Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(11):341-346

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

A pilot study of ambient air pollution of an emerging Nigerian city (Nnewi)

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ABSTRACT

Rapid urbanization occasioned by population explosion, rural-urban drift and industrialisation in most city centres of developing countries is impacting negatively on the environmental quality of such cities. In this study, the ambient air pollution of the city of Nnewi was assessed using on-site digital read out portable monitor for both dry and wet seasons. The parameters monitored were CO, SO_2, NO_2, total suspended particulate (TSP), particulate matter with aerodynamic size smaller than ten micrometre, (PM_{10}) and two and half micrometre ($PM_{2.5}$). The results showed that the mean dry season levels were 0.612±0.35 ppm, 0.146±0.06 ppm, 0.135±0.08 ppm, 105.83±24.98 µg.m^{-3}, 69.46±17.81 µg.m^{-3} and 26.35±13.40 µg.m^{-3} respectively; While the corresponding wet season mean values were 0.402±0.27 ppm, 0.074±0.05 ppm, 0.063±0.05 ppm, 46. 98±17.25 µg.m^{-3}, 22.35±8.64 µg.m^{-3} and 4.13±2.86 µg.m^{-3} respectively. The students t-test for difference in seasonal means of the pollutants showed that their differences were statistically significant ($p<0.01$). The gaseous and coarse particulate pollutants levels were within the WHO guideline limit for ambient air whereas the fine particulates (PM_{10}, $PM_{2.5}$) exceeded the WHO guideline limit for 8 hours averaging period.

Keywords: Ambient air, Nnewi urban, Pollutants, Portable monitor

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INTRODUCTION

Nnewi is the second largest city in Anambra State after Onitsha. As an emerging city, it has grown from rural status to urban area encompassing two local Government areas, Nnewi North and Nnewi South. The population has equally being soaring high from 28,777 in 1953 to 44, 393 (0.97% population growth) in 1963. By the 1991 Nigerian population census record, it has gone up to 201,763 and up to 391,227 in the last census (2006).This tremendous population explosion is due majorly to the high level of commercial and industrial activities in the area. The city has of late become characterized by inadequate and deteriorated road networks, walkways, unregulated building patterns, poor sanitation, uncontrolled street trading and chaotic transport systems, creating congestion, noise, air pollution and overcrowding. [1].

In an effort to address the malady and achieve environmental sustainability in the context of achieving state, local economic development goals and habitat agenda; the Anambra State Government in 2007 signed a technical cooperation agreement with United Nations Habitat, which produced a 20 year (2009-2028) structural plan for three major cities in the state namely: Onitsha, Nnewi and Awka capital territory to restore urban planning and guide their

growth into the future [2]. UN-Habitat report on the structural plan for the cities contain policies and proposals for land use, city beautification, road infrastructure, industrial development, housing, waste disposal (solid and liquid waste), water supply, health and educational facilities. Air pollution control strategies were not specifically captured in the report and of course the city at present lacked baseline data on air pollution.

Available air quality report of Nigerian cities, show an increasing pollutants trend [3-7]. The sources of air pollutants are majorly classified into natural sources which include: volcanoes that emit dust particles, SO_2, HCl, CO_2; bogs and marshes which emit, H_2S and CH_4; lighting which generates NOx and Sea spray which produces SO_2 and aerosol. The anthropogenic sources include: combustion processes such as indoor heating devices such as: stove, furnace, gas fired heaters and charcoal braziers that emit CO_2, CO, vehicular emissions that emit particulate matter, CO, CO_2, NOx, volatile organic compounds (VOCs) and SO_2 from the combustion of fossil fuel [4]. Other anthropogenic sources include industrial emissions that produce pollutants such as SO_2, particulate, CO_2, CO and emissions (SO_2, NOx) from electric power generation facilities that depend on fossil fuel, heating / cooking devices. The present study is aimed at estimating levels of important ambient air pollution parameters in Nnewi, which may guide development of future air pollution management strategy in this emerging city

EXPERIMENTAL SECTION

Study area

The study area is Nnewi urban, located between $6^0 1'$N 6^0 55'E and 6.017^0N 6.917^0E coordinates. It is the second largest city in Anambra State with a population density of 2,800 per square kilometre. The city spans over 2.789 km^2 with satellite towns and consists of two Local Governments Areas: Nnewi North and Nnewi South. The area has sub-equatorial climate type with characteristic dry and wet seasons, spanning between December to March and April to November respectively.

Site selection

In the absence of well demarcated city area into industrial, commercial and residential areas, the sampling sites were evenly spread to cover the entire urban area for the monitoring of the gaseous and particulate pollutants. Table 1 showed the details of the sites serial number, names and coordinates as measured using Garmin global position system, model etrex H

Table 1: **Site name, serial number and GPS coordinates of the study area (Nnewi Urban)**

S/No	Name	GPS Coordinate
1	Izuchukwu Junction	N06^O 01.103′
		E006^O 55.092′
2	Traffic By	N06^O 00.074′
	CPS	E006^O 54.981′
3	Eme By Area	N06^O 00.330′
	Command Junction	E-006^O 54.489′
4	St. Mary's Catholic	N06^O 01. 626′
	Church Uruagu, Nnewi	′E006^O 50.950′
5	Bethel Anglican	N06^O 02.473′
6	Amuko Junction	E006^O 53.079′
		N′06^O 02 .496′
7	Adil Junction/	E006^O 54.481′
	Motor Sparepart	N06^O 02.481′
8	Ibeto/Edo-Ezemewi	E006^{O}54.4361′
9	Nitel Junction	N06^O 01.913′
	Nnobi/ Awkaetiti Road	E006^O 55.454′
10	Umuanuka Otolonnewil	N06^O 01.377′
		E006^O 56.108′
11	Abada Junction, igwe Orizu Rd	N06^O 00.354′
12	Eke oche market	N06^O 00. 527′
	Junction Amaechi Rd	E006^O 56.302′
13	Nwanyiocha Junction	N06^O 00.065′
		E06^O 56.576′
14	Nacil Junction, Nkpo/Ozubulu -	N06^O 01.319′
	Owerri Rd Umudim	E006^O 01.310′

Monitoring of the gases

CO, NO_2 and SO_2 levels in the selected sites were monitored using on site portable digital instrument, multirae plus programmable gas monitor, 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, SO_2, NO_2 and H_2S in the environment. The range, resolution and response time ($t_{90\ diffusion}$) of CO, SO_2 and NO_2 were 0-500 ppm, 1 ppm and 40 seconds; 0-20 ppm, 0.1 ppm and 35 seconds; 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%.

Monitoring protocol for CO, SO_2 and NO_2

The monitoring of CO, SO_2 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 readings were taken in each site three times a day (by 7.00 am, 1.00 pm and 5.00 pm). The frequency of the sampling was one day per week, four weeks per month for four months in the dry season, December, 2009 - March, 2010 and four months in the wet season, June - September, 2010. The three readings obtained in a day per week were averaged; the resulting 16 weeks (four months) figures in each site for dry and wet seasons were averaged to obtain the seasonal mean.

Monitoring of the particulate matter (TSP, PM_{10} and $PM_{2.5}$)

The levels of the TSP, PM_{10} and $PM_{2.5}$ in the sites were monitored using a photometric–laser technology based particle counter instrument, Aerocet-531-9800 Rev.C, manufactured by Metone Instrument Inc. USA. The instrument provides readings of particulate matter in mass concentration and particle count modes. In the mass mode, the sizes measured by the instrument include PM_1, $PM_{2.5}$ and PM_7, PM_{10} and TSP, while the particle count mode was ≤ 0.5 and ≤ 10 microns. 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.

RESULTS AND DISCUSSION

Table 2 and Fig. 1 showed the CO, SO_2 and NO_2 levels in the studied area. The highest dry and wet season level of 1.0 ± 0.41 and 0.85 ± 0.03 ppm occurred in site 8 (Ibeto/Edo – Ezemewi Road junction), while the minimum CO level of 0.21 ±0.06 ppm was obtained in site number 12 (Eke oche market junction by Amaechi Road). For SO_2, the ranges of the site mean values span from 0.05± 0.06 ppm to 0.19±0.04 ppm in dry season and 0.03±0.05 to 0.09±0.04 ppm in the wet season (Table 2).

The site seasonal mean levels of NO_2 ranged from 0.04±0.05 to 0.22±0.05 ppm in the dry season and 0.03±0.05 to 0.10±0.05 ppm in the wet season. The seasonal (dry and wet) mean levels of CO, SO_2 and NO_2 were 0.61±0.35 and 0.40±0.27 ppm, 0.15 ±0.05 and 0.07±0.05 ppm and 0.13±0.08 and 0.06±0.05 ppm respectively (Table 2).

Pollutants showed highest values in sites with greater human activities. For instance sites 6, 7 and 8 were corridors of high vehicular and human traffic and were also within the market area. This is in line with literature which showed that the levels of these gaseous pollutants are elevated in areas with high traffic density and human activity relative to isolated and low traffic areas [5, 8].

Table 3,showed the sites seasonal mean and overall city mean level of total suspended particulate (TSP), particulate with diameter less or equal ten micrometer (PM_{10}) and particulate with diameter less or equal to 2.5 micrometer ($PM_{2.5}$) in the study. The highest and least dry seasonal TSP values were 148.00±13.34 and 76.00±9.27 $\mu g.m^{-3}$ recorded in site 8 and 13 (Ibeto/Edo Ezemewi and Nwanyiocha junction) respectively. The corresponding wet season highest and least values were 40.00±9.56 and 10.00±1.63 $\mu g.m^{-3}$ respectively. Similarly $PM_{2.5}$ had the highest dry seasonal value of 58.50±7.55 μgm^{-3} and least value of 16.50 ± 6.45 $\mu g.m^{-3}$. The wet season maximum and minimum values were 8.25± 3.86 and 1.75 ±0.50 $\mu g.m^{-3}$. The overall (annual) mean TSP, PM_{10} and $PM_{2.5}$ values were 46.98±17.25, 22.35±8.64 and 4.13±2.86 $\mu g.m^{-3}$respectively (Table 3). The level of PM_{10} in this study is below the range of 198-257 $\mu g.m^{-3}$ and 36-306 $\mu g.m^{-3}$ reported by Abam and Unachukwu, (2009) [5] and Ngele (2009) [7] in study of Calabar urban and Abakaliki urban cities in Nigeria respectively.

Table 2: Site seasonal mean levels (ppm) of CO, SO_2 and NO_2 in Nnewi Urban

	CO		SO_2		NO_2	
	DRY	WET	DRY	WET	DRY	WET
1	**0.71**	**0.5**	**0.05**	**0.06**	**0.16**	**0.08**
	0.2	0.11	0.06	0.05	0.05	0.05
2	**0.51**	**0.35**	**0.15**	**0.09**	**0.09**	**0.05**
	0.15	0.15	0.05	0.04	0.04	0.05
3	**0.66**	**0.5**	**0.18**	**0.09**	**0.13**	**0.04**
	0.13	0.15	0.04	0.04	0.05	0.05
4	**0.66**	**0.33**	**0.13**	**0.08**	**0.08**	**0.04**
	0.13	0.13	0.05	0.05	0.05	0.05
5	**0.39**	**0.24**	**0.11**	**0.08**	**0.18**	**0.09**
	0.38	0.09	0.04	0.04	0.03	0.04
6	**1.04**	**0.75**	**0.17**	**0.09**	**0.09**	**0.09**
	0.38	0.33	0.05	0.04	0.04	0.04
7	**1.03**	**0.68**	**0.16**	**0.08**	**0.22**	**0.09**
	0.34	0.34	0.05	0.05	0.05	0.04
8	**1.2**	**0.85**	**0.19**	**0.09**	**0.22**	**0.1**
	0.41	0.29	0.04	0.04	0.05	0.05
9	**0.45**	**0.25**	**0.19**	**0.09**	**0.18**	**0.08**
	0.1	0.08	0.04	0.04	0.07	0.05
10	**0.54**	**0.36**	**0.13**	**0.06**	**0.11**	**0.05**
	0.11	0.11	0.05	0.05	0.04	0.05
11	**0.45**	**0.3**	**0.13**	**0.03**	**0.04**	**0.03**
	0.09	0.07	0.05	0.05	0.05	0.05
12	**0.21**	**0.11**	**0.12**	**0.09**	**0.09**	**0.03**
	0.06	0.08	0.09	0.06	0.04	0.04
13	**0.29**	**0.13**	**0.09**	**0.05**	**0.21**	**0.09**
	0.11	0.07	0.04	0.05	0.08	0.06
14	**0.45**	**0.26**	**0.12**	**0.07**	**0.09**	**0.05**
	0.12	0.11	0.05	0.05	0.04	0.05
seasonal	**0.61**	**0.4**	**0.15**	**0.07**	**0.13**	**0.06**
mean/std	0.35	0.27	0.05	0.05	0.08	0.05

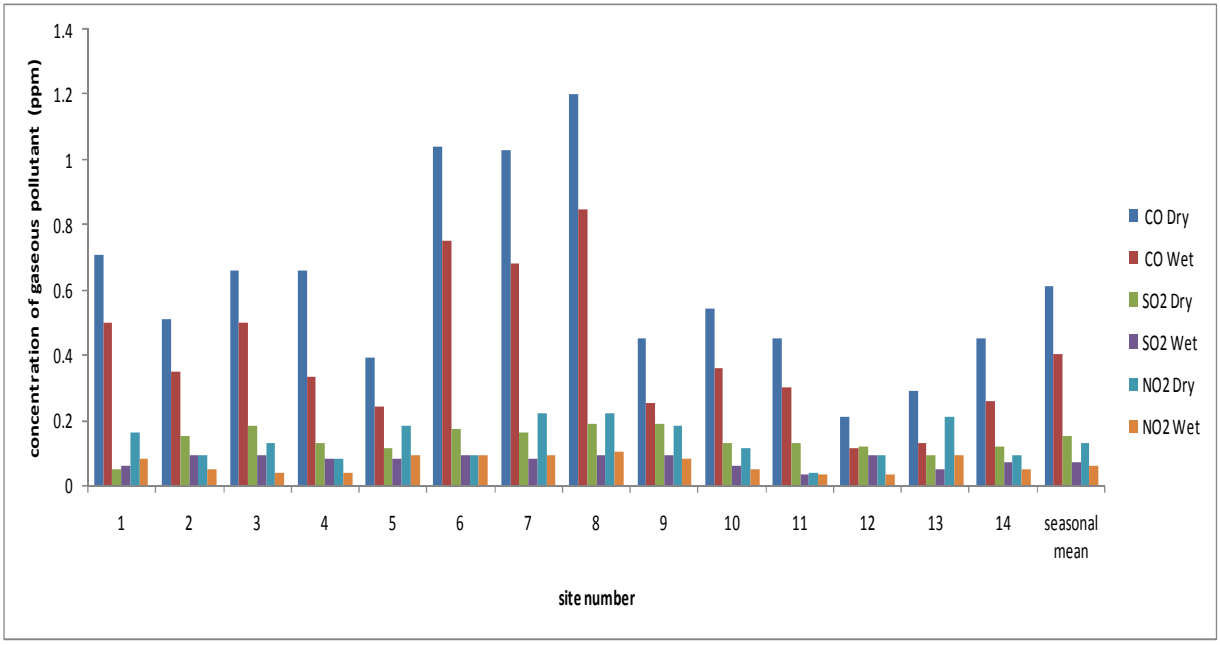

Fig. 1: Concentration of Gaseous Pollutants (ppm) in Dry and Wet Seasons

Table 3: Sites mean levels (μgm^{-3}) of TSP, PM_{10} and $PM_{2.5}$

		TSP		Pm_{10}		$Pm_{2.5}$	
Site number		Dry	Wet	Dry	Wet	Dry	Wet
1	Mean	143.00	39.25	77.25	25.25	48.25	8.25
	SD	5.72	7.63	6.90	2.50	16.70	3.86
2	Mean	97.25	31.00	67.75	24.25	26.75	6.25
	SD	9.71	2.94	8.02	0.96	6.24	3.10
3	Mean	79.75	29.00	53.00	18.25	16.50	3.75
	SD	11.38	5.10	9.31	7.09	6.45	2.06
4	Mean	103.75	39.00	75.25	27.25	24.75	3.75
	SD	12.69	4.97	5.74	2.22	3.77	2.87
5	Mean	107.50	27.25	64.50	24.00	21.25	2.50
	SD	11.33	7.50	9.04	4.24	2.99	1.91
6	Mean	100.25	32.00	74.25	24.75	19.25	5.00
	SD	15.56	5.35	8.18	3.59	4.11	2.71
7	Mean	132.25	44.50	91.00	28.75	22.00	4.25
	SD	7.41	16.05	6.58	5.56	3.65	2.99
8	Mean	148.00	51.50	103.25	22.00	58.50	5.00
	SD	13.34	18.45	14.31	3.65	7.55	3.83
9	Mean	117.25	64.75	81.25	40.00	25.75	3.00
	SD	20.87	13.30	13.45	9.56	3.77	2.16
10	Mean	82.25	61.00	59.25	21.00	24.50	3.75
	SD	11.64	9.02	5.12	2.16	1.73	2.87
11	Mean	93.00	65.25	44.50	13.75	18.25	1.75
	SD	7.30	8.77	4.43	2.63	1.71	0.50
12	Mean	76.00	55.50	52.75	10.00	20.00	3.00
	SD	9.27	10.54	10.78	1.63	2.16	1.83
13	Mean	95.50	70.75	59.00	11.25	16.75	3.50
	SD	14.48	6.75	7.39	2.50	3.40	2.08
14	Mean	91.05	40.69	59.97	19.57	23.11	3.89
	SD	41.46	20.61	27.62	8.55	14.52	2.54
		104.77	46.53	68.78	22.15	26.12	4.12
	Seasonal Mean/SD	22.70	14.84	16.08	7.71	12.15	1.64
Annual mean /SD	**77.62**		**45.47**			**15.12**	
	18.77		**11.89**			**6.89**	

Table 4 depicted the paired sample t- test of seasonal mean values of gaseous and particulate pollutants studied. The data showed that the difference between the dry and wet seasonal means of all the pollutants were statistically significant at all levels (evident from the 0.00 values of prob. <t> for all the pollutants in Table 4.

The mean levels of CO, SO_2 and NO_2 obtained in this study were within the Federal Ministry of Environment (FMENV) values of 10, 0.01 and (0.04 – 0.06) ppm and WHO guideline values of 9.00, 0.02 and 0.02 ppm respectively[9,10]. The mean annual TSP value obtained in the study was within the WHO guideline values of 230-250 μg.m^{-3}; however the PM_{10} and PM 2.5 mean values were above the 50 μg.m^{-3} and 20 μg.m-^{3} recommended limits for PM_{10} and $PM_{2.5}$ respectively. This has serious health consequences as the finer particles have been reported to possess greater potential to cause or aggravate lung and cardio- vascular diseases [11]

Table 4: Paired Sample t-test of Seasonal Mean Values of Gaseous and Particulate Pollutants

Paired	Mean	Std. Deviation	**T**	**Prob<t>**
COD – COW	0.213	0.082	9.675	0.000
SO2D - SO2W	0.062	0.033	7.127	0.000
NO2D - NO2W	0.070	0.041	6.396	0.000
TSPD – TSPW	58.934	27.772	7.940	0.000
PM10D - PM10W	47.089	12.511	14.083	0.000
PM2.5D - PM2.5W	22.176	11.188	7.416	0.000

CONCLUSION

This study has provided estimate of the levels of CO, SO_2, NO_2 and particulate matter in the ambient air of Nnewi urban. Presently, the levels of the gaseous and coarse particulate pollutants are within the WHO guideline limit but the fine particulates were above the limit. It is hoped that the findings may give future direction on air quality monitoring campaign strategy in this emerging Nigeria city.

Acknowledgements
The author is grateful to Prof. A. N. Eboatu of Nnamdi Azikiwe University, Awka and also thank Dr Uwem Ubong, Management and staff of Faithlink Consult Port Harcourt for providing the equipment used and for their technical support in the course of the study.

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