INTERNATIONAL JOURNAL FOR INNOVATIVE RESEARCH IN MULTIDISCIPLINARY FIELD ISSN: 2455-0620 Volume - 6, Issue - 7, July – 2020
Monthly, Peer-Reviewed, Refereed, Indexed Journal with IC Value: 86.87 Impact Factor: 6.719
Received Date: 27/06/2020 Acceptance Date: 13/07/2020 Publication Date: 31/07/2020

Assessment of Current Concentration of Particulate Matter in the Indoor Air on AIT Campus

[1]Shahla Sharifi, [2]Shakeba Faqery
[1]Master of Environmental Engineering Management,
Faculty of Engineering, Balkh University
[2]Professor of Biology &Head, Department of Biology, Faculty of Education, Balkh University
Email: [1]Sharefi.shahla@gmail.com, [2]shakebafaqery16@gamil.com

Abstract. Indoor *pollutants concentration, including PM2.5, PM10 and TSP had been monitored in distinctive locations within the AIT campus, located in the Northern suburb of Bangkok Region. Sampling turned into performed at: Environmental Engineering Laboratory (EEM Lab), scholar villages (SV), Standard dormitory, EEM workplaces and classroom. All samples have been collected during dry and rainy seasons 2018The indoor level of PM2.5, PM10 and TSP were found highest within the accommodation campus, with 45.1 µg/m3,150.7 µg/m3,160.4 µg/m3, severally. office one had all-time low concentration of all PM2.5, PM10 and TSP, however the concentration within the room and laboratory were over the WHO guideline. The room and dormitory standard room had PM10 concentrations over the WHO guideline. For the magnitude relation of PM2.5 to TSP, some variations may be discovered, starting from 0.47 in SV to 0.73 in office. Higher level of stuff concentration was found throughout cooking in AIT. The survey was conducted at completely different AIT clusters. The survey was conducted with 166 respondents. Among on campus accommodations concerning 55 percent of the campus accommodations have kitchen within the house (attached kitchen), 30 percent of the homes have separated kitchen and 15 percent don't have kitchen. Among the full classroom designated for the survey, concerning 63 percent of the lecture rooms failed to have windows. concerning 97% of students felt some symptoms throughout class time. Among the full workplace samples, about 62.5 percent of the offices did not have windows. Of all the respondents, 13 folks thought of smart indoor air quality within the areas*.

Keywords: *Indoor air quality. PM2.5, PM10 and TSP ·Exposure assessment · AIT ·University classroom · Bangkok.*

1. INTRODUCTION:

Indoor pollution started back within the primal times once individual's determinate at one place in community and commenced victimization hearth for heat, preparation and lightweight. Biomass fuel burning is one among the most important sources of indoor pollution. (IAP) caused by fine particulates with a diameter capable or not up to a pair of.5 µm (PM2.5), this PM2.5 is liable for the death of quite 1,000,000 individuals worldwide annually. Indoor PM emissions are liable for incidence of appreciable health hazards appreciate metastasis diseases (acute and chronic), respiratory organ run-down, respiratory disorder and high premature births (Atmane&Dupert,2003)). Recently, pollution (indoor and outdoor) is listed because the world's largest single environmental health risk with the ever-increasing association to the incidence of heart and blood vessels diseases and cancer (Kim,2004).

AIT is a global institute wherever students and staffs from totally different countries stay on the campus. though there's no solid fuel use for cookery and heating in AIT, data on indoor pollution during this community are terribly restricted. totally different activities within the field, as well as operating in laboratory, attending room, staying in dormitory, could result in totally different levels of indoor pollution. Primary assessment of the folks living in AIT has been found that some symptoms, like headache, nausea, are complained from AIT residents. The study was conducted within the AIT field. AIT field was based in 1959, located in Pathum Thane province, concerning forty kilometers north of national capital, Thailand. Accommodation space takes most of the AIT area. or so, AIT encompasses a population of 2,943 in 2015. The age of the building's ranges from twenty to fifty-five years within the campus. during this study, sampling was conducted at six locations: Environmental Engineering Laboratory (EEM Lab), student villages (SV), standard dormitory, EEM offices and classroom. All the samples were collected throughout dry and rainy seasons at 2018.

2. MATERIALS AND METHODS:

The study was conducted within the AIT campus. AIT campus was supported in 1959, placed in Pathum Thane province, regarding forty kilometers north of capital of Thailand. Accommodation space takes most of the AIT area. The age of the building's ranges from twenty to fifty-five years within the campus. During this study, sampling was conducted at six locations: Environmental Engineering Laboratory (EEM Lab), student villages (SV), standard dormitory, EEM offices and classroom. All the samples were collected throughout dry and rainy seasons at 2018. The survey was conducted at totally different AIT clusters (staffs, students and family). In this study the sampling size calculation was based on the Taro Yamane formula (Yamamoto et al., 2014).

$$n = \frac{N}{1+N(e)^2}$$

Where: N= total population of AIT community
e = error limit (5-10 % will be taken)
n = sample size

The level of pollutants. $PM_{2.5}$, PM_{10} and TSP were obtained through the monitoring of indoor air pollution. The concentrations of the pollutants were obtained by two IAP monitoring devices, Aerocet 531S Handheld Particle Counter and personal pump Air check sampler (model 224- PCXR8, SKC – USA). Personal Environmental Monitor pump SKC (Aircheck Sampler Model 224-PCXR8), was accustomed collect total suspended particles (TSP) at a pumping rate of 4 L/min. The PTFE Membrane Filter 0.45µm by 47mm diameter was used, that were pre-fired at 60°C for a minimum of two hours.

Table 1: Summary of Indoor Air Pollution Monitoring Schedule

Sites	Specification		No of days	Date	
				Dry Season	Rainy Season
SV (Student Village)	VC & NVC Cooking, non-cooking		20	15,17,20,26 July 2018 1-5, 12,19 August 2018	1-7 September 2018 20,22 October 2018
Standard Room –56 J	VC & NVC Cooking, non-cooking		11	28,29 July 2018 8,15,29,30 August 2018	2,26 September 2018 8-10 October 2018
Classroom (E222)	Weekdays	VC & NVC	17	16,18 July 2018 16,24,30,31 August 2018	1,2 October 2018
	Weekend	VC & NVC		12,19 August 2018	2,3,23,15,16 September 2018 & 6, 7 October 2018
EEM Secretariat Printer Office	Weekdays	VC & NVC VC & NVC	14	18-20 July 2018 31 August 2018	11,12 September 2018 & 5 October 2018
EEM Laboratory	Weekdays		10	27 July 2018	28,29 September 2018 & 3,4 October 2018
	Weekend			25,26 August 2018	8, 9 September 2018

VC ventilation Condition
NVC Non-ventilation Condition

2.1 Questionnaire survey:

Among the total on campus accommodations samples about 55 percent of the campus accommodations have kitchen inside the house (attached kitchen), 30 percent of the houses have separated kitchen and 15 percent don't have kitchen. Around 65 percent of the houses of the total accommodations used LPG cook stoves as the main stoves, followed by Liquefied Petroleum Gas (LPG) stoves. The remaining 35 percent of the houses used electricity stoves for cooking.

All respondents have felt that indoor air pollution was related to different symptoms they experienced in AIT. All the campus accommodations have mechanical ventilation and /or windows for ventilation.

Among the total respondents 85 people were 30-40 years 67 were less than 30 Y. Figure 1: shows the compression of IAQ in three study area.

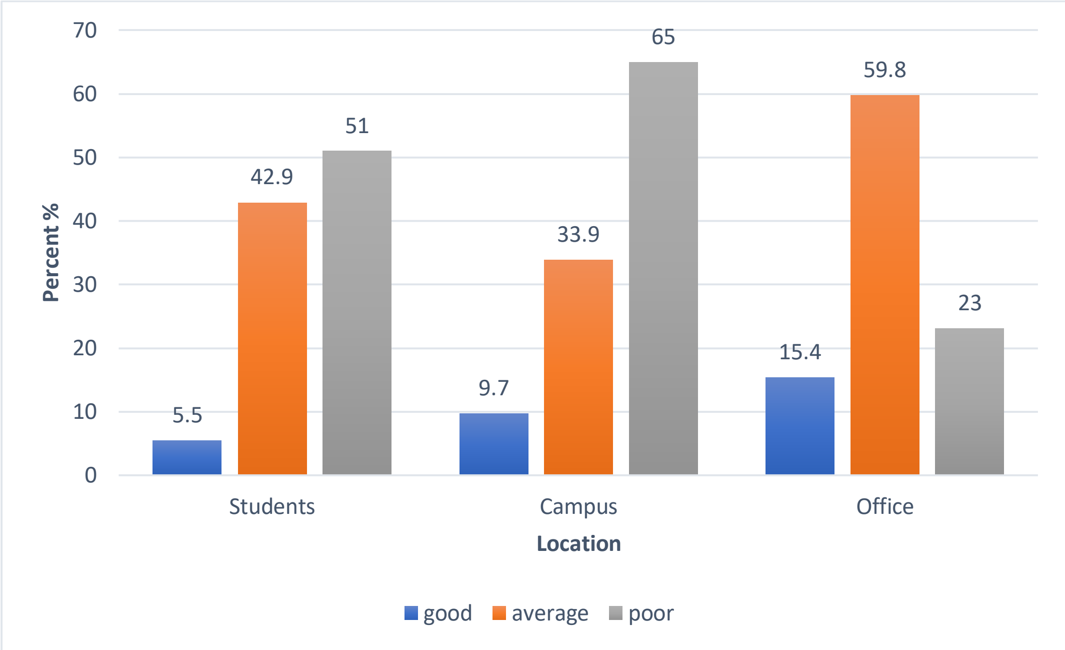


Figure 1: Perception of IAQ in three target areas

When comparing, it was found that 51% of students, 65% of resident and 23 % of office respondents considered poor IAQ. Ventilation system is one of the major causes of indoor air pollution. If the smoke from indoor activities, such as cooking cannot go out of the room, the pollutant would be built up to higher concentration. According to the survey data. People believed that they were having proper ventilation system in their dorms.

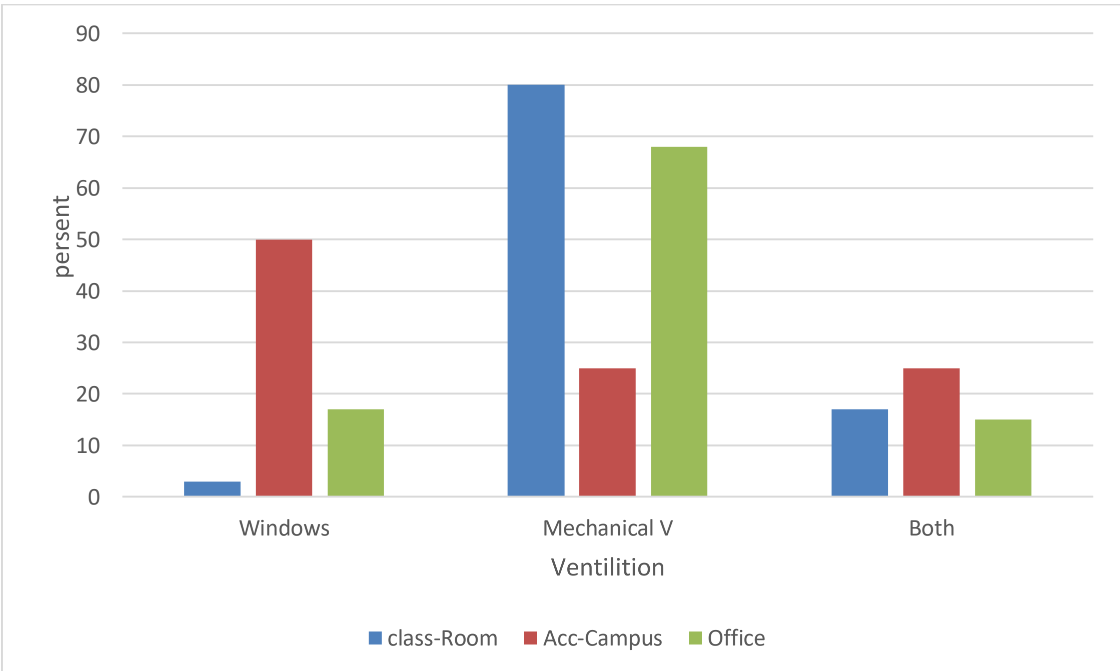


Figure 2: Ventilation facilities in three target areas

22 % of the classroom, 17 % of campus accommodation and 15 % of offices were ventilated by both mechanical and windows. Figure 2: shows ventilation facilities in three target areas.

INTERNATIONAL JOURNAL FOR INNOVATIVE RESEARCH IN MULTIDISCIPLINARY FIELD ISSN: 2455-0620 Volume - 6, Issue - 7, July – 2020
Monthly, Peer-Reviewed, Refereed, Indexed Journal with IC Value: 86.87 Impact Factor: 6.719
Received Date: 27/06/2020 Acceptance Date: 13/07/2020 Publication Date: 31/07/2020

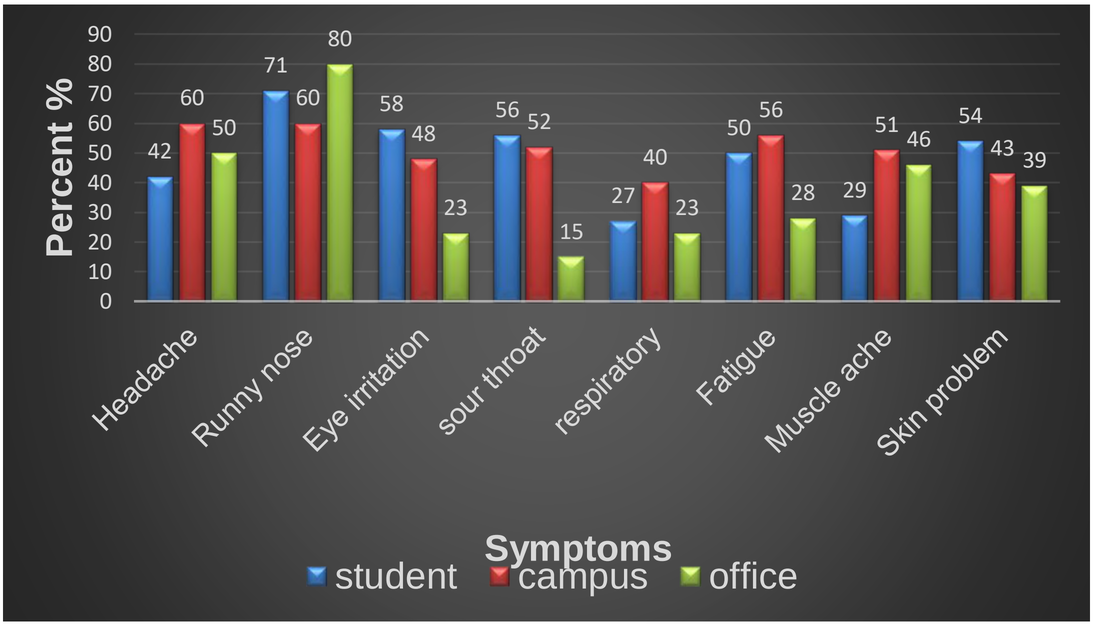


Figure 3: Symptoms statistics in three study area

When comparing within the scale of IAQ in tree target area, respondents got at least one acute symptom in AIT. Figure 3: shows symptoms statistics in three study area.

2.2 Monitoring:

The indoor air quality monitoring was conducted in the dry and rainy season (from July to October 2018). In this study the Aerocet 531S Handheld Particle Counter and personal pump Air check sampler (model 224- PCXR8, SKC – USA) were used for monitoring. Indoor air quality was monitored in all selected places to investigate levels of indoor air quality in different area. The sampling duration for each sample was 24-hours.

The monitoring results included total 1728 measurement pairs of $PM_{2.5}$ and PM_{10} and 1765 measurements of TSP in all the monitoring sites. The characteristics of indoor environment in the selected locations are shown in Table 2.

Table 2: Summary of Sites Characteristics

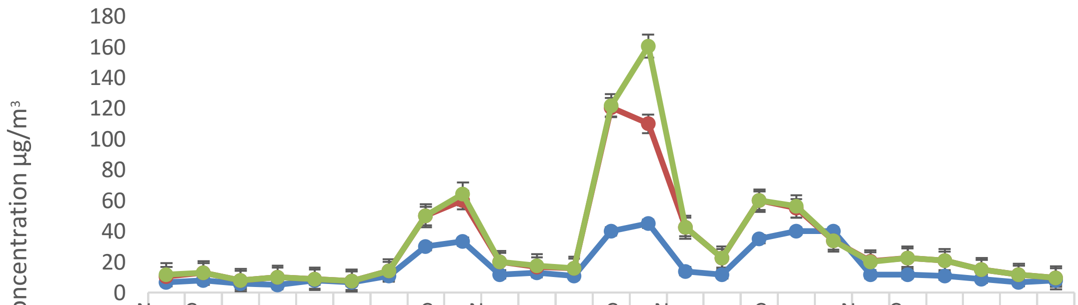
Characteristics	SV (kitchen)	Standard room	Classroom	Office 1	Office 2	Laboratory
Age(year)	More than 20	20	10	10	15	15
Volume(m^3)	8	30	162	75	45	224
Surface area (m^2)	20	10	36	30	15	168
Roof material	Concrete	Concrete	Concrete	Concrete	Concrete	Concrete
Floor Type	Cement	Cement	Cement	Cement	Cement	Cement
No of window	2	2	0	3	0	2
No of door	1	1	2	1	1	4
Ventilation type	Open windows	Standard AC	Standard AC	Open windows and Standard AC	Standard AC	Standard AC

i. Levels of $PM_{2.5}$, PM_{10} and TSP in the campus accommodation student village (SV) by Aerocet 531S Handheld Particle Counter

Diurnal variation under different conditions during study period (15th July 2018 to 22th October 2018) is shown in Figure 4. The values showed the fluctuation during different times of the day. The most noteworthy concentration of PM2.5, PM10 and TSP showed up amid cooking time (stamped as "C" in Figure 4). Opening the windows and utilizing washroom ventilation framework made a difference for the ventilation and decrease outflow concentration in family.

The lower PM concentration, amid morning and evening cooking compared to lunch cooking happened since littler parcel of nourishment cooked. Hourly normal diurnal PM2,5 concentration extended from 7.4 to 40.1, µg/m3.

The normal PM10 concentration extended from7.8 to 120.7 µg/m^3 and the TSP concentration extended 7.8 to160.7 µg/m3. The greatest concentration showed up amid lunch cooking, with the esteem of 10 times higher than the normal values amid non – cooking period



	Non-C							C	Non-	c			C	Non-	c		C		Non-	C					
	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	24:00:00
PM2.5	7	8	6	5	8	7	11	30	33	12	13	11	40	45	14	12	35	40	40	12	12	11	9	7	8
PM10	11	13	8.2	10	8.9	7.8	14	50	60	20	17	16	121	110	43	23	60	55	34	20	23	21	15	12	9.8
TSP	12	13	8.2	10	9.1	7.8	15	50	64	20	18	16	122	161	43	23	60	56	34	20	23	21	15	12	9.8

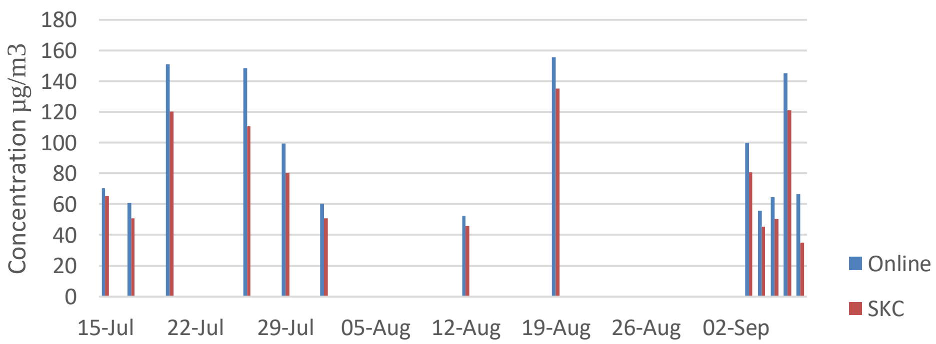
Time

Figure 4: Diurnal variation of PM during cooking and non-Cooking time in accommodation campus (SV)

As seen in Figure 4 comparable worldly variety of particulate things were watched in all cooking occasions. Figure 4 uncovered that PM2.5, PM10 and TSP were by and large most noteworthy amid 6:00- 8:00, 12:00- 2:00 and 6:00- 8:00, when cooking exercises happened. This relationship between indoor activates and the high PM concentration was also well reported in the previous studies conducted by Klinmalee et al. (2009) in Thailand and Etal (2003) in China.

ii. Levels of $PM_{2.5}$, PM_{10} and TSP in the campus student village (SV) by Personal Environmental Monitor pump SKC.

The Aerocet and SKC gadgets were utilized at the same time and date for co- checking of poison concentration. Amid checking separate between two gadgets was almost two meters. The gadgets were set 1.5 meters from the ground to speak to human presentation test. Figure 5 appears 2-hr concentration of TSP on campus convenience (SV- 50) by two gadgets.



	15-Jul	17-Jul	20-Jul	26-Jul	29-Jul	01-Aug	12-Aug	19-Aug	03-Sep	04-Sep	05-Sep	06-Sep	07-Sep
Online	70.4	60.7	150.8	148.5	99.6	60.2	52.3	155.7	99.8	55.7	64.7	145.2	66.5
SKC	65.3	50.7	120.4	110.7	80.3	50.7	45.6	135.4	80.6	45.2	50.5	120.9	35.2

Date

Figure 5: Concentration compression of TSP on campus accommodation (SV- 50)

TSP concentration ranged from 34.7 to 160.4 µg/$m^3$with the online device monitoring, and TSP concentration ranged from 27.7 to 159.5 µg/m^3 with the SKC device monitoring. Concentration of TSP measured by the Online and SKC were almost the same with only 2- 9 % difference. With this study, the concentration by the online device monitoring is higher.

2.2.3 Levels of $PM_{2.5}$, PM_{10} and TSP in the classroom

In AIT classroom, sampling was conducted for 17 days including eight weekdays and nine weekends, both with ventilation and non-ventilation.

During the weekends, when the sampling was collected, there was no student in the classroom. Therefore, sampling on weekdays, represented high-occupancy period while sampling on weekends represented the non-occupancy period.

In the classroom, indoor air pollution levels were generally fluctuated from day- to- day, depending on the classroom occupancy. Figure 6 shows, the average 19 hours concentration of $PM_{2.5}$, PM_{10} and TSP in the classroom on weekdays. On weekends when there was no student in the classrooms, the pollutant levels were lower than the pollutant levels on weekdays.

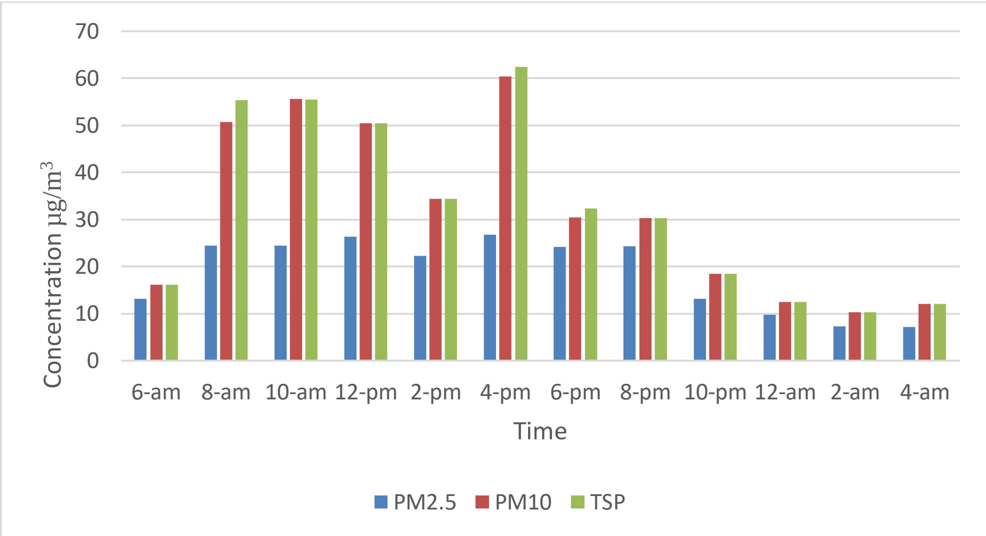


Figure 6: Average 24- hours concentration of $PM_{2.5}$, PM_{10} and TSP in the classroom on weekdays

As show in the Figure 7, the repeated fluctuation of the pollutants has occurred because of changing classes in a day and the indoor level of $PM_{2.5}$, PM_{10} and TSP were higher. The level of $PM_{2.5}$ changed from 7.3 to 26.7 µg/m^3, the PM_{10} changed from 10.3 to 60.4 µg/m^3, and TSP changed from 10.3 to 60.4 µg/m^3.

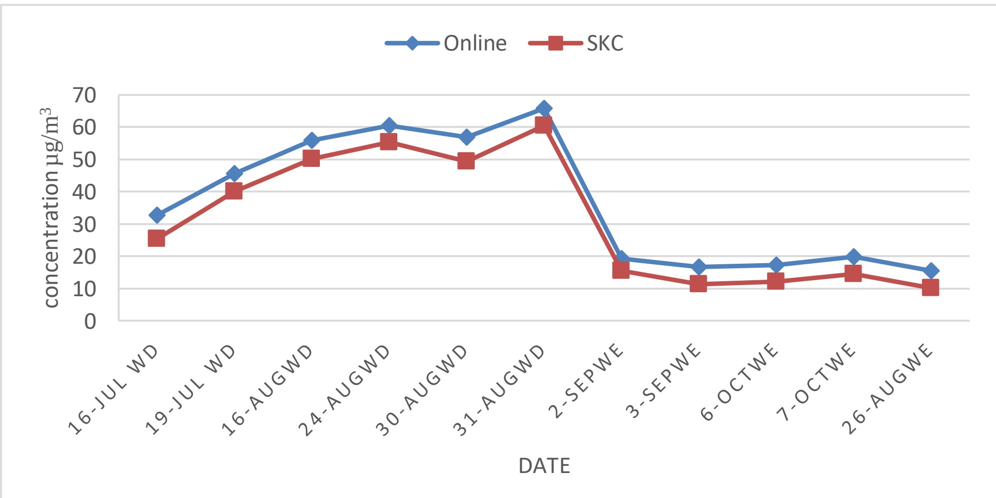
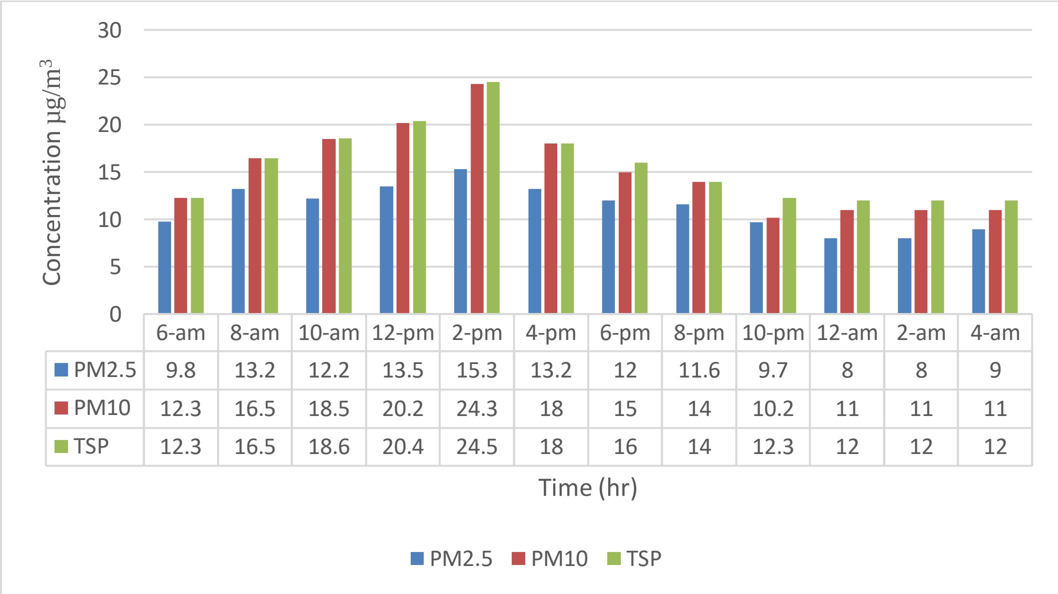


Figure 7: TSP concentration in the classroom by two devices

As seen in Figure 7, similar temporal variation of particulate matters was observed for both devices. TSP concentration ranged from 15.6 to 65.8 μg/m^3 with the online device monitoring, and TSP concentration ranged from 10.2 to 60.5 μg/m^3 with the SKC device monitoring. Concentration of TSP measured by the Online and SKC were almost the same with only 2- 9 % differences. The concentration by online device monitoring is higher.

2.2.4 Levels of $PM_{2.5}$, PM_{10} and TSP in the offices

There are total 14 days monitoring conducted at two sites, including two offices. In the selected offices, sampling was divided into ventilation and non- ventilation period. Figure 8 shows the average 24 hours concentration of $PM_{2.5}$, PM_{10} and TSP in the secretary office with windows and AC ventilation on weekdays.



	6-am	8-am	10-am	12-pm	2-pm	4-pm	6-pm	8-pm	10-pm	12-am	2-am	4-am
PM2.5	9.8	13.2	12.2	13.5	15.3	13.2	12	11.6	9.7	8	8	9
PM10	12.3	16.5	18.5	20.2	24.3	18	15	14	10.2	11	11	11
TSP	12.3	16.5	18.6	20.4	24.5	18	16	14	12.3	12	12	12

Figure 8: Concentrations of $PM_{2.5}$, PM_{10} and TSP on Office 1

AS seen, in the office with opened windows and AC on the weekdays, the lower levels of $PM_{2.5}$, PM_{10} and TSP were observed during ventilation time. The type of ventilation facilities in the office 1 was both windows and AC, the door was open all the time in the office.

The hourly average $PM_{2.5}$ concentration ranged from 8 to 15.3 μg/m^3, average PM_{10} concentration ranged from11 to 24.5 μg/m^3, and TSP concentration ranged from 12 to 24.5 μg/m^3 with ventilation.

PM concentration on ventilation time was lower than, indoor standard (WHO,2005). Monitoring also conducted on non-ventilation time. Figure 9 is shown the concentration of pollutants on ventilation and non-ventilation periods.

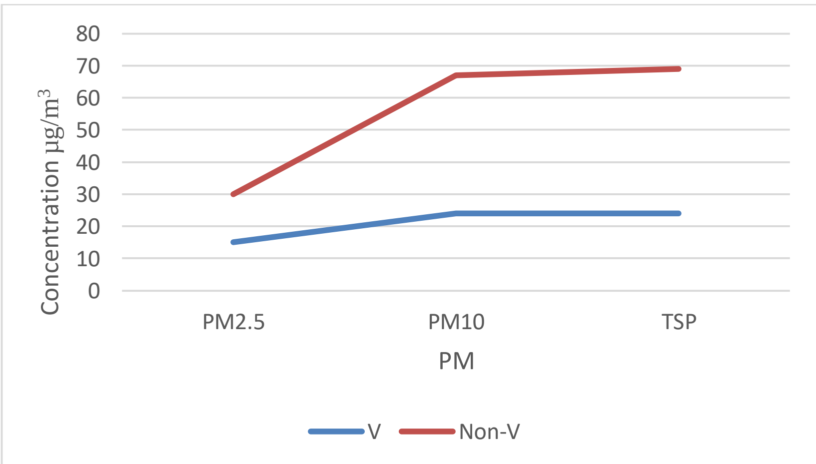


Figure 9: Concentrations of $PM_{2.5}$, PM_{10} and TSP in the office 1 with and without ventilation

The TSP levels ranged from 69 to 24 μg/m^3. The levels of PM_{10} ranged from 67 to 24 μg/m^3 and $PM_{2.5}$ ranged from 30 to 15 μg/m^3 by two hours ventilation. According to the ventilation, PM_{10} was reduced to 43 μg/m³ from 67 μg/m³.

INTERNATIONAL JOURNAL FOR INNOVATIVE RESEARCH IN MULTIDISCIPLINARY FIELD ISSN: 2455-0620 Volume - 6, Issue - 7, July – 2020
Monthly, Peer-Reviewed, Refereed, Indexed Journal with IC Value: 86.87 Impact Factor: 6.719
Received Date: 27/06/2020 Acceptance Date: 13/07/2020 Publication Date: 31/07/2020

Our results provided evidence that increasing office ventilation was effective in decreasing the concentrations of some indoor pollutants. People activities significantly increased the particulate matter, which inevitably influenced the levels of PM_{10} and $PM_{2.5}$ in every area, suggesting that the indoor concentration was potentially affected by people activity.

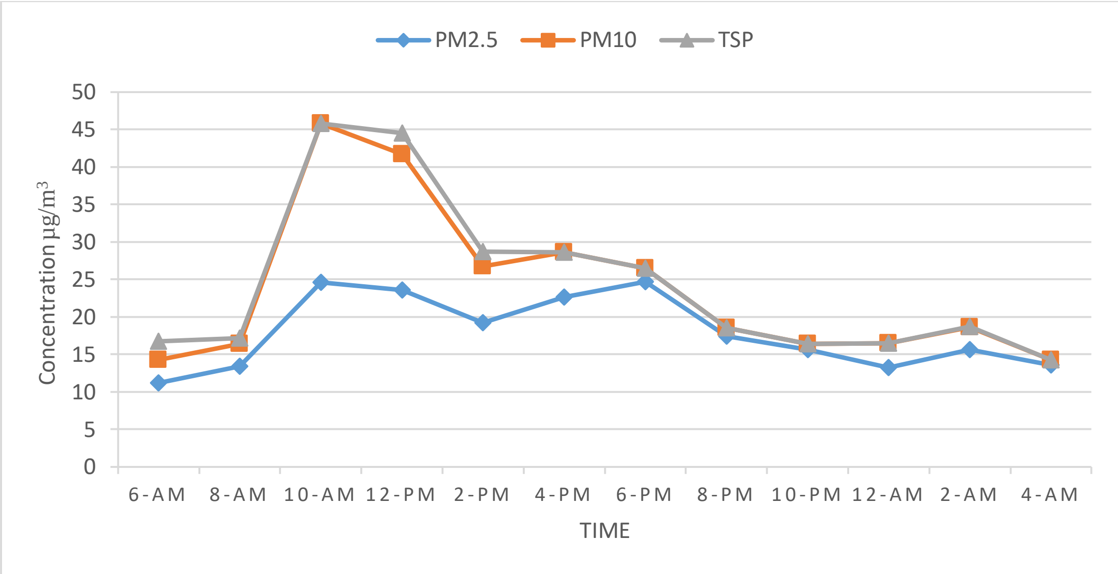


Figure 10: Average 24 h concentration of $PM_{2.5}$, PM_{10} and TSP on office2 with and without ventilation on weekdays

The concentrations of $PM_{2.5}$, PM_{10} and TSP in the office 2 is presented in Figure 10. The TSP levels ranged from 14.3 to 45.8 µg/m^3 the PM_{10} ranged from 14.3 to 45.8 µg/m^3, rate of $PM_{2.5}$ varied between 11.2 and 24.6 µg/m^3. The levels of $PM_{2.5}$, PM_{10} and TSP in office 2 were higher than the indoor concentration, in office 1. The indoor levels of $PM_{2.5}$, PM_{10} and TSP in these two offices during ventilation periods were all lower than standard (WHO, 2005).

2.2.5 Levels of $PM_{2.5}$, PM_{10} and TSP in the EEM Laboratory

In the EEM Laboratory, sampling was conducted for 10, days including five weekdays and five weekends. During the sampling, all doors were closed. During the weekends, when the sampling was conducted, there were some students. The indoor air pollution levels were generally fluctuating from day- to- day depending on the laboratory occupancy. When no students were in the laboratory the pollutant levels were lower.

The higher concentration of PM was found during student's laboratory session and during 8-10 pm. The level of $PM_{2.5}$ ranged from 8.9 to 30.2 µg/m^3, PM_{10} ranged from 10.1 to 55.3 µg/m^3 and TSP ranged from 10.1 to 60.5 µg/m^3.

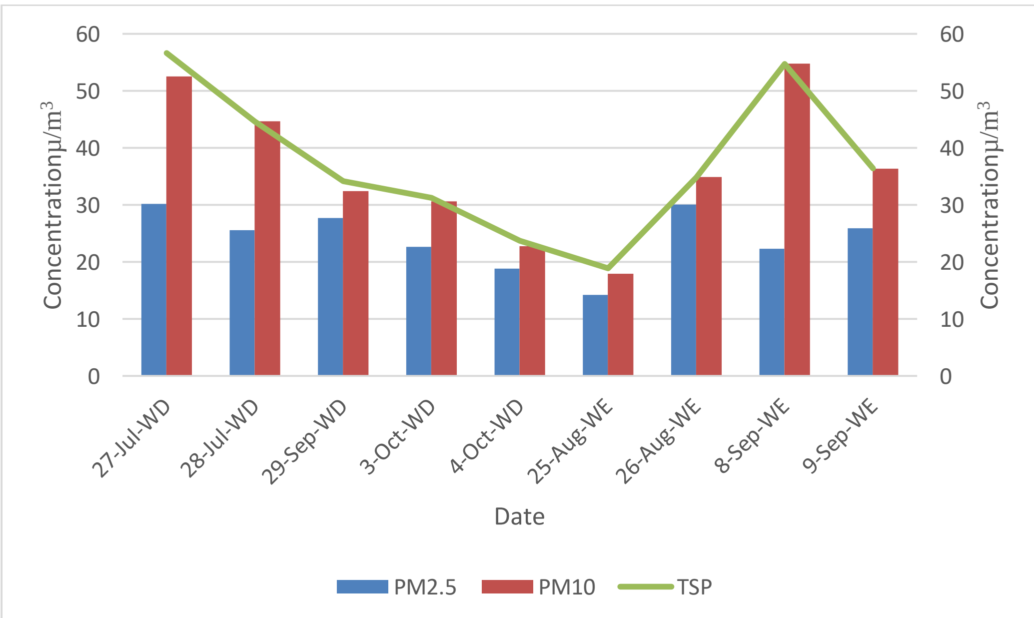


Figure 11: The average 24 hours concentration of $PM_{2.5}$, PM_{10} and TSP in the EEM Laboratory

WD-week days
WE-Weekend

2.2.6 Exposure assessment

In the university campus, the average fraction of time that people spend in classroom, laboratory, office, and dormitory was obtained from the time-activity surveys. On average, on weekdays each student spends 11 hours in classroom and laboratory, and 13 hours in dormitory and outdoor in the campus. On weekends, each student spends about 6 hours in classroom and laboratory, and 18 hours in dormitory and outdoor.

The time fraction that the officers spent at the building were estimated based on their average working period of 8 hr/day on the weekdays, according to the questionnaire. After the working hours, it was assumed that they spend the rest of the day (16 hours) in the environment nearby student village. The $PM_{2.5}$ exposure in all location (Table 4.4) were higher than the 24-hours USEPA indoor air quality standard of 35 μg/m^3 and, the WHO guidelines of 25 μg/m^3.

Exposure to $PM_{2.5}$, PM_{10} and TSP, according to the time spent in each location and total exposure estimated from the 24 hours monitoring on 23/10/2018 is shown on Table 3.

Table 3: Twenty- Four Hours Personal Exposure at The University Campus

location	Time spent (hours)	Average Concentration measured μg/m^3			Exposure μg/m^3		
		$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Classroom	2:00	16.25	35.9	40.7	32.5	71.8	81.4
Lab	2:30	17.9	42.3	42.3	41.17	97.29	97.29
Home	19.70	19.4	50.3	50.5	382.18	990.91	994.85
Total exposure (μg/m^3)					12	20	21

According to the time-activity diary (TAD), the participant went to classroom at 9:00am, the concentrations inside the classroom at that time were 16.25 μg/m^3 for $PM_{2.5}$, 35.9, μg/m^3 for PM_{10} and 40.7 μg/m^3 for TSP. At 11:00 am the participant stayed the Laboratory for two hours. The average concentrations of PM inside the laboratory were 17.9 μg/m^3 and 42.3 μg/m^3 and, 42.3μg/m^3 for $PM_{2.5}$, PM_{10}, and TSP, respectively. At 17:20, the participant arrived at home stayed there for almost 19 hours. The average concentrations of the PM were 5.3μg/m^3 for PM_{10}, 19.4μg/m^3 for $PM_{2.5}$, and 50.51μg/m^3 for TSP.

Table 4: Exposure to $PM_{2.5}$ According to the Indoor Activities in SV and Total Exposure Estimated from the 24hours Monitoring on 15/08/2018

Activity	Duration of activity(hours)	Average $PM_{2.5}$ concentration μg/m^3	Exposure
Cooking	3.42	13.67	46.75
Frying	0.42	34.5	14.49
Windows opining	0.17	14	2.38
Nothing/rest	20	11.87	237.40
Average		Total exposure μg/m^3	12.54

Another measurement resulted, including exposure levels and time spent in SV on 15/08/2018 are presented in Table 4. The exposure to $PM_{2.5}$ of the person who stayed at home (SV- 50) almost 99% of their time was in 24 hours averaged values. Diary entries of cooking and specially frying coincide with time period of high exposure. Table 4.5 shows another example of a complete 24-hour sampling period which was accomplished on 15/08/2018. The participant woke up at 07:01 and performed some in-house duty (breakfast preparation, cleaning, window-opening and tidy up) and left home approximately at 16:00. The average $PM_{2.5}$ PM_{10} and TSP concentrations just before waking up were 6, 19 and 19 μg/m^3, respectively and just before exiting the house were 15, 26 and 28 μg/m^3. During cooking, $PM_{2.5}$ increase to 13.67- 34.5 μg/m^3. It was again indicating that indoor concentration increasing when people were active, especially with the closed windows.

3. RESULT:

Twenty-four hours average concentrations of $PM_{2.5}$, PM_{10} and TSP are presented in Figure 12, 13 and 14.

INTERNATIONAL JOURNAL FOR INNOVATIVE RESEARCH IN MULTIDISCIPLINARY FIELD ISSN: 2455-0620 Volume - 6, Issue - 7, July – 2020
Monthly, Peer-Reviewed, Refereed, Indexed Journal with IC Value: 86.87 Impact Factor: 6.719
Received Date: 27/06/2020 Acceptance Date: 13/07/2020 Publication Date: 31/07/2020

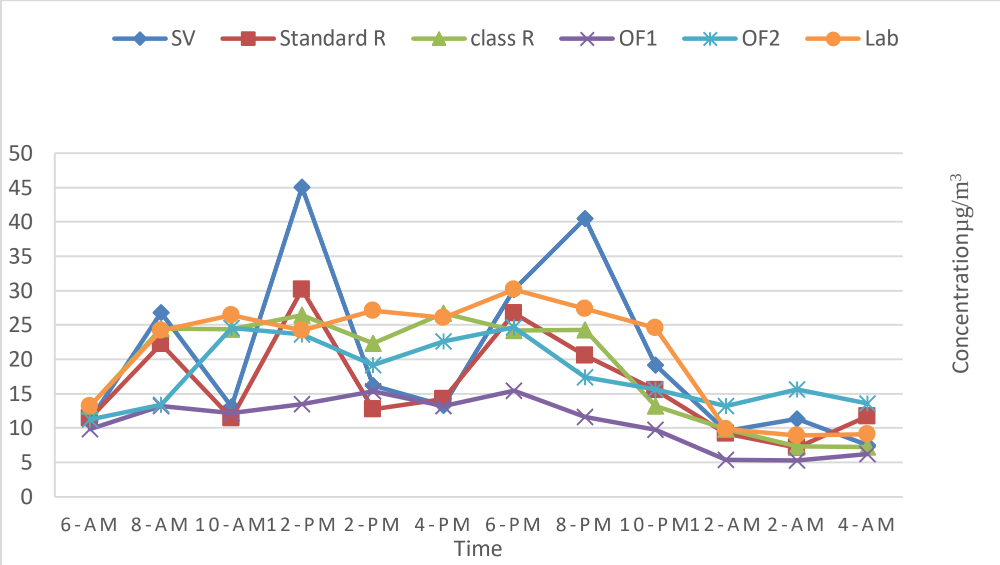


Figure 12: $PM_{2.5}$ concentration comparison

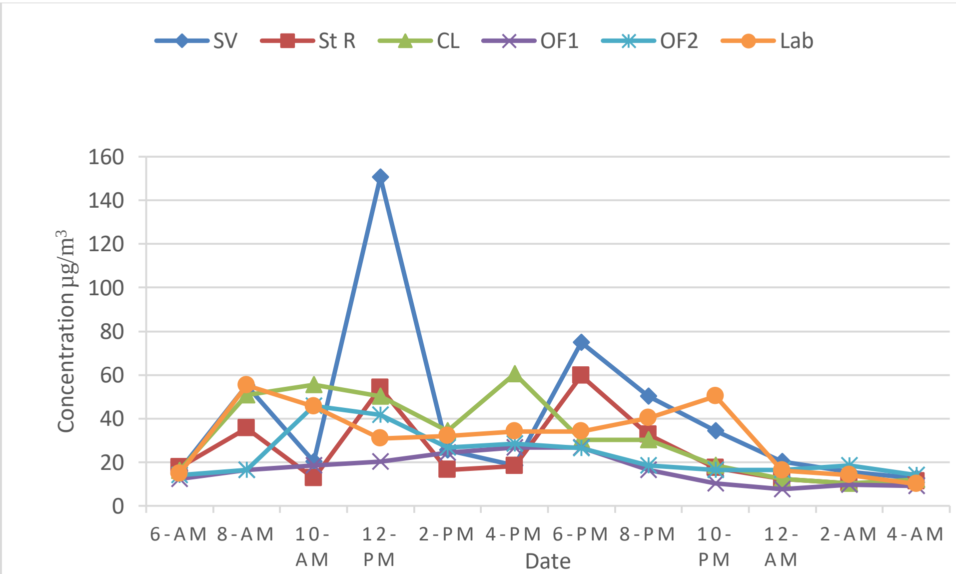


Figure 13: PM_{10} concentration comparison

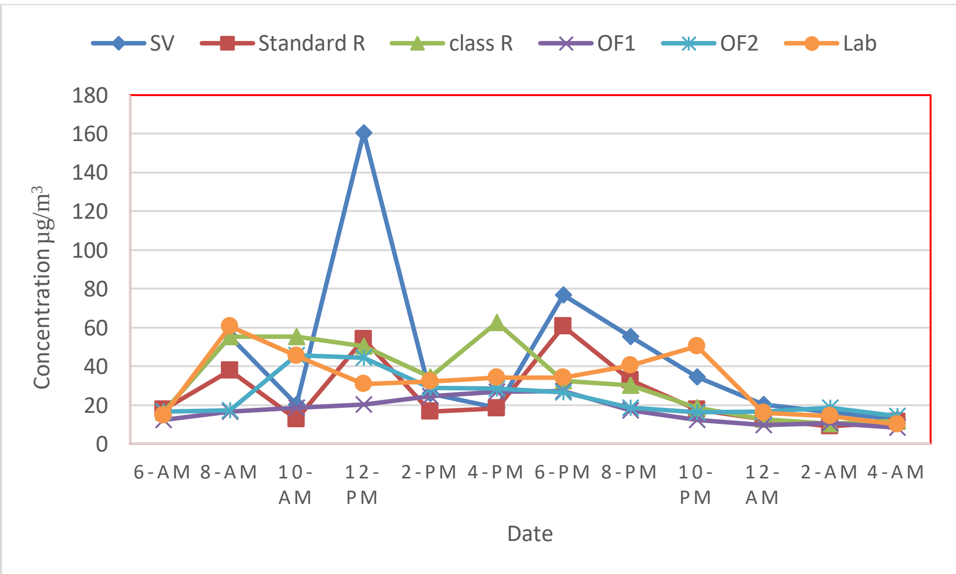


Figure 14: TSP concentration comparison

As seen in the Figure 12 – 14, the indoor level of $PM_{2.5}$, PM_{10} and TSP were found highest in the accommodation campus, at 45.1 µg/m^3, 150.7 µg/m^3, 160.4 µg/m^3, respectively, office1 had the lowest concentration of fine particles, PM_{10} and TSP at 15.3µg/m^3, 26.7 µg/m3, 27.1 µg/m^3. The average concentration of $PM_{2.5}$ in office 2 was also less than the WHO guideline (WHO, 2005), but the classroom and laboratory concentration levels were more than the WHO guideline (WHO, 2005). As presented in Figure 14, the indoor concentration levels of PM_{10} was found highest in the accommodation campus (SV), at 150.6 µg/m^3. For the office 1 the lowest concentration of PM_{10}, at 15.3µg/m^3 was observed. The average concentration of PM_{10} in office 1, office 2, and Lab was less than the WHO guideline (2005). The classroom and dormitory standard room had PM_{10} concentrations more than the WHO guideline (WHO, 2009).

Table 5: The Ratios of $PM_{2.5}$/TSP and PM_{10}/TSP for Different Types of Indoor Environments

Pollutants Ratio	Concentration (µg/m^3)					
	SV	**Standard room**	**Classroom**	**Office 1**	**Office 2**	**Lab**
$PM_{2.5}$/TSP	0.47	0.63	0.57	0.64	0.73	0.65
PM_{10}/TSP	0.96	0.98	0.98	0.94	0.97	0.98

The average values of $PM_{2.5}$/TSP and PM_{10}/TSP are shown in Table 5. in general, there is no difference among the ratio between PM $_{10}$ and TSP in all location. For $PM_{2.5}$ to TSP, some variations can be observed, ranging from 0.47in SV to 0.73 in office.

4. CONCLUSIONS AND RECOMMENDATION:

The present study has monitored and analyzed the $PM_{2.5}$, PM_{10} and TSP concentrations in different locations under different ventilation conditions in AIT campus Thailand. The monitoring was supplemented the questionnaire survey to obtain the data on the amount of fuels used by household, types of stoves, health symptoms, ventilation facilities, indoor air quality, spending time in the different area on campus.

$PM_{2.5}$, PM_{10} and TSP were monitored continuously using the online monitoring device and personal SKC in order to capture the cooking and non- cooking concentration in the kitchen, open windows and non- open windows ventilation facilities in offices and classrooms and PM concentration on weekdays and weekend. The average 24 hours concentrations of $PM_{2.5}$, PM_{10} and TSP were found higher in the student village with only windows ventilation facilities, while the corresponding values were fond lowest in office with both windows and AC ventilation system.

In this respect the most burdened MEs were the student village and the classroom. The concentrations were lowered in the office, followed by multiple ventilation facilities. The standard dorm residential presented the lowest concentrations due to its greater distance from the street and the fact that less indoor activities took place daily.

Exposure within the residential indoor ME were lower at night and maintained background levels due to particulate accumulation. PM concentrations was higher during daytime because of the activities taking place. The people moving around the different MEs was exposed to higher PM concentrations as compared to the pensioner. The time spent in different MEs played a decisive role on exposure. The residential indoor ME may be considered as the most important one as people tend to spend most of their time indoors. Overall, the people lifestyle produced significantly higher exposure values as compared to the pensioner case since most of the day was spent indoors.

The study can be useful for monitoring air pollution for other areas in Thailand, where similar characteristic is found.

This study suggested that the combination of consumer education and awareness of health risks can lead to reduced risk exposure.

Adoption of practical strategies, such as regular vacuuming with a high-efficiency particulate air (HEPA) vacuum cleaner, thorough house cleaning, and source control when combined with education and assistance can improve health outcomes.

The result of this study can be used by the either governors or policy decision makers to assess the strategies on air pollution control.

REFERENCES:

1. Albalak, R., Bruce, N., McCracken, J.P., & Smith, K.R. (2001). Indoor respirable particulate matter concentrations from an open fire, improved cook stove, and LPG/open fire combination in a rural Guatemalan community. *Environment Science Technology, 35*, 2650–2655.

2. Atmane, N., Dairou, J., Paul, A., & Dupret, J.M. (2003). Redox regulation of the human- xenobiotic metabolizing enzyme aryl amine. *Chemosphere, 278*, 5086-5092.
3. Baklanov, A., Molina, L.T., & Gauss, M. (2016). Megacities air quality and climate. *Atmosphere Environment, 126*, 235-249.
4. Hussain, M., Winkler-Heil, R., & Hofmann, W. (2011). Lung dosimeters for inhaled long lived radionuclides and radon progeny. *Radiate Protection Dosimeter, 7*, 145, 213.
5. Jones, A. P. (1999). Indoor air quality and health. *Atmospheric Environment, 33*, 4535–4564. doi:10.1016/ S1352-2310(99)00272-1
6. Kim Oanh, N. T. (2004). *Emission from rice straw open burning and potential impacts.* In Proceedings of the BAQ04 conference. Agra, India.
7. Kim Oanh, N. T., Upadhyay, N., Zhuang, Y. H., Hao, Z. P., Murthy, D. V. S., & Lestari, P. (2006). Particulate air pollution in six Asian cities: Spatial and temporal distributions, and associated sources. *Atmospheric Environment, 40*, 3367–3380.
8. Smith, C.A., & Harrison, D.J. (1997). Association between polymorphism in gene for microsomal epoxide hydrolase and susceptibility to emphysema. *Lancet, 350*, 630-633
9. Taneja, A.R., & Masih, A. (2008). Indoor air quality of houses located in the urban environment of Agra, India. *Annals of the New York Academy of Sciences, 12*, 19-27.
10. USEPA. (1996). *Revisions to the National Ambient Air Quality Standards for Particulate Matter.* NC: USEPA.
11. WHO. (2005). *Indoor air pollution: National burden of disease estimates*. Geneva, Switzerland: WHO.
12. WHO. (2009). *Global health risks: Mortality and burden of disease attributable to selected major risks*. Geneva, Switzerland: WHO.
13. WHO. (2014). *Seven million Premature Deaths Annually Linked to Air Pollution: Air Quality & Climate Change.* Geneva, Switzerland: WHO.
14. Yamamoto, S., Phalkey, R., & Malik, A. (2014). A systematic review of air pollution as a risk factor for cardiovascular disease in South Asia: Limited evidence from India and Pakistan. *International Journal Egypt Environment Health*, *21*, 133-144.