Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(10):871-875

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Assessment of ambient air particulate matter level in Orlu urban

***[1]Ngele S. O. and [2]Onwu F. K.**

[1]Department of Industrial Chemistry, Ebonyi State University, Abakaliki, Ebonyi State, Nigeria
[2]Department of Chemistry, Michael Okpara University of Agriculture Umudike, Umuahia, Abia State, Nigeria)

ABSTRACT

This work assessed the ambient air particulate matter (PM) concentrations in three sites in Orlu urban in the dry and wet seasons using Aerocet-531 particulate monitor. The particulate matter size monitored were Total Suspended particulate(TSP),Particulate matter less than ten micro meter(PM_{10}) in diameter and particulate matter less than two and half micrometer($PM_{2.5}$).The result showed dry season mean concentrations of 105.94±23.96, 68.31±9.72, 29.06±10.57µgm^{-3} for TSP PM10 and PM2.5 respectively in site 1; 122.00±22.09, 83.31±17.29, 30.25±18.87µgm^{-3} for site 2 and 92.13±18.16, 59.44±15.74, 22.19±3.63 µg.m^{-3} for site 3. Results generally show that site 2 PM concentration > site 1 > site 3. The highest PM concentration was recorded in January while the least was in the month of September. Student t-test statistics showed that in the dry season only PM2.5 in sites 1 and 2 were significant p<0.5 while PM10 in sites 2 and 3 were significant in the wet season. The coarse particulate pollutants levels in the three sites were within the WHO guideline limit for ambient air whereas the fine particulates (PM_{10}, $PM_{2.5}$) in the dry season exceeded the WHO guideline limit for 8 hours averaging period.

Keywords: Aerocet monitor, ambient air, Orlu urban, particulate matter

---

INTRODUCTION

Ambient air suspended particulate matter (SPM) contamination remains one of the environmental problems of global concern as the atmosphere is a global common. SPM is emitted into the air from various sources and activities usually classified as natural and anthropogenic. The level and composition of the SPM varies with location, human and natural activities in the area, topography, meteorological and atmospheric condition of an area. Particulate matter (PM) load in an area consists of direct emission from natural and anthropogenic sources and indirectly from secondary PM sources such as those formed from gaseous precursors. Globally, PM emissions have been estimated to reach 3400 million tonnes / year [1]. Man's continual quest to improve on the quality of life has led to increase in activities that pollute the air in our environment such as industrialization, energy generation and transport .These activities are usually powered by fossil fuel from coal, petroleum and natural gas whose combustion by- products are potential air pollutants.

Specifically, suspended particulate matter (SPM) emissions come from such human activities as mineral extraction and processing, mining and quarrying activities, road construction, farming activities, combustion of solid waste, re-suspension of road side dust by vehicles, particulate emissions from vehicular exhaust pipe, combustion of wood for domestic purposes etc., [2-7]. SPM air contamination has generated much attention in recent times and several studies have shown that at certain concentrations, contact between the PM and the outer (skin) or inner (respiratory tract epithelium) surface of human body can cause adverse health responses [8-11].

Reported health and environmental effects of PM air pollution include heart disease, provocation of asthma attack on asthmatics, heart failure, irritation of the upper respiratory tract, lung cancer and lung fibrosis, damage to the central nervous system, neurological and psychological disorder and reduction of visibility [12-15].

The particle size distribution of total suspended particulate (TSP) is also important as it defines the region in which an inhaled particle will be deposited in the respiratory tract [15,16].

In spite of the importance of quality air to health, some developing countries including Nigeria have not given it the desired attention. National ambient air quality standard (NAAQS) is yet to be formulated in Nigeria and as well, there is no air quality monitoring station in place.

Baseline data in the area of this study is lacking hence this work aims at a ascertaining the PM load in the area.

EXPERIMENTAL SECTION

STUDY AREA: Orlu urban is the second largest urban area in Imo State (second to Owerri) South East Nigeria. It is located between longitude 05^0 47.31N 007^0 2.9^1E and 05^0 48.6N 0.4^1E and has a population of 220,000 [17]. The area has subequatorial climatic condition with two distinct seasons namely dry season and wet season. Dry season occurs between December and March while wet season is from April to November.

Site location: The area is not demarcated on land use type resulting in mixed industrial, commercial and residential areas.

Three sites were selected to cover the entire centre in terms of geographical spread and visible air pollution sources such as area of relatively high human and vehicular traffic volume, market, small scale industries, petrol filling stations, automobile repair (mechanic) sites and refuse dump sites. Table1 shows the description of the sites.

Table 1: Sampling location (sites) for Orlu Urban, Imo State Nigeria

Site S/No	Location Name	GPS Coordinates
1	Amaifeke Junction	$N05^0$ 47.867′ $E007^0$ 01.167′
2	International market/Amaigbo/Nkwere Road Junction	$N05^0$ 47.300′ $E007^0$ 02.869′
3	Ihioma Junction	$N05^0$ 48.614′ $E007^0$ 01.387′

Suspended particulate matter monitoring protocol in the sites

The PM levels of total suspended particulate, (TSP), Particle size 10 micro- meter in diameter, (PM_{10}) and particle size 2.5 micrometer or less in diameter ($PM_{2.5}$) were monitored in three sites simultaneously using a portable particle counter on-site readout electronic instrument, Aerocet – 531 (Met one instrument, USA). Three of these instruments were deployed one per site with the help of six trained field assistance (two per site). The three samplers calibrated according to manufacturer's instruction were run simultaneously in one site for five hours per day within the period of December, 2009 before the commencement of the proper monitoring to ascertain their consistency prior to their separate deployment to the different sites. Their readings were found to be consistent as the difference in their PM levels' record within the five hours of test-run were within the manufacturer's instrument error.

A regime of monitoring used measured the ambient air level of the parameters every 30 min. for 12h per day.
The parameters were measured by hand holding the instrument to a height of about 2m above the ground in the ambient air. The instrument gives the reading of each parameter (TSP, PM_{10} or $PM_{2.5}$) on switch-on within 3 min. This gave two readings of each parameter in an hour, 24 readings in 12 hours (*i.e.*, 6.00 am - 6.00pm) and 168 readings (sampling) in a week. These weekly sampling (records) were averaged to obtained the weekly average and four weeks average used to calculate the monthly mean. The sampling lasted between December to March 2010 for the dry season and June to September, 2010 for the wet season. The monthly averages for four months were used to calculate the seasonal average. Invernizi *et al.*[18] had earlier reported the use of the Aerocet-531 instrument in the measurement of black carbon concentration as an indicator of air quality benefits of traffic restriction policies within the ecopass zone in Milan, Italy using the following PM sizes: PM_{10}, $PM_{2.5}$ and PM_1.

RESULTS AND DISCUSSION

The dry seasonal mean for the total suspended particulate (TSP) was 105.94 ± 23.96 μm^3 with a range of 81.75 ± 12.97 – 139.00± 12.68 μm^{-3}; 122.00±22.09 and range of 100.25± 15.56 -148.00±13.34 μm^{-3} for site 2 and site 3 with seasonal mean of 9.13±13 and range of 76±9.27- 117.25±20.87 μm^{-3}. The month of January had the highest mean TSP of 148.00 ± 13.34 within period of study in site 2 (Table 2A). The highest load of TSP in the month of January may likely be due to the harmattan episode which usually attains peaks in Nigeria between December and January each year and is characterized by the North-East trade wind laden with dust from the Sahara desert.

Table 2A: Weekly mean of TSP, PM_{10} and $PM_{2.5}$ in sites 1, 2 and 3 For Dry Season

Weekly PM	site1 in Orlu			site2 in Orlu			site3 in Orlu		
	TSP	PM_{10}	PM_{25}	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
December									
week1 PM mean ($\mu g/m^3$)	86	60	35	127	84	18	89	50	19
week2 PM	93	63	20	126	87	20	85	40	18
week3 PM	84	56	21	134	98	26	97	46	20
week4 PM	137	70	55	142	96	24	101	42	16
Dec mean±	**100.00**	**62.25**	**32.75**	**132.25**	**91.25**	**22.00**	**93.00**	**44.50**	**18.25**
std dev.	24.97	5.91	16.34	7.41	6.80	3.65	7.30	4.43	1.71
January									
week1 PM mean ($\mu g/m^3$)	140	86	30	162	106	68	141	88	27
week2 PM	150	79	40	156	122	56	128	95	30
week3 PM	145	74	68	141	96	50	104	78	25
week4 PM	121	80	29	133	89	60	96	64	21
Jan mean±	**139**	**79.75**	**41.75**	**148**	**103.25**	**58.50**	**117.25**	**81.25**	**25.75**
std dev.	12.68	4.92	18.19	13.34	14.31	7.55	20.87	13.45	3.77
February									
week1 PM mean ($\mu g/m^3$)	108	78	27	123	64	22	99	65	25
week2 PM	102	70	25	104	53	18	81	62	26
week3 PM	105	76	26	96	75	25	76	54	26
week4 PM	97	67	20	107	66	20	73	56	22
Feb mean±	**103.00**	**72.75**	**24.5**	**107.50**	**64.50**	**21.25**	**82.25**	**59.25**	**24.75**
std dev.	4.69	5.12	3.11	11.33	9.04	2.99	11.64	5.12	1.89
March									
week1 PM mean ($\mu g/m^3$)	92	78	24	121	82	24	81	57	21
week2 PM	78	50	12	103	78	19	76	43	17
week3 PM	92	64	23	86	74	20	84	66	22
week4 PM	65	42	10	91	63	14	63	45	20
Mar mean±	**81.75**	**58.50**	**17.25**	**100.25**	**74.25**	**19.25**	**76.00**	**52.75**	**20.00**
std dev.	12.97	15.86	7.27	15.56	8.18	4.11	9.27	10.78	2.16

Table 2B: Weekly mean of TSP, PM_{10} and $PM_{2.5}$ in sites 1, 2 and 3 for Wet Season

Weekly PM	site1in Orlu			site2 in Orlu			site3 in Orlu		
June									
	TSP	PM_{10}	PM_{25}	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
week1 PM mean ($\mu g/m^3$)	50	26	12	67	26	10	80	44	6
week2 PM	37	25	10	60	18	6	70	51	2
week3 PM	38	28	8	54	20	2	61	36	3
week4 PM	32	22	3	26	14	2	49	29	1
Jun mean±	**39.25**	**25.25**	**8.25**	**51.75**	**19.5**	**5**	**65**	**40**	**3**
std dev.	7.63	2.5	3.86	17.97	5	3.83	13.19	9.56	2.16
July									
week1 PM mean ($\mu g/m^3$)	41	25	3	60	31	8	56	16	2
week2 PM	45	28	8	55	34	5	70	16	1
week3 PM	36	30	2	38	29	3	72	10	2
week4 PM	34	26	2	25	21	1	60	14	2
July mean±	**39**	**27.25**	**3.75**	**44.5**	**28.75**	**4.25**	**64.5**	**14**	**1.75**
std dev.	4.97	2.22	2.87	16.05	5.56	2.99	7.72	2.83	0.50
August									
week1 PM mean ($\mu g/m^3$)	30	24	9	39	24	6	50	21	8
week2 PM	35	25	8	32	23	6	60	23	3
week3 PM	28	25	6	31	20	7	62	18	2
week4 PM	31	23	2	26	16	1	58	22	2
Aug.mean±	**31**	**24.25**	**6.25**	**32**	**20.75**	**5**	**57.5**	**21**	**3.75**
std dev.	2.94	0.96	3.10	5.35	3.59	2.71	5.26	2.16	2.87
September									
week1 PM mean ($\mu g/m^3$)	27	17	4	35	22	5	40	10	1
week2 PM	36	21	6	32	19	3	53	12	2
week3 PM	24	13	4	23	17	1	58	10	4
week4 PM	29	12	1	19	12	1	51	8	3
Sept.mean±	**29**	**15.75**	**3.75**	**27.25**	**17.5**	**2.5**	**50.5**	**10**	**2.5**
std dev.	5.10	4.11	2.06	7.50	4.20	1.91	7.59	1.63	1.29

Table 2C: Concentration of TSP, PM_{10} and $PM_{2.5}$ (μgm^3) for four hours sampling (at 30 min. interval) in site 1 for samplers A, B, C

TSP											
Time	8.00	8.30	9.00	9.30am	10.00	10.30	11.00	11.30	12.00	12.30	1.00pm
Portable Sampler A	80.10	81.5	75.60	87.30	76.40	74.50	73.0	74.0	72.80	72.50	72.50
Portable Sampler B	80.00	81.6	75.60	78.20	76.20	74.40	73.0	74.3	72.90	72.40	72.50
Portable Sampler C	80.20	81.6	75.50	78.30	76.30	74.40	73.0	74.2	72.90	72.50	72.40
PM_{10}											
Portable Sampler A	63.5	65.6	64.00	64.50	63.20	63.10	63.0	64.0	62.0	61.0	61.4
Portable Sampler B	63.6	65.5	64.10	64.50	63.20	63.10	63.2	64.0	62.10	61.0	61.3
Port able Sampler C	63.5	65.5	64.20	64.50	63.30	63.20	63.1	64.0	62.1	61.1	61.4
$PM_{2.5}$											
Portable Sampler A	30.5	31.10	33.00	30.60	29.7	30.2	29.30	30.1	30.3	30.4	30.5
Portable Sampler B	30.5	31.10	33.90	30.50	29.8	30.2	29.40	30.0	30.2	30.3	30.4
Portable Sampler C	30.0	31.10	33.00	30.50	29.8	30.1	29.50	30.0	30.2	30.4	30.4

Table 3A Student't-Test Results for Dry Season

		Mean	Std. Deviation	T	Prob,<t>
Pair 1	DRTSP1 - DRTSP2	-16.06250	17.19484	-3.737	.002
Pair 2	DRTSP1 - DRTSP3	13.81250	15.07412	3.665	.002
Pair 3	DRTSP2 – DRTSP3	29.87500	10.44270	11.443	.000
Pair 4	$DRPM_{10}1$ - $DRPM_{10}2$	-15.00000	17.57650	-3.414	.004
Pair 5	$DRPM_{10}1$ - $DRPM_{10}3$	8.87500	11.90448	2.982	.009
Pair 6	$DRPM_{10}2$ - $DRPM_{10}3$	23.87500	17.75340	5.379	.000
Pair 7	$DRPM_{2.5}1$ - $DRPM_{2.5}2$	-1.18750	17.10056	-.278	.785
Pair 8	$DRPM_{2.5}1$ - $DRPM_{2.5}3$	6.87500	14.58709	1.885	.079
Pair 9	$DRPM_{2.5}2$ - $DRPM_{2.5}3$	8.06250	15.70337	2.054	.058

Note: DR=Dry season and 1, 2 and 3 represent sites 1, 2 and 3 respectively.

Table 3B Student's t-Test Results for Wet season

		Mean	Std. Deviation	T	Prob(t)
Pair 1	WTSP1 - WTSP2	-4.31250	10.53071	-1.638	.122
Pair 2	WTSP1 - WTSP3	-24.81250	7.24080	-13.707	.000
Pair 3	WTSP2 - WTSP3	-20.50000	12.51666	-6.551	.000
Pair 4	WPM101 - WPM102	1.50000	4.91257	1.221	.241
Pair 5	WPM101 - WPM103	1.87500	11.67262	.643	.530
Pair 6	WPM102 - WPM103	.37500	14.50919	.103	.919
Pair 7	WPM2.51 - WPM2.52	1.31250	2.57472	2.039	.059
Pair 8	WPM2.51 - WPM2.533	2.75000	2.93258	3.751	.002
Pair 9	WPM2.52 - WPM2.533	1.43750	2.87446	2.000	.064

WT=Wet season and 1, 2 and 3 represent sites 1, 2 and 3 respectively.

Comparatively, site 2 had the maximum seasonal mean of TSP, PM_{10} and $PM_{2.5}$ in the dry season and site 3 had the minimum. The pattern in the wet season was irregular with site 3 having the maximum TSP and least $PM_{2.5}$ (Table 2A). The trend in the monthly mean showed that the highest particulate load in the ambient air occurred in the month of January while the least occurred in the month of September. These two periods correspond respectively to month of harmattan peak in Nigeria with the characteristics North-East trade wind laden with dust and peak of raining season characterized by wet precipitation. Generally, the particulate load in site 2 seems to be relatively higher than that of the other two sites and this may be due to higher anthropogenic activities in the site relative to others. Even though there is no pollution source inventory of the city and the present work did not cover that aspect, site two was observed during the sampling to have relatively higher human activities such as market place, net work of roads with high vehicular (including the two stroke engine popularly called 'Okada' present) traffic density compared to the other sites. This is also in agreement with earlier studies which observed higher particulate load in areas of higher human activities [4, 19-20].

Table 2C showed the result of the three portable samplers A,B,C running simultaneously in site 1 before their separate deployment, while the difference in the level of each parameter as recorded by the three portable monitors were within the instrument precision.

The Paired sample t-test analysis in the dry season showed that pairs $PM_{2.5}$ in site 1 and $PM_{2.5}$ in site 2 had mean differences that were statistically significant ($p<0.05$) (Table 2A) whereas in the wet season only the pair of PM_{10} in site 2 and PM_{10} in site 3 were significant ($p<0.05$) (Table 2B)

CONCLUSION

The study has provided estimate of particulate load in Orlu urban .The study points to the fact that PM load in the area is dependent on anthropogenic activities as the areas area known to have high anthropogenic activities such as market, high vehicular density *etc*. Site 2 (International market/Amaigbo/Nkwere Road junction) has the highest ambient air particulate matter load among the three sites considered in this study.

REFERENCES

[1] IPCC (**1996**). Climate change In: Houghton, J. T; Merira-Filho, L. G; Callander, B. A; Haris, N; Kattenbery, A; Maskell, K (eds). The Science of Climate Change, Cambridge University Press, Cambridge U.K.
[2] Fennelly P. F (**1976**). *Amer. Sci*. 64, 46-53
[3] Gomez D. R., Reich S. L., Dawidowski L. E. and Vazquez C (**2005**). *J. Environ. Monit.* 7, 52-59.
[4] Abam, F. I. and Unachukwu, G. O. (**2009**). *Eurojournal 34(4)*,550-560.
[5] Sodhi G. S. (**2005**). Fundamental Concepts of Environmental Chemistry 2nd Edition, Narosa Publishing House, New Deihi, pp 56-65, 219-3.
[6] Miroslav R and Vladimir B (**1998***). Practical Environmental Analysis*, Royal Society of Chemistry U. K. pp. 74-137.
[7] Samet,C., Dominic F., Currieo F. C,. Coursac T and Zeagr S (**2000**). *N. Engl. J. Med*. 343**,** 1742-1749.
[8] Schendell, D. G and Naeher, L. P. (**2002**). *Environment International* 28,375-382.
[9] Schwantz, J. Laden, F. and Zanobetti, A (**2000**). *J. Environ. Health Perspect*. 110: 1025-1029.
[10] Künzli, N; Jerret, M; Garcia-Esteban, R (**2010**). Ambient Air Pollution and the progression of atherosclerosis in adults. PLoS One 5, e9096.
[11] Kim, Y. J., Lee, K.W, Kim, S and Ham, J. S (**2006**) *Atmospheric environment* 40, 5593-5605.
[12] Pope, A. C., Thum, M. J., Nambodiri, M. M., Dockery, D. N., Evans, J.S. Speizer, F.E. and Health, C.W (**1995**). Amer. J. Respir. Crit Care Med. 151: 669.
[13] Smith, K. R (**1997**). Pollution and Health, Amer. Med. Association, **27**: 795.
[14] Norris, G., Youngpong, S. N., Koening, J. O., Larson T. V., Sheppard, L. and Stout, J. W (**1999**). *Environ. Health Perspect*. 107, 489-493.
[15] Pope, A. C (**2000**). *Environ. Health Perspect.* 108 (suppl 14), 713-723.
[16] Natusch, D. E and Wallace, J. R. (**1974**). Science, 186: 695.
[17] National Population Census (**2006**). NPC 2006 Nigeria Population and Demographic Data Report.
[18] Inveenizzi, G., Ruprecht, A., Mazza, R., DeMarco, C., Močnik, C., Sioutas, C and Westerdahl, D (**2011**). *Amospheric Environment*, 45:3522-3527
[19] Efe, S. I (**2008**). Spatial distribution of particulate air pollution in Nigerian cities: Implication for human health. *J. environmental health research 2(7).*, retrieved online @www.cieh.org/jehr/jehr3.aspx%3fid on 01-09-13
[20] Koku, C. A and Osuntogun, B. A (**2007**). *Journal of Applied Sciences, 7*(16), 2536-2550