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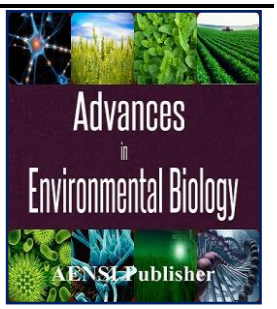

Diurnal Variation of ambient Air Pollutants Concentration in two Motor Parks in Ebonyi State, Nigeria

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ABSTRACT

This study monitored ambient air day-time concentration of particulate matter less than ten micrometer (PM_{10}) in size, CO and NO_2 daily for twenty-eight days in the dry season in two motor parks in Ebonyi State. The results showed that during the study period, PM_{10}, CO and NO_2 had a range and mean values of 32-58 and 46.429± 6.161 μgm^{-3}, 0.1-0.4 and 0.162±0.079 ppm and 0.01-0.04 and 0.013±0.006 ppm respectively in site1. The corresponding values in site2 were 45-69 and 55.845±5.416 μgm^{-3},0.1-0.6 and 0.225±0.120 ppm,0.01-0.02 and 0.013±0.004 ppm respectively. The diurnal variation as depicted by the morning, afternoon and evening mean concentrations showed that for PM_{10} in both sites, afternoon mean concentration > evening mean > morning mean; for CO morning mean concentration > evening mean > afternoon mean while NO_2 had afternoon mean concentration > evening mean > morning mean. Comparatively site 2 had higher concentrations of the pollutants monitored relative to site1.However, analysis of variance (ANOVA) of difference in mean of pollutants in the two sites in the different periods of the day showed that except for CO mean in the morning period, other monitored pollutants were not statistically significant ($p<0.05$). The research findings concludes that the mean concentrations of pollutants in this study were within the guideline limit of Nigerian National Environmental Standard Regulation and Enforcement Agency (NESREA) and United State Environmental Protection Agency (USEPA*) for air quality.*

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INTRODUCTION

Vehicular emission is a cause of major environmental problems affecting environment locally, regional and globally [29]. Pollution due to traffic constitutes 90-95% of the ambient air CO levels, 80 -90% of NOx, hydrocarbon and particulate matter globally [5,24,14,20,18]. According to UNEP,2013, Fu [12] and Goyal, [13], traffic emissions contribute about 50 – 80% of NO_2 and CO concentrations in developing countries. The authors argued that the traffic emission scenario in developing countries is predicated by the fact that greater automobile fleet in use in these countries is dominated by imported old vehicles (fairly used vehicles) and compounded by the poor vehicle maintenance culture of the people due to economic hardship. The result is that high numbers of the vehicles plying the road, in developing countries are classed as supper 'emitter' with high emission of harmful pollutants. Brunc keef, [4] reported that these super-emitters contribute about 50% of harmful emissions to the entire average emissions in the developing countries. Experts believe that automobiles emit more pollutants when the engine is idle [16,32]. Such idle times occur during engine start up, and such other times when the engine is on but the automobile is not moving as is often the case in traffic jams and motor- parks. It is a common practice for commercial car and bus drivers to allow the engine to idle for minutes when loading in the parks to create impression on the passengers that they are about to leave with the aim of luring them to board their car or bus. In Nigeria, available studies on high density vehicular traffic areas point to fact that vehicular emissions contribute majorly to air pollution in Nigerian cities [2,23,1]. Akintonwa *et al* [2] using portable monitor reported higher concentrations of CO, NO_2, SO_2, and volatile organic compounds (VOCs) in Eko –

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Idumota/ IJora park, Opebi/ Allen park, Oyingbo park and masha/ Kilo park, all within Ojuelegba Bus stop, Ilupeju park, Ibadan / mile 2 park, Atagbado / IJaye park within Oshodi Bus stop (all in Lagos, Nigeria) relative to FESTAC town, Lagos taken as control. The CO, NO_2 and SO_2 in the motor parks ranged between 2-17ppm, Not detected – 6ppm and Not detected -2ppm as against 0.1- 2ppm, not detected and not detected for CO, NO_2 and SO_2 respectively in the control. NESREA air quality control unit reported monitoring of some areas in Federal Capital Territory (FCT) Abuja, Nigeria including Jabi park, Air port road, Lugbe, Kubuwa express way, River plate park, Wuse II, Eagle square, National Assembly and NESREA car park using mobile Air quality control monitoring station and some hand- held equipment such as AEROCET -531 particulate counter and Gray – wolf TG-501 Toxic gas probe, the parameters were instantly recorded over a 1-3 hour averaging time period. Jabi park recorded the highest average concentrations of SO_2, NO_2, NO and NOx with values of 0.375ppm, 0.165ppm, 0.260ppm and 0.345ppm respectively, the value for SO_2 was below the USEPA 3-hr average permissible limit of 0.5ppm, NO_2 was 50% above WHO 1 – hr averaging time standard of 0.11ppm, the report attributed the high NO_2 concentration to the increased vehicular emissions from the high volume of motor vehicles, in and out of the park and open air burning of refuse, kerosene and charcoal stove cooking in the park.

In the present investigation, the objective of the research is to obtain a base line data on the levels of the monitored pollutants in the sites; evaluate the intra and inter-site levels within the different periods of the day as well as compare the pollutants concentrations with that of national and international guideline limit for air quality.

MATERIALS AND METHODS

The study area:

The study area is located within Ebonyi State, Nigeria where farming, fishing, trading, quarrying and transportation are the predominant occupation of the people. The climatic condition is tropical, characterized by wet and dry seasons. The wet season sets in between April and October while the dry season is usually between November and March [25]. The average annual temperature ranges between 21°C to 29°C and the humidity is very high .The average annual rainfall varies between 1150 mm to 2000 mm.

Sampling site selection:

One major motor park each from Ezza North local Government Area and Afikpo North local Government Area of Ebonyi State constituted the study sites.. The parks studied were Onueke (site1) and Afikpo (site 2) motor parks. Site 1 (Onueke motor park) is located between latitude N06◦10.184′and E008◦01.788′ with elevation of 78.029m above sea level while the corresponding coordinates of site 2 (Eke Afikpo motor park) is N05◦52.989′,E007◦56.185′ with elevation of 68.275m above sea level. The coordinates and elevation of each site was measured with Garmin global position system, model etrex H (Taiwan).

PM_{10} monitoring:

The suspended particulate matter (SPM) concentration in the ambient air of the monitored sites was measured by means of a digital read out photometric -laser particle counter, Aerocet Model 531-9800 Rev. C (Metone Inc. U.S.A.). The instrument has in-built particle count data for eight different particle size ranges including total suspended particulate (TSP), PM_{10}, $PM_{2.5.}$ The particulates collected by the particulate monitor through its internal pump that draws in air at a flow rate of 2.83 litres per minutes, uses the in-built particle count data and algorithm to derive the mass concentration in microgram per cubic meter of the air drawn into the instrument. The instrument has a sensitivity of 0.5 micrometer. The sampler was held at a height of 2 m above ground level, height of human breathing zone [9] and the ambient air PM concentration reading recorded as displayed on the instrument's screen. Sampling time was two minutes (that is time taken from switch on of parameter knob to display of reading on the screen). The frequency of the monitoring was such that each site was monitored daily for 28 days in three sessions: morning (7.00 am-8.00 am), afternoon (1.00 pm-2.00 pm) and evening (4.30-5.30pm) at an interval of thirty minutes for each session. The duration of the monitoring was from 6th January to 2nd February, 2014 (dry season). The thirty minutes interval instrument logged data readings for each session (morning, afternoon and evening) were later imported into the computer for further analysis. Invernizi *et al.,* had earlier reported the use of the Aerocet-531 instrument in the measurement of black carbon concentration (of the following PM sizes: PM_{10}, $PM_{2.5}$ and PM_1) as an indicator of air quality benefits of traffic restriction policies within the ecopass zone in Milan, Italy

Monitoring protocol for CO and NO_2:

CO and NO_2 levels in the two sites were monitored using on- site portable digital instrument (Programmable gas monitors) VRAE, model PGM 7840, ISO 9001 certified (made in USA by RAE systems Inc.). The instrument is equipped with electro chemical sensors that monitor CO and NO_2 (and two other gases

SO_2 and H_2S not part of this study) in the environment. The range, resolution and response time (t90 diffusion) of CO and NO_2 were 0-500 ppm, 1 ppm and 40 seconds and 0-20 ppm, 0.1 ppm and 25 seconds respectively. The instrument operates maximally within temperature range of -20 to 45ºC and relative humidity of 0 to 95%.

The monitoring of CO and NO_2 in the sites was done by switching on the specific sensor for each gas and holding the portable monitor at a height of two meters above the ground and the displayed reading recorded at the stability of the instruments reading which occurred within a minute. The monitoring duration and frequency followed that described for PM_{10} above. The prevailing meteorological parameters in the sites during the monitoring such as temperature, relative humidity and wind speed were measured using Anemometer Extech Model L 934853 while the prevailing wind direction was monitored using compass.

Quality assurance/validation of the instruments:

The two Aerocet-531 instrument and two programmable gas monitor, VRAE, model PGM 7840 used in the monitoring were calibrated according to manufacturers' instruction [30] and ran simultaneously in site 1 a day (for two hours in the afternoon) prior to the commencement of the monitoring to test for their consistency and precision, where it was observed that the difference their readings were consistent and within manufacturer's margin of error; before their separate deployment to the different sites. Presently, the areas and pollutants monitored have no official baseline data and no monitoring network; hence the data obtained in site 1 during the pre-monitoring campaign could not be validated.

Statistical data analysis:

The daily 28 days mean and F-test statistics of the down- loaded data from the instrument's log data port were computed using OriginPro Software Version 8.6.3.

RESULTS AND DISCUSSION

Pollutants concentrations for the 28 days campaign:

The daily concentrations of PM_{10}, CO and NO_2 in the different periods of the day (morning, afternoon and evening) in the sites were depicted in Tables 1 and 2. The 28 days mean concentration ± standard deviation for PM_{10}, CO and NO_2 were 46.43±6.16 μgm^{-3}, 0.162±0.079 ppm, 0.013±0.006 ppm and 55.85±5.42μgm^{-3}, 0.225±0.004 ppm and 0.018±0.004 ppm for sites 1 and 2 respectively (Table3)**.** The daily mean concentrations of the pollutants show peaking on Saturdays and dipped on Thursdays in sites 1. The pattern observed for the daily means in site 2 was such that the concentrations peaked on Saturdays but had lowest values on Sundays with few exceptions.

The mean concentrations for CO and NO_2 were within the 10 ppm and 0.02-0.04 ppm annual guideline of WHO but the PM_{10} mean in site 2 is above the annual 50 μgm^{-3} guideline limit of USEPA. Also PM_{10} limit was exceeded four times(14.3%), ten times (35.7%) and ten times (35.7%) in the morning, afternoon and evening periods respectively in site1 and 25 times(89.3%),26 times(92.8%) and 24 times (85.7%) respectively in site 2.

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Table 1: Morning, Afternoon and Evening Concentrations of PM_{10} (μgm^{-3}), CO (ppm) and NO_2 (ppm) in Onueke(sites 1)

		Site1(Onueke motor park) GPS N06◦10.184′ ,E008◦01.788′ Elevation:78.029m								
Date	day	Morning 7-8am			Aftermoon1. 00-2.00pm			Evening 4.30-5.30pm		
		CO(ppm)	NO2(ppm)	PM10(μgm^{-3})	CO	NO2	PM10	CO	NO2	PM10
6/1/2014	Mon	0.2	0.01	46	0.1	0.02	50	0.2	0.01	48
7/1/2014	Tue	0.1	0.01	48	0.1	0.02	51	0.1	0.01	51
8/1/2014	Wed	0.1	0.01	54	0.1	0.02	56	0.1	0.01	52
9/1/2014	Thur	0.1	0.01	44	0.1	0.02	48	0.1	0.01	45
10/1/2014	Fri	0.2	0.01	50	0.2	0.02	55	0.2	0.01	52
11/1/2014	Sat	0.3	0.02	54	0.3	0.02	55	0.3	0.02	55
12/1/2014	Sun	0.1	0.01	42	0.1	0.01	45	0.1	0.01	42
13/1/2014	Mon	0.2	0.01	43	0.2	0.02	46	0.2	0.01	45
14/1/2014	Tue	0.2	0.01	38	0.1	0.01	44	0.1	0.01	41
15/1/2014	Wed	0.1	0.01	40	0.1	0.01	45	0.2	0.01	42
16/1/2014	Thur	0.1	0.01	35	0.1	0.02	42	0.3	0.02	39
17/1/2014	Fri	0.2	0.02	47	0.1	0.02	52	0.2	0.02	51
18/1/2014	Sat	0.4	0.01	52	0.2	0.03	58	0.3	0.02	58
19/1/2014	Sun	0.1	0.01	40	0.1	0.01	41	0.1	0.01	40
20/1/2014	Mon	0.2	0.01	46	0.1	0.01	48	0.2	0.01	48
21/1/2014	Tue	0.1	0.01	36	0.1	0.01	39	0.1	0.01	37
22/1/2014	Wed	0.2	0.01	32	0.1	0.01	40	0.1	0.01	35
23/1/2014	Thur	0.2	0.01	32	0.1	0.01	38	0.2	0.01	35
24/1/2014	Fri	0.1	0.01	45	0.1	0.02	52	0.2	0.02	48
25/1/2014	Sat	0.2	0.01	51	0.2	0.01	57	0.2	0.01	53
26/1/2014	Sun	0.2	0.01	45	0.2	0.01	48	0.1	0.01	46

27/1/2014	Mon	0.2	0.01	46	0.1	0.01	50	0.1	0.02	52
28/1/2014	Tue	0.1	0.01	48	0.2	0.01	49	0.2	0.01	55
29/1/2014	Wed	0.1	0.01	45	0.1	0.02	47	0.1	0.01	48
30/1/2014	Thur	0.1	0.01	43	0.1	0.01	45	0.1	0.02	42
31/1/2014	Fri	0.2	0.01	49	0.3	0.04	54	0.1	0.02	50
1/2/2014	Sat	0.4	0.01	50	0.3	0.03	56	0.4	0.02	51
2/2/2014	Sun	0.2	0.01	41	0.1	0.01	44	0.1	0.01	42

Table 2: Morning, Afternoon and Evening Concentrations of PM_{10} (μgm^{-3}), CO (PPM) and NO_2 (PPM) in Afikpo motor park (site2)

		Site2 (Afikpo Motor Park) GPS: N05◦52.989′,E007◦56.185′, Elevation:68.275m								
Date	Day	Morning (7-.00-8.00am)			Afternoon (1-2.00pm)			Evening (4.30-5.30pm)		
		CO (ppm)	NO_2 (ppm)	PM10 (μgm^{-3})	CO	NO_2	PM10	CO	NO_2	PM10
6/1/2014	Mon	0.2	0.01	52	0.1	0.02	65	0.3	0.01	52
7/1/2014	Tue	0.1	0.01	50	0.2	0.01	59	0.2	0.01	50
8/1/2014	Wed	0.2	0.01	56	0.1	0.01	62	0.1	0.01	56
9/1/2014	Thur	0.1	0.01	60	0.1	0.01	60	0.2	0.01	60
10/1/2014	Fri	0.3	0.01	62	0.2	0.02	68	0.3	0.02	64
11/1/2014	Sat	0.4	0.01	60	0.3	0.02	69	0.4	0.02	65
12/1/2014	Sun	0.2	0.01	51	0.1	0.01	58	0.2	0.01	55
13/1/2014	Mon	0.2	0.01	53	0.1	0.02	56	0.2	0.01	54
14/1/2014	Tue	0.1	0.01	50	0.1	0.01	55	0.1	0.01	55
15/1/2014	Wed	0.2	0.01	52	0.2	0.01	57	0.2	0.01	54
16/1/2014	Thur	0.2	0.01	54	0.1	0.01	60	0.2	0.01	56
17/1/2014	Fri	0.3	0.02	58	0.2	0.02	67	0.2	0.01	60
18/1/2014	Sat	0.3	0.01	56	0.2	0.02	64	0.3	0.02	61
19/1/2014	Sun	0.2	0.01	49	0.1	0.01	52	0.2	0.01	50
20/1/2014	Mon	0.3	0.01	54	0.2	0.02	59	0.2	0.01	56
21/1/2014	Tue	0.2	0.01	48	0.1	0.02	56	0.1	0.01	51
22/1/2014	Wed	0.1	0.01	52	0.1	0.02	57	0.3	0.01	53
23/1/2014	Thur	0.1	0.01	55	0.1	0.02	60	0.2	0.01	55
24/1/2014	Fri	0.4	0.01	50	0.2	0.01	65	0.4	0.01	58
25/1/2014	Sat	0.5	0.01	54	0.2	0.02	64	0.6	0.02	60
26/1/2014	Sun	0.2	0.01	48	0.1	0.01	50	0.3	0.02	50
27/1/2014	Mon	0.4	0.01	45	0.2	0.01	52	0.2	0.02	51
28/1/2014	Tue	0.2	0.01	46	0.1	0.01	50	0.2	0.01	48
29/1/2014	Wed	0.2	0.01	50	0.1	0.01	56	0.3	0.01	52
30/1/2014	Thur	0.2	0.01	52	0.1	0.01	60	0.2	0.01	55
31/1/2014	Fri	0.5	0.01	52	0.3	0.02	64	0.4	0.02	59
1/2/2014	Sat	0.6	0.01	55	0.3	0.02	65	0.5	0.02	61
2/2/2014	Sun	0.3	0.01	49	0.1	0.02	55	0.4	0.02	52

NB: PM_{10} bold values exceeded the $50\mu gm^{-3}$ USEPA annual guideline limit

Table 3: 28 Days Minimum, Maximum, Mean ± Std Dev of PM_{10}, CO and NO_2 in the monitored sites

	Sites 1			Sites 2		
	Minimum	Maximum	Mean ± std dev	Minimum	Maximum	Mean ± std dev
PM_{10} (μgm^{-3})	32	58	46.429 ±6.161	45	69	55.845 ±5.416
CO (PPM)	0.1	0.4	0.162 ±0.079	0.1	0.6	0.225 ±0.120
NO_2 (PPM)	0.01	0.04	0.013 ± 0.006	0.01	0.02	0.013± 0.004

Table 4: Mean Diurnal Variation of PM_{10}, CO and NO_2 in the monitored Sites

	Sites 1			Sites 2		
	PM_{10}	CO	NO_2	PM_{10}	CO	NO_2
Morning mean ± std dev.	44.357±6.020	0.175 ± 0.084	0.011 ± 0.003	52.607 ± 4.168	0.257 ±0.132	0.010 ± 0.002
Afternoon mean ± std dev	48.393 ± 5.718	0.140 ±0.073	0.016 ± 0.003	59.464 ± 5.316	0.154 ± 0.069	0.015 ±0.005
Evening mean ± std dev	46.536 ± 6.269	0.168±0.082	0.013 ± 0.005	55.464 ±4.468	0.264 ±0.119	0.013 ± 0.005

Diurnal variation:

The concentration of the pollutants varied differently according to the time of the day. For instance PM_{10} had one month (28 days) mean of 44.36 ± 6.02, 48.39 ± 5.72 and 46.54 ±6.27μgm^{-3} concentration for morning (7-8.00am), afternoon (1-2pm) and evening (4.30 -5.3pm) respectively for site 1 For site 2, the 28-days mean concentrations for morning, afternoon and evening were 52.61 ± 4.1.7, 59.46 ±5.32 and 55.86 ± 3.40 μgm^{-3}respectively (Table4) indicating higher levels in the afternoon relative to morning and evening periods in the two sites. For CO, the morning mean concentrations were higher than that of the afternoon and evening mean concentrations where as for NO_2 the afternoon mean values were comparably higher than the morning and evening values. The higher levels of CO in the morning period may be attributed to higher vehicular volume in

the morning (peak period) and higher NO_2 in the afternoon suggest increased formation of NO_2 and other compounds resulting from the reaction of NO, a vehicular exhaust gases constituent and sunlight atmosphere. Literature has reported [3,23] elevated levels of vehicular exhaust - related pollutants in the peak periods of the day (morning and evening). The elevated levels of PM_{10} in the afternoon may be due to dust re-suspension from human and vehicle traffic in the park, fugitive dust suspension and other anthropogenic PM sources in the parks which usually peak in the afternoon. Comparatively site 2 had higher morning, afternoon and evening mean levels of the pollutants relative to site 1 (Figs1-9)

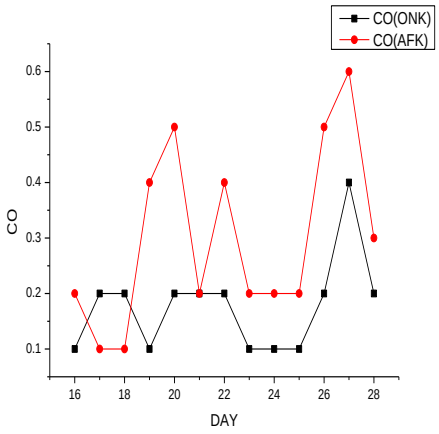

Fig. 1: The plot of CO(ppm) between 7-8AM

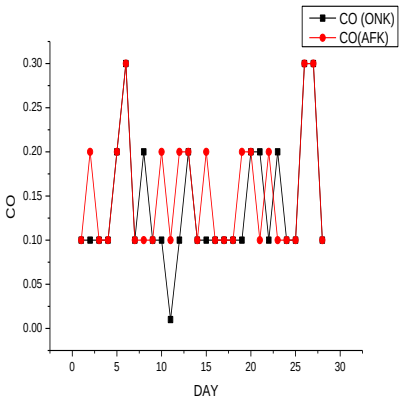

Fig. 2: The plot of CO(ppm) between 1-2PM

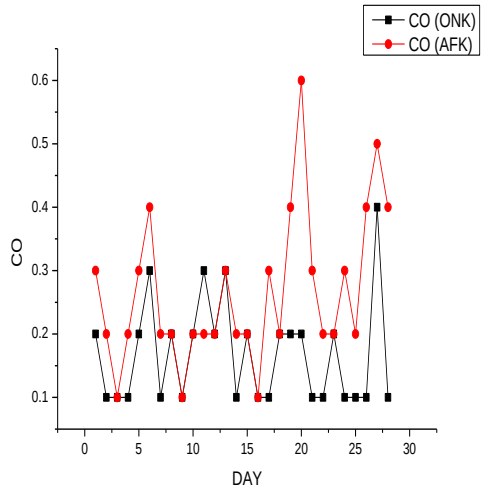

Fig. 3: The plot of CO(ppm) between 4:30-5:30PM

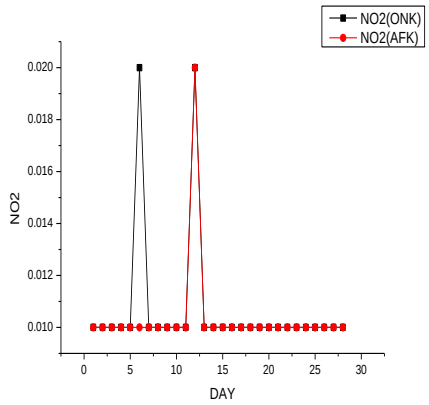

Fig. 4: the plot of NO_2(ppm) between 7-8AM

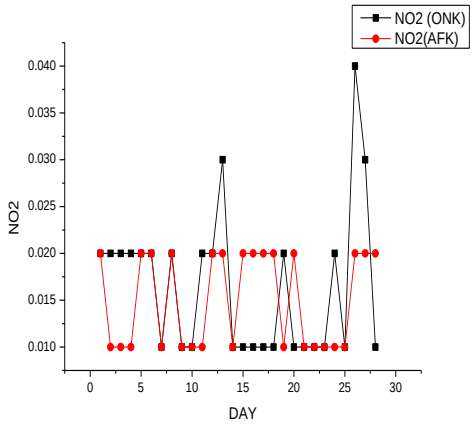

Fig. 5: The plot of NO_2(ppm) between 1-2PM

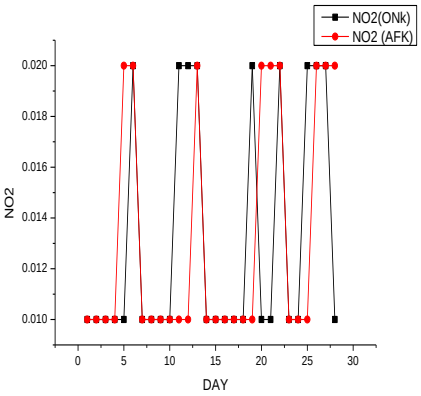

Fig. 6: The plot of NO_2(ppm) between 4:30-5:30PM

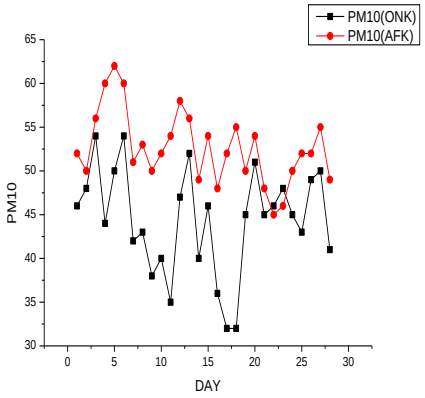

Fig. 7: The plot of PM10(µgm-3) between 7-8AM

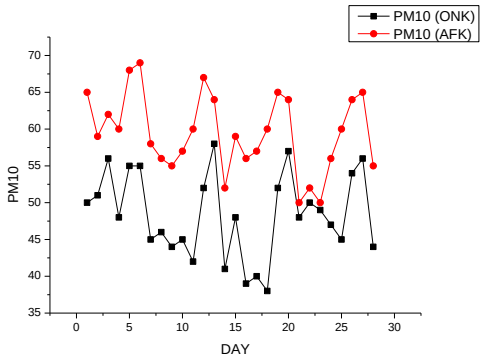

Fig. 8: The plot of PM10(µgm-3) between 1-2PM

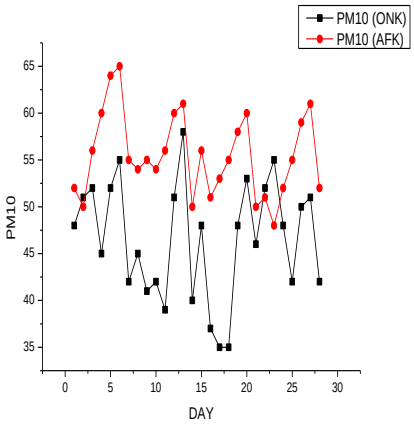

Fig. 9: The plot of PM10(µgm-3) between 4:30-5:30PM

Inter-variation of pollutants in sites 1 and 2:

Comparatively site 2 had higher mean concentrations of the pollutants monitored relative to site 1 (with few discrepancies observed in NO_2) (Figs. 4--6). This trend may be due namely to the topography of site 2 (surrounded by hills) hence less prone to venting, dispersal and dilution of pollutants and proximity (few kilometers) from Julius Berger owned stone crushing site at Akpoha, a potential source of suspended particulate matter in the area. Pollutants proximity, source strength, topography, local meteorology and atmospheric reactivity have been reported to influence pollutant concentration in an area [7,6,11]. Site 2 had an elevation of 68.273 m above sea level and average temperature, relative humidity and wind speed of 35.3±0.58 ◦C, 61.8±4.2% and 0.7±0.2 m/s respectively as against 78.029 m, 35.4±0.4 ◦C, 62.2±2.5% and 0.65±0.3 m/s for site 2. The predominant wind direction in the sites during the period of the study was north-east. Sunlight (high temperature) favours the formation of photochemical compounds such as NO_2. Wind speed is a major factor in pollutants dispersion ,diffusion and concentration at any time in a place [26,8] hence air stagnation (low wind speed) as obtained in site 2 does not allow for timely dispersal of pollutants. It has been reported that temperature, relative humidity, air pressure and wind velocity are basic meteorological parameters influencing air pollutants as heat and moisture controls the stability of the boundary layer while air pressure and wind velocity affects the dispersion of air pollutants [17]

The mean concentrations of the pollutants monitored in the two sites showed some variation however, analysis variance (ANOVA) for difference in mean among the pollutants in the two sites (Table5) showed that their differences were not statistically significant ($p < 0.05$) except for CO concentration in the morning period. The non-significant difference in the concentration of the pollutants in the two sites may point to possible common sources of the pollutants such as emissions from vehicular exhaust, dust re-suspension from paved and unpaved roads by vehicular and human traffic, emission from electric generation sets, use of charcoal and firewood by food vendors in the parks/market and homes around the parks, open solid waste burning and bush fire around the parks.

The concentration of the pollutants monitored except for PM_{10} in site two were on the average within the USEPA and NESREA guideline limits for air quality.

Conclusion:

Baseline data is paramount in environmental policy formulation and standard setting. The present study has provided baseline data on the ambient air concentrations of PM_{10} ,CO and NO_2 in the monitored areas which hitherto does not exist in literature. The study concludes that within the period of the study, the ambient air mean concentrations of the pollutants monitored (with exception of NO_2) showed higher values in site 2 relative to site 1 and varied variously in the different periods of the day but the variation were not statistically significant($p < 0.05$). Also the mean concentrations of the pollutants monitored were within the guideline limit, however the fact that PM_{10} levels in several of the monitored periods exceeded the guideline limit is not environmentally healthy.

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Table 5: Analysis of variance (ANOVA) showing mean and p-values of the pollutants at the two sites and in different periods of the day.

SITES		ONUEKE	AFIKPO	p-value
Parameter	PERIOD	MEAN		
CO	7-8AM	0.175	0.257143	0.03872970
	1-2PM	0.139643	0.153571	0.36955934
	4:30-5:30PM	0.257143	0.264286	0.12762014
NO_2	7-8AM	0.010714	0.010357	4.22181599
	1-2PM	0.016429	0.015000	0.36955934
	4:30-5:30PM	0.013214	0.013214	0.07215131
PM10	7-8AM	44.35714	52.60714	0.09748006
	1-2PM	48.39286	59.46429	0.15684258
	4:30-5:30PM	46.53571	55.46429	0.91200373

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