure 1: Monitoring locations

2.2 Monitoring Procedure

Proper monitoring procedure has been followed to collect data. The indoor and outdoor air quality has been monitored using an air sampler manufactured by SMILEDRIVE. The first step includes taking preliminary reading for one of the selected site so that possible obstacle is avoided while taking final readings. Indoor

and outdoor air quality has been monitored at the same time. The sampler is been placed at a distance of 1.5m from ground level and 1 m away from wall.

2.4 Data Collection and Analysis

Data have been collected for three continuous days for each site for eight hours continuous at ten minutes interval. Collected data have been analyzed to make a comparative assessment. The data collected have been used to analyze air quality on hourly and daily basis. Graph of pollutant concentration vs. time have been plotted for temporal and diurnal variation.

3 Results and Discussion

Variation of PM 2.5 and PM 10 during the months of February – March 2023 for the major canteens present at the university campus has been discussed in this part of the study. Comparison between indoor and outdoor has been done by monitoring air quality at the inner and outer sitting area of the canteen simultaneously. The collected data have been averaged on hourly basis.

Figure 2 shows Temporal Variation of FET Canteen at Indoor and Outdoor. PM concentration decreases from morning to evening. Maximum Hourly average concentration of PM10 and PM2.5 at indoor is between 9 am to 10am equal to 170.0556 and 152.889 μg/m3 respectively. For, outdoor maximum is between 10am to 11am equal to 146.83 and 112.83 μg/m3.

High Particulate Matter concentration at indoor may be due to the constant cooking that takes place to offer breakfast, lunch etc. to the students of the Faculty of Engineering and Technology. The other faculty students may come but the main crowd is from the students of Faculty of Engineering and Technology. The other sources for high PM concentration may be its being near parking for vehicles. The high PM concentration can also be due to the presence of some laboratories and workshops of engineering stream like Civil and Mechanical. The outdoor environment may also be impacted by the presence of Building Material lab for Civil Engineering students, workshops of foundry, welding and other works

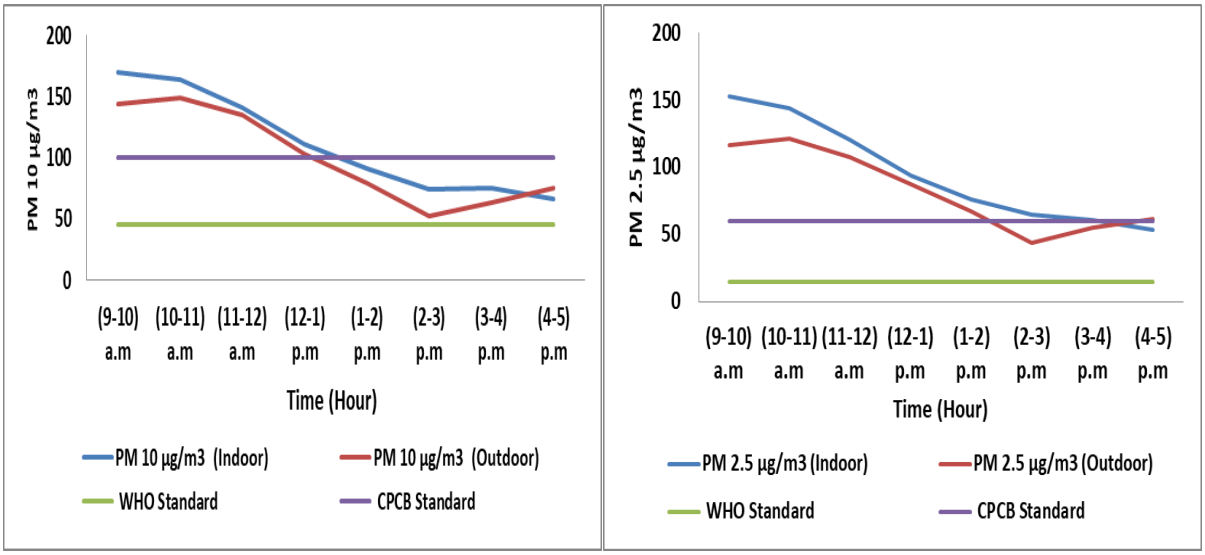

Figure 2 Temporal Variation of FET Canteen at Indoor and Outdoor

Figure 4shows Temporal Variation of Central Canteen at Indoor and Outdoor. Maximum Hourly average concentration of PM10 is between 3 pm to 4 pm equal to 382.44 µg/m3 and PM2.5 at indoor is between 2pm to 3pmequal to 159.33 µg/m3. For, outdoor maximum hourly concentration of PM10 and PM2.5 is between 10am to 11 pm equal to 110.67 and 100.67 µg/m3.

Central Canteen is the main and largest canteen of Jamia Millia Islamia. Situated at the main campus of the university, it is the most crowded canteen of the university and the only canteen that is fully functional even on Sundays. It has the maximum particulate matter concentration at indoor of the canteen all the sites monitored. This may be due to poor ventilation and presence of several food counters inside the canteen. The constant heating of food and other cooking activities have polluted the inner air substantially.

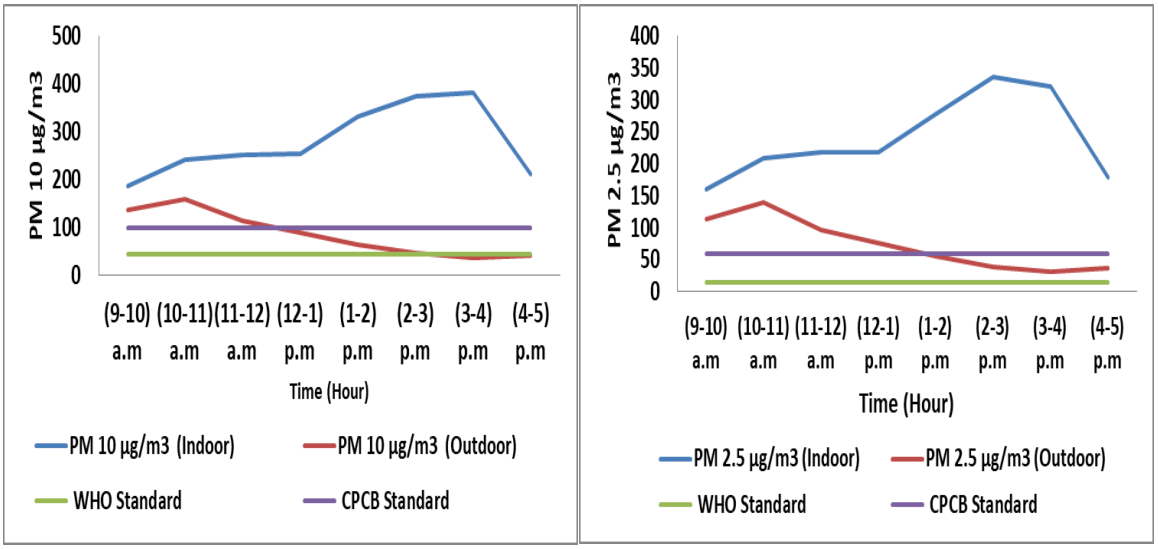

Figure 3 Temporal Variation of Central Canteen at Indoor and Outdoor

Figure 6shows Temporal Variation of Castro Café at Indoor and Outdoor. PM concentration decreases from morning to evening. Maximum Hourly average concentration of PM10 and PM2.5 at indoor is between 9 am to 10am equal to 131 and 118 µg/m3 respectively. For, outdoor maximum is between 9 am to 10 pm equal to 102.83 and 90.944 µg/m3.

Castro Cafe is the most fancy of all the three canteens monitored. It has nice facilities, good utensils and the most hygienic of all the canteens. It is the most well ventilated canteen and has least concentration of PM10 and PM2.5 at both indoor and outdoor. This may be due to being far away from the main road and absence of any faculty near the canteen.

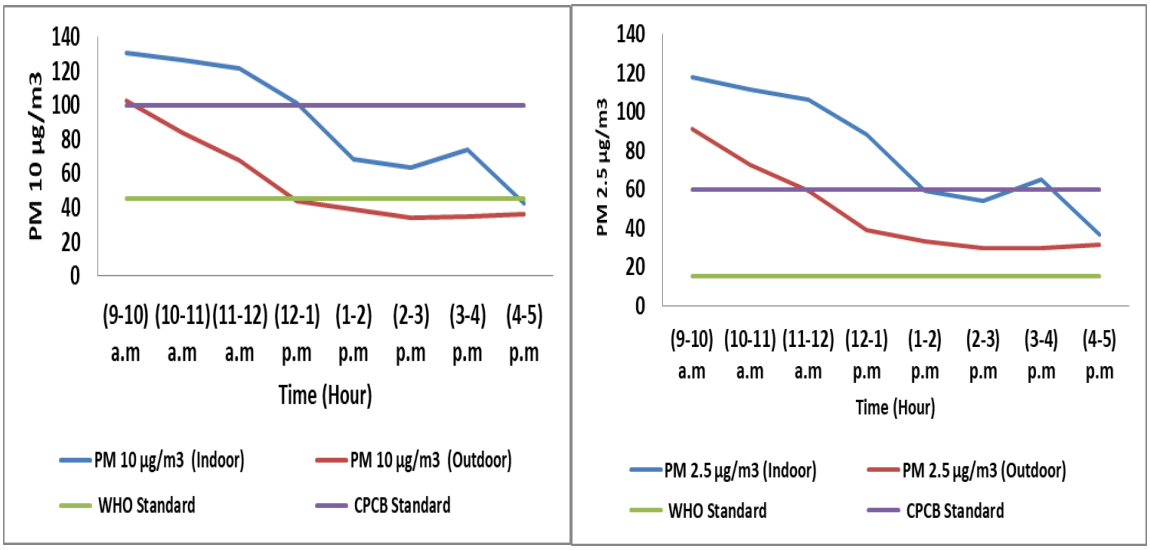

Figure 4 Temporal Variation of Castro Cafe at Indoor and Outdoor

It is observed that the outdoor concentration of PM10 and PM2.5 is less at all the three canteens for most of the time as shown in Figure- 2, 3 and 4. It can be due to the rainfall which occurred several times during the month of March 2023. The indoor PM concentration decreased at FET canteen and Castro canteen from morning to evening except the indoor of Central canteen. This can be due to the reason that the FET canteen and Castro canteen generally works till lunch time, but the Central canteen is main canteen which is opened until night time.

Upon analysis of PM10 and PM2.5 measurement results it was found that PM concentration is most in canteen with more number of peoples i.e. the Central Canteen. It can be observed that increase in PM concentration measured in canteen is effective only for one hour after that it decreases. As seen in FET Canteen (Figure 2) between 10am-11am, in Central Canteen (Figure 3) between 3 pm -4pm and in Caste

Café (Figure 4) 12 am-1pm. While examining the PM10 and PM2.5 levels inside every canteen, it was noticed that in all cases the values exceeded the WHO specified standard i.e. 45µg/m3 and 25 µg/m3 [22]. In general, PM10 and PM2.5 level varies between 42.11 –382.44µg/m3 and 36.66 – 336.38µg/m3 respectively. ***Zhu (2015)***has studied concentration of Particulate matter at inside and outside and suggested the possible strategies to tackle the indoor air quality (IAQ) problem due to cooking. Zhu found that particulate matter concentration is significantly high in canteens. Zhu concluded that uncirculated air also increases PM concentration[23].**Kumar and Jain** monitored PM concentration in an institutional area. Of all the sites canteens had the highest PM concentration. Average PM10 and PM2.5 concentration was between PM10: 138 ± 34.19µg/m3and PM2.5: 87 ± 26.45 µg/m3 respectively [24].

Figure 7 shows PM10 and PM2.5 concentration of FET Canteen, Central Canteen and Castro Café during morning (9 am-10 am), lunch time (1 pm-2 pm) and evening (4 pm-5 pm). During lunch time Central Canteen has the maximum particulate matter concentration equal to 331.67µg/m3. PM Concentration at the Central Canteen is more than CPCB for all the three time period. Castro Café has minimum concentration during lunch time equal to 75.94µg/m3.

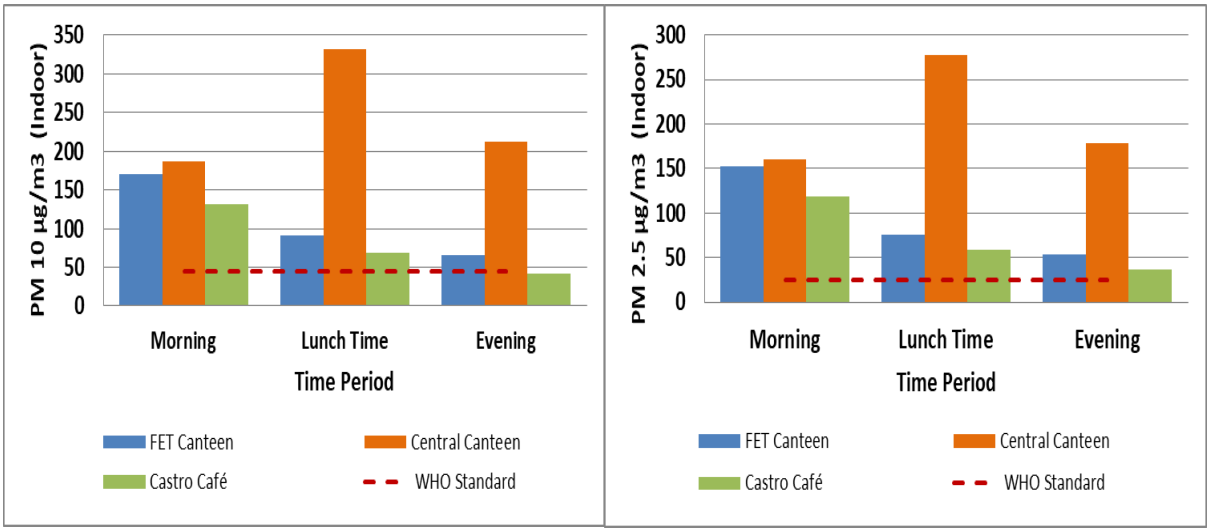

Figure 7 Particulate Concentrations during Morning, Lunch Time and Evening

At the FET Canteen and Castro Café the PM concentration is more in the morning. This can be because in the morning time the kitchen is cleaned and most of the cooking activity starts at this time (During Lunch time only serving takes place). At Central Canteen the PM Concentration is most during lunch time. This is due to the fact Central Canteen is the main canteen therefore the busiest canteen and constant cooking takes place.

During evening the Particulate matter concentration at the FET Canteen and Castro Café is less than CPCB and WHO standards because the canteen almost closes at this time. On the other hand at the Central canteen it is still above the standard value, this can be because the Central Canteen operates till night time

I/O Ratio Graph

I/O ratio is used to represents an easy to understand relationship between the Particulate concentration at indoor and at outdoor. Graphical representation of I/O ratio provides a simple and summarized effect of indoor and outdoor particulate concentration on each other. Figure 8 shows I/O ratios of PM10 and PM 2.5. Indoor/Outdoor ratio of PM10 and PM2.5 is highest for central canteen for working days. Maximum I/O ratio for PM10 and PM2.5 concentration is for non-working day is also for central canteen. Working days had higher I/O ratio than non-working days.

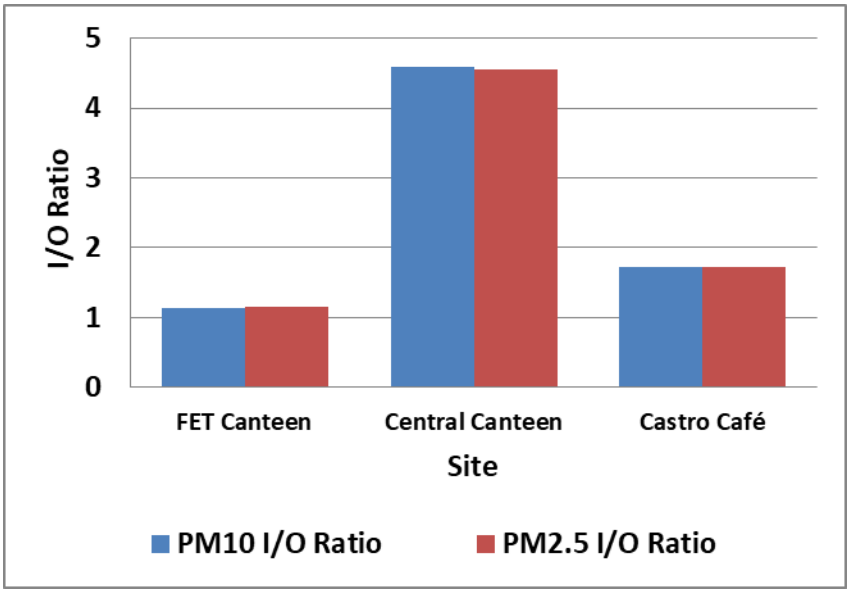

Figure 4.16I/0 ratio of PM10 and PM 2.5

From the graph shown above it is observed that Central Canteen (4.5) has highest I/O ratio followed by Castro Café (1.72) and FET Canteen (1.55) has lowest. Higher I/O ratio inside the Central Canteen indicates higher pollutant concentration inside the canteen when compared with ambient air concentration

4 Conclusions

While examining the results from the present investigation it is found that the concentrations of PM2.5 and PM10 it was noticed that concentration of both is more than World Health Organization (WHO) standard. This high concentration of PM can be very harmful to the health of occupant and may reduce their efficiency.Indoor particulate matter concentration is higher than outdoor maybe due topoor ventilation,

indoor activities like constant cooking and poor circulation of particles in the air. Higher I/O Ratio at the Canteens can be due to them being poorly ventilated that restricts flow of air with PM outside the canteen. Therefore it is suggested to provide proper ventilation to disperse the particulate matter and improve the air quality

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