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GASEOUS AIR POLLUTANTS AND PARTICULATES IN AMBIENT AIR OF AHLONE TOWNSHIP, YANGON CITY

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Abstract

Rapid and unsystematic industrialization has become a major environmental concern for both developed and developing countries. Long-term and short-term effects on human health have been observed due to poor quality. In this study, a number of pollutants such as total suspended particulate matter (TSPM), particulate matter(PM-10), SO_2 and NO_2 affecting ambient air quality were measured for specified location in Ahlone Township, Yangon City. During study period from November 2015 to October 2017, variations of the pollutants have been monitored weekly, monthly and seasonally. On the basis of the monthly average, the statistical distribution parameters such as average, standard deviation (SD), minimum (Min) and maximum (Max) values for each of the pollutants were obtained. The average concentrations of TSPM, PM-10, SO_2 (24 h) and NO_2 (24 h) observed during the period of (2015-2017) were found to be 73.24 ± 43.44 μg m^{-3}, 38.43 ± 27.27 μg m^{-3}, 0.109 ± 0.271 μg m^{-3}, 6.38 ± 8.46 μg m^{-3} and 19.31 ± 33.41 μg m^{-3} respectively. All pollutants were observed to be high in concentration during summer as compared to winter and rainy, due to slow dispersion and dilution of pollutants. The results of this study identified the degree of air pollution in Ahlone Township, Yangon City. The data obtained will be statistically treated using SPSS (Statistical Package for the Social Science) software version 22.

Keywords : Pollutants, particulates, ambient air, TSPM, PM-10

Introduction

Air pollution results mainly from gaseous and particulates emission of industries, thermal power stations, automobiles, domestic combustion etc. which sources are natural as well as anthropogenic (Narayanan, 2009). Industrial pollution is one of the primary sources of environmental contamination. Factories pollute the air through fossil fuel emissions. Combustion creates toxic pollutants. Gases such as oxides of nitrogen (NO_x), oxides of sulphur (SO_2) and carbon monoxide (CO) may constitute some forms of pollutants. Presence of atmospheric air contaminants in such

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quantities and duration that many tend to be injurious to life or properties, health repose and safety constitute air pollution. High temperature combustion of hydrocarbon fuel sources such as gasoline, coal, and oil with air produce NO and smaller quantities of NO_2 from reactions between the oxygen and nitrogen present in the combustion air. Most of the NO in ambient air rapidly turns into NO_2. High temperature combustion of hydrocarbon fuel sources such as coal and oil can produce sulphur dioxide (SO_2) and sulphur trioxide (SO_3) from the oxidation of any sulphur in these fuels (Abdullahi *et al.,* 2017). Emissions of these sulphur compounds are associated with industrial operations and contribute to the majority of SO_2 emissions from man's activities. Long-term exposure to sulphur dioxide may cause respiratory symptoms and illness, and aggravate asthma (USEPA, 2014). All of the air pollutants are associated with a range of health impacts. Particulate matter is a major cause of all kinds of respiratory problems (Kumar and Kriti, 2016). The aim of this study is to achieve better understanding of the condition of atmosphere due to the air pollution.

Materials and Methods

General Description of Sample Collection Area

Sampling site was selected at the urban area in Yangon Region. Ahlone Township in the western part of Yangon is located between 16° 47.248′ N and 96° 07.793′ E. The township covers an area of 4 km^2 (1.4 sq. miles). The population was found to be 55428 in census 2014. The area which is very much close to Hteen Dan Port Jetty, Asia World Port Jetty, Kyee Myint Dine International Port, Myanmar Industrial Port, palm oil storage tank, white rice mill, CNG and LPG gas filling station, gas turbine plant, public transport station is surrounded by commercial complexes and residential area. Map of the study area is shown in Figure 1.

Samples, Study Area and Sampling Periods

The samples studied are airborne particulate matter (APM) samples including total suspended particulate matter (TSPM) and PM-10 and the gaseous air pollutants (GAPs) such as sulphur dioxide (SO_2) and nitrogen dioxide (NO_2). Sampling site is Occupational Health Department, Lower Kyee Myint Dine Road, Ahlone Township in Yangon (Figure 1). Air sampling was conducted weekly for 2 years from November 2015 to October 2017. Samples were collected from November to February representing cold season, March to May representing hot season and June to October representing rainy season.

Sample Collection and Data Collection

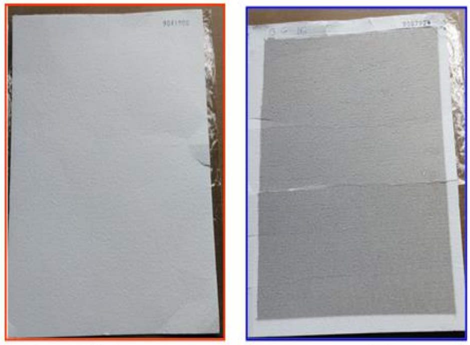
The air sampling pump (High Volume Sampler (HVS), Envirotech APM 460 NL., New Delhi, India) was used to collect particulate matters (TSPM and PM-10) and the gaseous air pollutants (SO_2 and NO_2). Figure 2 depicts the HVS with gaseous sampling attachment and interior view of gaseous sampling attachment.PM-10 samples were collected on glass microfiber filter (460 x 570 mm) and pore size is 1.0 μm. Figure 3 shows the unloaded and loaded filters. TSPM was collected from the fiber container which was placed into the HVS. The average TSPM and PM-10 concentration were determined by dividing the net weight gain of the sample by the total volume of air sample. The gas-phase air pollutants (SO_2 and NO_2) were collected from impingers into the gaseous sampling attachment which was connected with HVS. All samples were collected for 24 h from 8.00 am first day to 8.00 am next day on every Thursday of the whole year. Temperature and pressure were also simultaneously measured hourly during the sampling period. Automatic air flow meter was set at a nominal flow rate of 1.5 Lm^{-1}. The HVS was placed about 5 m above the ground. The modified West and Gaeke Method IS 5218 Part II and Jacob and Hochheiser Method IS 5182 Part IV were used for absorbing the SO_2 and NO_2 contents respectively from the air which was analyzed with suitable spectrometer (Kamyotra and Saha, 2011).

Results and Discussion

In this study, four different numbers of pollutants (TSPM, PM-10, SO_2 and NO_2) affecting ambient air quality were measured for specified location of Occupational Health Department, Lower Kyee Myint Dine Road, Ahlone Township, Yangon City during the two-year period from November 2015 to October 2017. On the basis of the monthly average, the statistical distribution parameters such as average, standard deviation (SD), minimum (Min) and maximum (Max) values for each of the pollutants were determined.

Figure 1: Location of sampling site on the map of Ahlone Township

Figure 2: Photographs of high volume sampler (a) exterior view of HVS with gaseous sampling attachment
(b) interior view of gaseous sampling attachment



(a) (b)

Figure 3: Filter papers (a) Unloaded filter paper and (b) loaded filter paper
(460 x 570 mm)

The concentrations of TSPM were found to be in the range of 24.53 to 180.58 μg m^{-3} with the mean value of 89.15 ± 45.42 μg m^{-3} in the period of November 2015 to October 2016 and 10.46 to 152.31 μg m^{-3} with the mean level of 57.33 ± 34.45 μg m^{-3} in the periods of November 2016 to October 2017 (Table 1 and Figure 4). The concentrations of TSPM were lower than the permissible level of USEPA (1997) standard 150 μg m^{-3} except the month of January, February and May 2015 and September 2017. But, no significant difference in TSPM was observed during the study period ($p>0.05$).

The results of mean monthly concentrations of PM-10 are presented in Table 2 and Figure 5. It was observed that the mean monthly concentrations of PM-10 were found to be in the range of 2.48 to 120.41 μg m^{-3} with the mean value of 53.94 ± 29.37 μg m^{-3} in the periods of November 2015 to October 2016 and those of 2.06 to 63.60μg m^{-3} with the mean value of 22.91 ±12.28μg m^{-3}in the period of November 2016 to October 2017. In the period of November 2015 to October 2016 (except rainy season such as June, September and October), the level of PM-10 was found to be higher than the permissible level (50 μg m^{-3}) of WHO standard (2000).In the period of November 2016 to October 2017 (except rainy season such as July), PM-10 concentrations were found to be lower than the WHO standard (2000). PM -

10 concentrations were not significantly different to each other during the study period ($p>0.05$).

The mean monthly levels of SO_2 within24 h in ambient air that were found to be in the range of 0.006 to 1.930µg $m^{-3}$with the mean level of 0.103 ± 0.201 µg m^{-3} in the periods of November 2015 to October 2016 and 0.001 to 1.160µg $m^{-3}$with the mean value of 0.114 ± 0.228 µg m^{-3} in the periods of November 2016 to October 2017 (Table 3 and Figure 6). The mean monthly levels of SO_2 were lower than the WHO (2000)standard (20 µg m^{-3}). The mean monthly levels of SO_2 were significantly different during the study period ($p=0.001$).

The results of mean monthly concentrations of NO_2 within 24 h in ambient air were presented in Table 4 and Figure 7. It was observed that the mean monthly concentrations of NO_2 were found to be in the range of 0.49 to 17.51 µg m^{-3} with the mean value of 3.88 ±4.63 µg m^{-3} from November 2015 to October 2016 and those of 0.16 to 52.10µg m^{-3} with the mean level of 8.89 ± 10.83 µg m^{-3} from November 2016 to October 2017. All of the values in the periods of 2 years (except April 2017) were lower than the permissible limit(40 µg m^{-3}). The mean monthly concentrations of NO_2 were significantly different during the study period ($p< 0.001$).

Table 5 and Figures 8 -11 show the mean seasonal levels of PM (TSPM and PM-10) and GAPs (SO_2 and NO_2). The mean seasonal levels of TSPM, PM-10, SO_2 and NO_2 were found to be highest which were 120, 72.26, 0.19 and 5.76 µg m^{-3} respectively, in hot season 2016 and those were 67.02, 23.45, 0.33 and 17.35 µg m^{-3}respectively, in hot season 2017. During the study period (November 2015 – October 2017) in Ahlone Township, high concentrations of PM and GAPs were observed during hot season and low concentrations of pollutants were observed during rainy season. The ambient air PM and GAPs concentrations are within the acceptable limits of WHO (2000) and USEPA (1997) standard. Analysis of the data on seasonal basis revealed low concentration of particulate matter (TSPM and PM-10) in rainy season. In the rainy season, pollutants were dissolved and settle down on the earth due

Table 1: The Monthly Average, Standard Deviation (SD), Minimum (Min) and Maximum (Max) Values of TSPM (24h) Collected from Ahlone Township for the Period of 2 Years from November 2015 to October 2017

Sampling Periods	Mean monthly concentrations of TSPM (µg m^{-3})					
	2015- 2016 (Year one)			2016- 2017 (Year two)		
	Mean ± SD	Min	Max	Mean ± SD	Min	Max
November	61.47 ± 22.27	31.57	94.32	47.22 ± 29.69	18.15	87.57
December	96.64 ± 50.99	60.58	132.70	107.8 ± 34.10	72.68	140.78
January	139.66 ± 33.06	107.54	168.98	47.04 ± 15.01	30.39	61.46
February	132.13 ± 21.29	100.12	159.84	64.26 ± 42.39	34.70	125.00
March	120.99 ± 35.09	69.65	148.97	94.2 ± 30.19	61.93	128.94
April	91.12 ± 41.87	46.18	129.03	54.69 ± 31.86	33.53	91.34
May	147.91 ± 40.87	125.34	180.58	52.16 ± 27.10	24.78	85.49
June	49.66 ± 10.55	39.34	61.59	41.35 ± 13.71	20.80	58.45
July	75.32 ± 26.47	41.41	131.41	51.12 ± 25.73	28.27	76.23
August	65.01 ± 8.41	50.24	96.77	21.98 ± 14.13	10.46	42.24
September	53.14 ± 26.67	24.53	86.60	58.75 ± 53.49	18.37	152.31
October	36.73 ± 7.91	24.62	44.03	47.39 ± 13.51	37.10	62.69
	89.15 ± 45.42	24.53	180.58	57.33 ± 34.45	10.46	152.31
	(number of weeks) n = 50			n = 47		

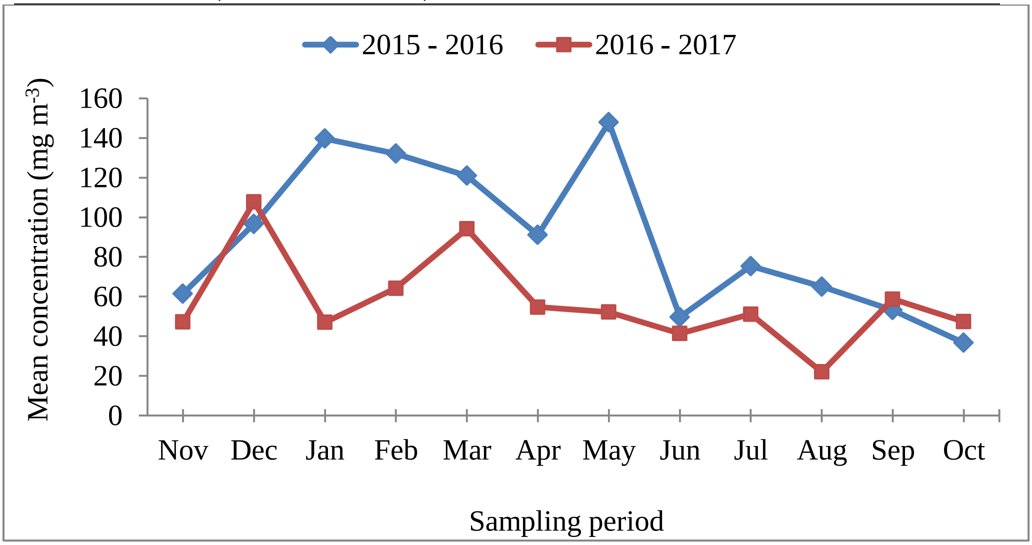


Figure 4: Variation of mean concentration of TSPM (24 h) collected from Ahlone Township for the period of 2 years

Table 2: The Monthly Average, Standard Deviation (SD), Minimum (Min) and Maximum (Max) Values of PM-10 (24h) Collected from Ahlone Township for the Period of 2 Years from November 2015 to October 2017

Sampling Periods	Mean monthly concentrations of PM-10 (µg m^{-3})					
	2015- 2016 (Year one)			2016- 2017 (Year two)		
	Mean ± SD	Min	Max	Mean ± SD	Min	Max
November	36.90 ± 19.19	13.32	56.22	24.07 ± 14.59	11.45	43.55
December	70.32 ± 26.12	51.85	88.79	25.49 ± 9.62	17.96	36.34
January	78.34 ± 6.09	71.27	86.07	12.52 ± 9.68	5.16	26.79
February	81.56 ± 25.69	51.49	120.41	24.64 ± 4.91	20.43	30.50
March	75.27 ± 25.90	39.71	101.88	30.51 ± 3.56	27.60	35.04
April	56.05 ± 19.60	36.84	76.02	21.96 ± 6.25	16.40	28.73
May	85.45 ± 24.10	55.67	104.94	17.89 ± 12.76	6.37	34.74
June	28.25 ± 6.62	21.90	37.78	26.19 ± 12.48	15.42	40.29
July	41.35 ± 21.24	15.94	73.49	32.35 ± 21.07	17.45	63.60
August	51.65 ± 21.70	32.79	84.47	14.12 ± 15.03	2.06	36.00
September	28.14 ± 17.76	8.53	46.00	22.58 ± 15.10	8.44	48.24
October	14.01 ± 9.45	2.48	26.33	22.61 ± 7.00	15.16	29.06
	53.94 ± 29.37	2.48	120.41	22.91 ± 12.28	2.06	63.60
	(number of weeks) n = 50			n = 47		

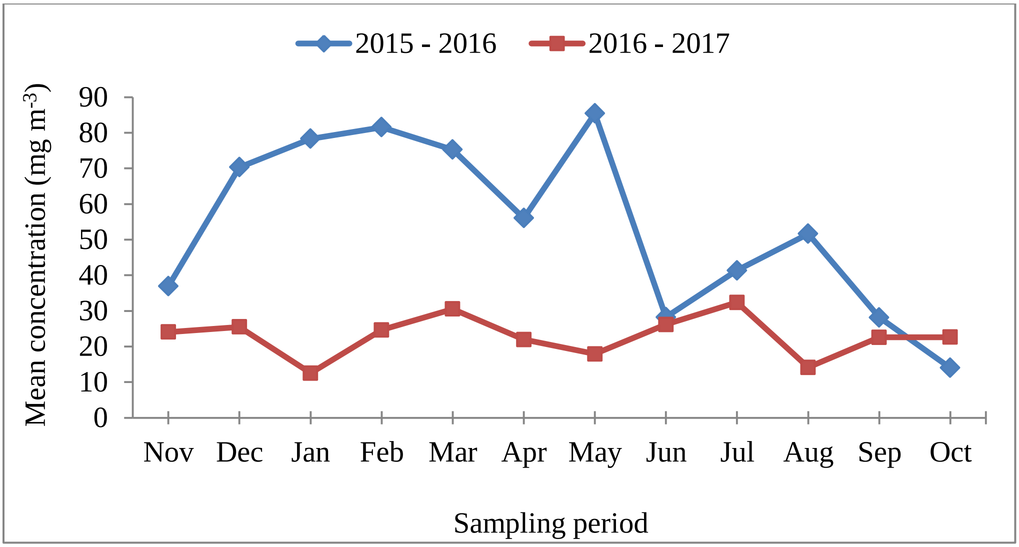


Figure 5: Variation of mean concentration of PM-10 (24 h) collected from Ahlone Township for the period of 2 years

Table 3: The Monthly Average, Standard Deviation (SD), Minimum (Min) and Maximum (Max) Values of SO_2 (24h) Collected from Ahlone Township for the Period of 2 Years from November 2015 to October 2017

Sampling Periods	Mean monthly concentrations of SO_2 ($\mu g\ m^{-3}$)					
	2015- 2016 (Year one)			2016- 2017 (Year two)		
	Mean ± SD	**Min**	**Max**	**Mean ± SD**	**Min**	**Max**
November	0.010 ± 0.000	0.010	0.010	0.010 ± 0.001	0.009	0.010
December	0.010 ± 0.001	0.010	0.011	0.123 ± 0.076	0.070	0.201
January	0.020 ± 0.000	0.020	0.020	0.168 ± 0.178	0.020	0.380
February	0.160 ± 0.007	0.006	0.020	0.010 ± 0.000	0.010	0.010
March	0.010 ± 0.005	0.010	0.020	0.175 ± 0.100	0.070	0.300
April	0.010 ± 0.006	0.010	0.020	0.553 ± 0.541	0.120	1.160
May	0.540 ± 0.006	0.010	1.930	0.252 ± 0.479	0.007	0.970
June	0.010 ± 0.000	0.010	0.010	0.013 ± 0.006	0.007	0.020
July	0.010 ± 0.433	0.010	0.020	0.019 ± 0.027	0.004	0.060
August	0.088 ± 0.021	0.060	0.110	0.020 ± 0.135	0.004	0.008
September	0.075 ± 0.039	0.030	0.120	0.010 ± 0.008	0.001	0.005
October	0.303 ± 0.463	0.007	1.110	0.020 ± 0.004	0.003	0.010
	0.103 ± 0.201	0.006	1.930	0.114 ± 0.228	0.001	1.160
	(number of weeks) n = 50			n = 47		

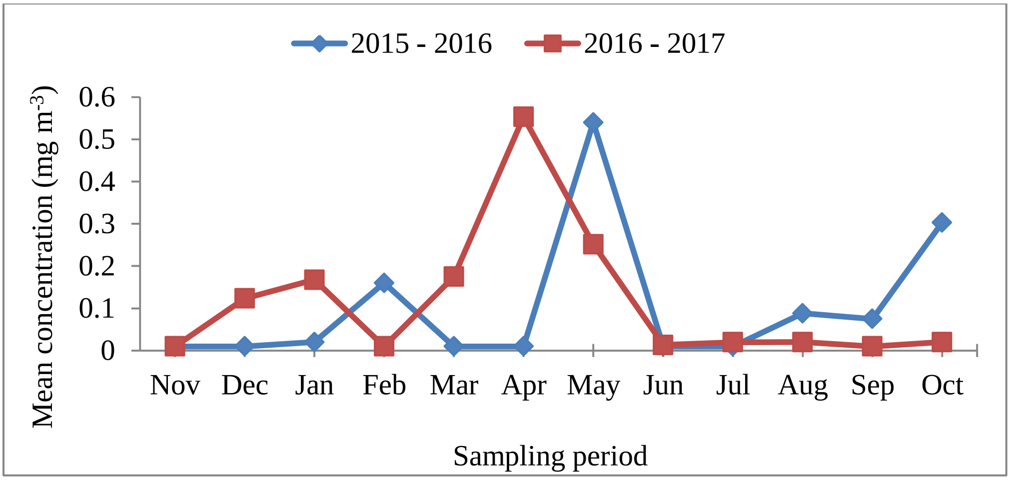


Figure 6: Variation of mean concentration of SO_2 (24 h) collected from Ahlone Township for the period of 2 years

Table 4: The Monthly Average, Standard Deviation (SD), Minimum (Min) and Maximum (Max) Values of NO_2 (24h) Collected from Ahlone Township for the Period of 2 Years from November 2015 to October 2017

Sampling Periods	Mean monthly concentrations of NO_2 ($\mu g\ m^{-3}$)					
	2015- 2016 (Year one)			2016- 2017 (Year two)		
	Mean ± SD	Min	Max	Mean ± SD	Min	Max
November	1.06 ± 0.25	0.89	1.49	1.21 ± 0.22	0.98	1.50
December	0.85 ± 0.18	0.72	0.97	14.75 ± 6.60	10.92	22.38
January	1.35 ± 0.12	1.25	1.50	16.30 ± 9.66	8.85	30.50
February	1.52 ± 0.67	0.66	2.48	6.56 ± 4.11	3.30	12.54
March	7.09 ± 7.12	0.84	13.60	8.36 ± 16.18	0.16	32.64
April	1.03 ± 0.16	0.88	1.19	35.13 ± 14.70	26.31	52.10
May	9.17 ± 0.14	0.78	17.51	8.57 ± 8.33	3.70	20.98
June	0.75 ± 0.29	0.49	1.15	7.17 ± 4.94	3.32	13.12
July	1.16 ± 7.11	1.01	1.28	4.57 ± 2.99	2.20	8.90
August	9.39 ± 2.29	6.16	1.90	2.89 ± 2.54	1.03	6.40
September	7.72 ± 2.65	5.08	10.46	0.82 ± 1.11	0.31	2.60
October	5.43 ± 5.31	0.90	11.60	0.34 ± 1.25	0.26	0.43
	3.88 ± 4.63	0.49	17.51	8.89 ± 10.83	0.16	52.10
	(number of weeks) n = 50			n = 47		

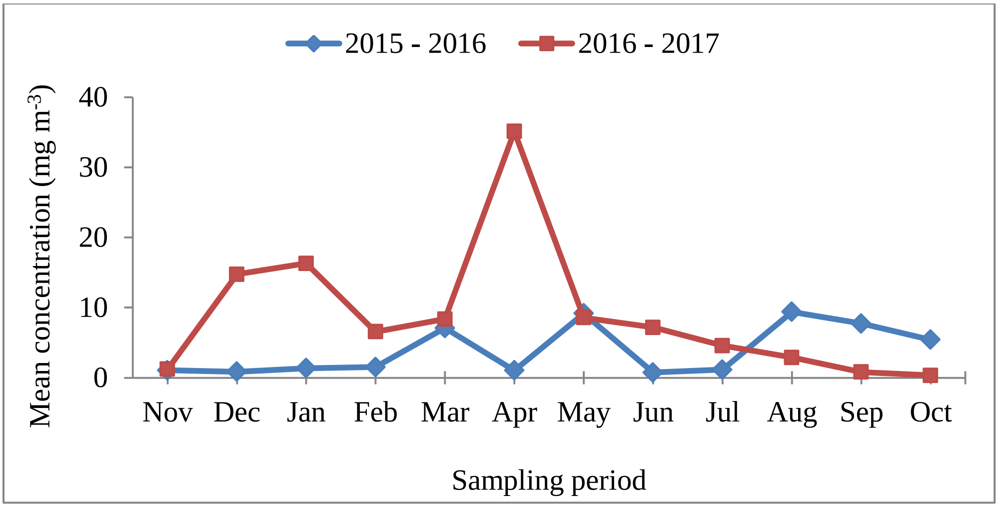


Figure 7: Variation of mean concentration of NO_2 (24 h) collected from Ahlone Township for the period of 2 years

Table 5: The Mean Seasonally Level of PM and GAPs Collected from Ahlone Township for the Period of 2 Years from November 2015 to October 2017

Sr No.	Season	Mean Levels of PM and GAPs (μg m^{-3})							
		TSPM		PM - 10		SO_2		NO_2	
		2015-2016	2015-2016	2015-2016	2015-2016	2015-2016	2015-2016	2015-2016	2015-2016
1	Cold	107.48	66.58	66.78	21.68	0.050	0.078	1.19	9.71
2	Hot	120.00	67.02	72.26	23.45	0.190	0.327	5.76	17.35
3	Rainy	55.97	44.12	32.68	23.57	0.097	0.017	4.89	3.16
Permissible level		150 **		50 *		20 *		40 *	

All were measured within 24 h

* WHO (2000)

** USEPA (1997)

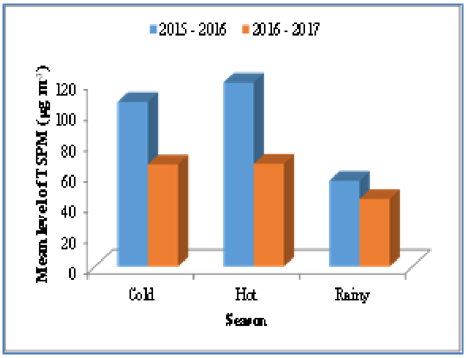


Figure 8:The histogram of the comparison of the mean levels of TSPM seasonally collected from Ahlone Township for the period of 2 years

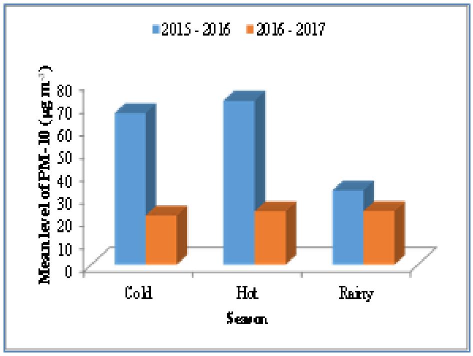


Figure 9:The histogram of the comparison of the mean levels of PM-10 seasonally collected from Ahlone Township for the period of 2 years

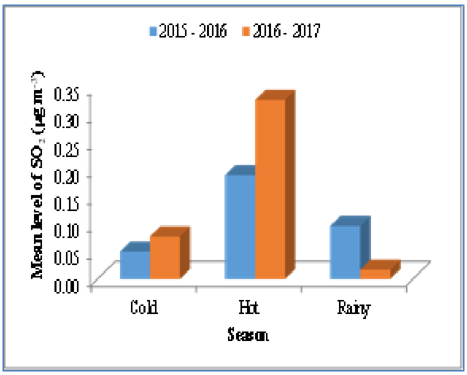


Figure10:The histogram of the comparison of the mean levels of SO_2 seasonally collected from Ahlone Township for the period of 2 years

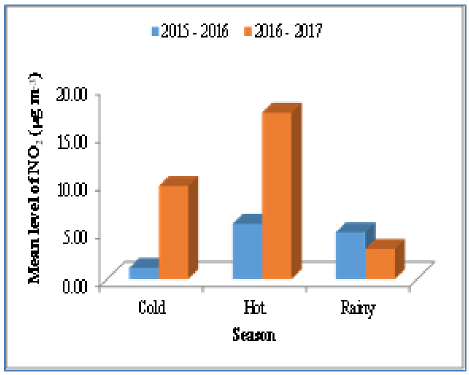


Figure11:The histogram of the comparison of the mean levels of NO_2 seasonally collected from Ahlone Township for the period of 2 years

to heavy rainfall and thunder, therefore, the quality of ambient air is good in this season. The concentration of PM was remarkably decreased in this season as compared to other seasons (Figures 8 and 9). This is significant as it establishes the correlation between the meteorological factors and pollutant concentrations. The high relative humidity, moderate temperature and heavy rains result in the decrease of concentration of PM. Low value of PM contents during cold season may be attributed to light wind and precipitation that prevails in cold season. These factors lead to dispersion of pollutants near the source resulting into less concentration of pollutants during the cold season.

Low value of pollutants during the cold season is also in line with the findings of Tripathy and Panigrahi (2000) and Sehra (2007). In addition, dry season is convenient for travelling, therefore traffic density is increased. So the large amount of exhaust emission and the PM-10 emission from vehicular sources (wear and tear of automobile tyres, clutch and brake ware, wiring of vehicles were increased. Construction works (building and road construction) were higher in dry season than in rainy season. So more GAPs and PM emission occurred in dry season than rainy season.

The summarized data of yearly average concentrations of PM and GAPs for the study periods are presented in Table 6 and Figure 12. The concentration of TSPM during the year one (2015-2016) was maximum (180.58 $\mu g\ m^{-3}$) in the hot season while a minimum was 24.53 $\mu g\ m^{-3}$ in rainy season with the mean value of 89.15 $\pm$ 45.42 $\mu g\ m^{-3}$ and during the year two (2016-2017) these values were 152.31 $\mu g\ m^{-3}$ and 10.46 $\mu g\ m^{-3}$ with the mean value of 57.33 $\pm$ 34.45 $\mu g\ m^{-3}$. The maximum and minimum values of PM-10 during the year one (2015-2016) were 120.41 $\mu g\ m^{-3}$ and 2.48 $\mu g\ m^{-3}$ respectively with the mean value of 53.94 $\pm$ 29.37 $\mu g\ m^{-3}$ and during the year two (2016-2017), these values were 63.6 and 2.06 $\mu g\ m^{-3}$ with the mean values of 22.91 $\pm$ 12.28 $\mu g\ m^{-3}$.The maximum and minimum values of SO_2 during the year one (2015-2016) were 1.930 and 0.006 $\mu g\ m^{-3}$ respectively with the mean levels of 0.103 $\pm$ 0.201 $\mu g\ m^{-3}$ and during the year two (2016-2017) these values were 1.160 and 0.001 $\mu g\ m^{-3}$ with the mean value of 0.114 $\pm$ 0.228 $\mu g\ m^{-3}$. The concentration of NO_2 during the year one (2015-2016) was maximum (17.51 $\mu g\ m^{-3}$) in the hot season while a minimum was 0.49 $\mu g\ m^{-3}$ in rainy season with a mean value of 3.88 $\pm$ 4.63 $\mu g\ m^{-3}$ and during the year two (2016-2017) these values were 52.1 and 0.16 $\mu g\ m^{-3}$ with a mean value of 8.89 $\pm$ 10.83 $\mu g\ m^{-3}$.

All of the particulates (TSPM and PM-10) were observed to be high in concentration during the year one (2015-2016) as compared to the year two (2016-2017). In the year one (2015-2016), high particulate concentration may be due to the fact that 24 h heavy transport activities in study area, construction activities, parking place for trucks in the vicinity, usage of generators during the frequent power cuts, narrow and poorly maintained roads. In the year two (2016-2017), there was a drop in PM concentration. This was because all of the loading trucks were restricted to enter the urban area from 6 am to 8 pm, reducing the construction activities, parking place for trucks was transferred to the suburban and no electricity failures in urban area of Yangon City.

The concentration of SO_2 had been observed to be not much different between 2 years of study period and found to be within the acceptable limits of WHO (2000) air quality guideline. The concentration of NO_2 had been observed to be higher in the year two (2016-2017) than in the year one (2015-2016) but these values were found to be lower than the permissible level of WHO (2000) standard. The average concentration of SO_2 and NO_2 increased in the year two (2016-2017) as compared to the year one (2015-2016). It may be due to the fact that number of vehicles is increasing every year. Emission of pollutants from the vehicles depends upon the type of fuel used. Diesel engines have substantial emissions of which particulate matter and SO_2 is vital. Most particulate matter results from incomplete combustion of the fuel, petrol run vehicles emit CO, hydrocarbon, Pb and NO_2 in the atmosphere (Angelika and Raina, 2013). Most of the salon cars are petrol run vehicles. Therefore NO_2 emission increased during the latter period.

Table 6: The Comparison of the Yearly Average, Standard Deviation (SD), Minimum (Min) and Maximum (Max) Values of PM and GAPs Collected from Ahlone Township for the Period of 2 Years from November 2015 to October 2017

Sr No.	Pollutants	Concentration of PM and GAPs ($\mu g\ m^{-3}$)					
		2015-2016 (Year one)			2016-2017 (Year two)		
		Mean ± SD	Minimum	Maximum	Mean ± SD	Minimum	Maximum
1	TSPM	89.15 ± 45.42	24.53	180.58	57.33 ± 34.45	10.46	152.31
2	PM-10	53.94 ± 29.37	2.48	120.41	22.91 ± 12.28	2.06	63.60
3	SO_2	0.10 ± 0.20	0.00	1.93	0.11 ± 0.228	0.00	1.16
4	NO_2	3.88 ±4.63	0.49	17.51	8.89 ± 10.83	0.16	52.10

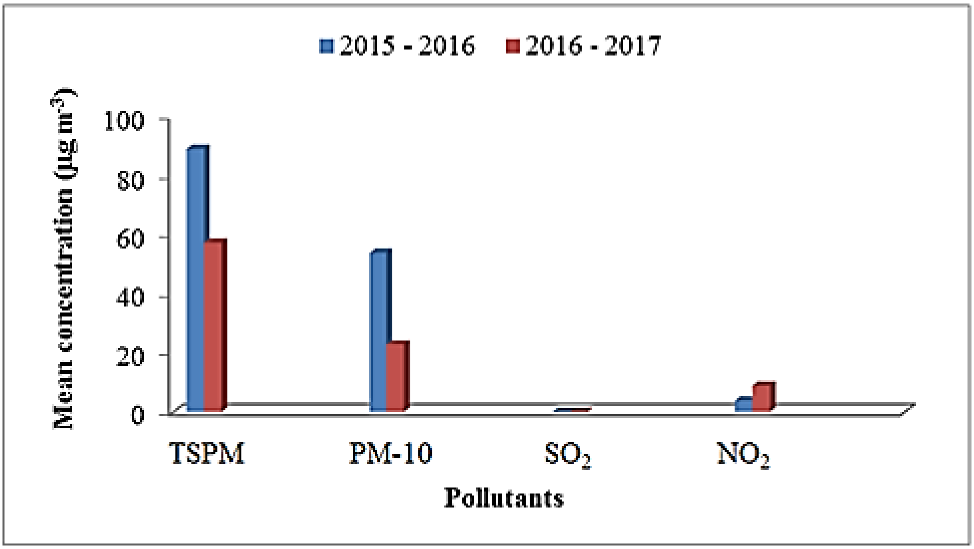


Figure 12: The histogram of the comparison of mean levels of pollutants collected from Ahlone Township for the period of 2 years

Conclusion

From the results of the present study, it was observed in the descending order of the concentrations of pollutants as: TSPM > PM-10 > NO_2> SO_2. This study reveals that both PM and GAPs are mostly below permissible limits of WHO (2000) and USEPA (1997) standards at the study site. Much is being done to control, monitor and rectify damage occurred by pollutants. The present study provides base line information and the results are useful for effective environmental pollution monitoring at Ahlone Township in Yangon City.

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