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SEASONAL ANALYSIS OF ATMOSPHERIC POLLUTANTS CONCENTRATIONS IN URBAN AND RURAL LANDUSE AREAS OF RIVERS STATE, NIGERIA.

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ABSTRACT: *The study examined the seasonal urban-rural difference in atmospheric pollutant concentration in Port Harcourt region. Sampling was performed at four different sites with two having urban and rural characteristics respectively, with the aid of multi-gas sampler and hand held weather tracker during the wet, transition and dry season from 2010-2011 on the bases of 24-hour continuous measurement. Data collected were analysed using t-test at p = 0.05. Findings showed that the pollutants (in urban and rural areas) with significant concentrations during the dry season were* PM_{10} *(384.0 ± 32.6 and 259µg/*m^3 *± 41.7 µg/*m^3*),* SO_2 *(1.4 ± 0.0 and 0 mg/*m^3 *± 0 mg/*m^3*) and* CH_4 *(61.4 ± 3.8 and 0 mg/*m^3 *± 0 mg/*m^3*); while in the wet season they were* PM_{10} *(101 ± 4.7 and 33.6µg/*m^3 *± 0.7µg/*m^3*), TSP (155.2 ± 15.5 and 42..3µg/*m^3 *± 1.2 µg/*m^3*) and CO (26.2 ± 0.2 and 17.5 mg/*m^3 *± 0.4 mg/*m^3*). For the transition period, the pollutants (in urban and rural areas) with significant concentrations were* PM_{10} *(215.7 ± 20.0 and 146.2 µg/*m^3 *± 19.2 µg/*m^3*), TSP (287.7 ± 45 and 204.6µg/*m^3 *± 55.4 µg/*m^3*),* NO_2 *(0.2 ± 0.0 and 0mg/*m^3 *± 0mg/*m^3*) and* CH_4 *(20.5 ± 0.6 and 0.9mg/*m^3 *± 0.0mg/*m^3*). The slashes and burn method of farm preparation and fuel wood which is used for cooking contributed to the high concentration of TSP,* PM_{10} *and CO during the dry season and this is why there was no significant difference in their concentration with the urban areas. In general however, there were significant differences in the mean concentrations of* PM_{10}*, TSP,* NO_2*, and CO;* PM_{10}*, TSP,* NO_2 *and* CH_4 *during the wet, transition an dry seasons respectively at 95% significant level between the rural and urban areas for the seasons at p = 0.05. Regular monitoring of pollutants especially at the rural areas of Port Harcourt region with heavy hydrocarbon industrial foundations is advocated.*

KEYWORD: Urban, Rural, Atmospheric Pollutants Concentration, Seasons, Port Harcourt,

INTRODUCTION

The effect of urbanization on local climate, pollution and health is a problem that has been recognized and documented for centuries (see, Oke, 1974, Ojo, 1981; Oliver, 1985, Ono et el., 1990, Olurin, 1991; Oni, 1998; Ayoade, 2004; Bamgboye, 2006); the inadvertent microclimatic change induced by urbanization and transport development are also well documented (Oke, 1974; Oguntoyinbo, 1974; Obioh, 1994, 2005; Taiwo, 2005). The detrimental impacts of acids that form from SO_2 and NO_2 emissions in the urban centres impact negatively on rural land use such as sensitive lakes, streams, forests and farmlands have been well documented (Guttikunda, et al, 2003). Acid rain is caused by emissions of compounds of ammonia, carbon, nitrogen and sulfur which react with the water molecules in the atmosphere to produce acids. When this occurs, it is

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carried away thousands of kilometers by the atmosphere from the urban centres to rural areas where it fall as rain affecting forest, streams and farm lands. As lakes and rivers become more acidic, biodiversity is reduced. Acid rain has eliminated insect life and some fish species, including the brook trout in some lakes, streams, and creeks in geographically sensitive areas, such as the Adirondack Mountains of the United State, Eastern Europe from Poland northwards into Scandinavia. Others include South Eastern coast of China and Taiwan (Siccama et al; 2002).

The soil biology and chemistry can also be seriously damaged by acid rain. For instance, the enzymes of soil microbes are denatured by the acid; the hydronium ions of acid rains also mobilize toxins such as Aluminium, and leach away essential nutrients and minerals such as magnesium (Owen et al; 1992). A related issue involves fertilization effects caused by the deposition of airborne fixed nitrogen spp. (PM NH_4^+ and NO_3^{2-} and their gas phase precursors) to buffered soils and surface waters that are not susceptible to acidification. Combined with fixed nitrogen and phosphorous from fertilizer, animal waste, and human sewage sources, atmospheric deposition of fixed nitrogen can over-fertilize soils, lakes, streams, and estuaries, in the rural areas leading to changes in primary productivity and, potentially, to eutrophication (Galloway,1996). When these acids are consumed, they cause acidosis in human body. Excess accumulation in human body can lead to death. Gaseous pollutants stimulate coughing in patients suffering from chronic bronchitis, and those patients with heart and lung disease may fatally succumb to sulphur IV oxide; more commonly referred to as sulphur dioxide. Particulate matter that enters the lungs may lodge there and result in chronic respiratory problems including emphysema, pneumonia, bronchitis asthma and respiratory tuberculosis, etc. Other consequences include pollution of surface and sub-surface systems, destruction of vegetal cover, and endangered human lives (health) among others. It is on this note that Okecha, (2000) and Efe, (2006) joined with Smith, (1975); Miller, (1994); Moore, (1995) and Botkin and Keller, (1995) in calling for regular studies on air pollution and its possible health effects in urban environments around the world as well as highlighting the need for appropriate policy development if the threat is to be mitigated.

Akeredolu et al, (1994) monitored the vehicular Carbon monoxide emission at one of the city's traffic light-controlled roadway junction with an automated NDIR system and noted that the modeled Co concentration range between 6-12 ppm and measured road side Co concentration (8-14ppm) while the national Co ambient standard is 10 ppm. They concluded that the model results indicated that the Co concentration is mainly a function of the red-light stopping interval. Baumbach et al., (1995) conducted a experiment in Lagos State of Nigeria to measure pollution levels in some 'hot spots' and noted that the northern wind transports much dust from Sahara and that most of the identified air pollution in Lagos is caused by the road traffic which can even be recognized without measurements, by strong turbidity, bad smell and eye irritation. They also noted that many petrol engine cars emits blue smoke caused by un-burnt oil, and that market places are established around bus stops and many people are exposed to unhealthy high concentrations of aromatic hydrocarbons, CO and particles. They opined that drastic measures are necessary to protect the population against this high pollution and that the measured benzene concentrations could cause a raise carcinogenic risk. Ogugbuaja et al., (2001), measured the suspended Particulate Matter (SPM) concentrations for Maiduguri and Yola areas of North-Eastern Nigeria and determined the concentrations of Cd, Fe, Mn, Pb, and Zn in the SPM. They noted that mean SPM

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levels were 28.3ug/m^{-3} (range, 1.3-144ug/m^{-3}) and 13.6ug/m-3 (range, 1.1-52ug/m-3) for Maiduguri and Yola areas, respectively and that these were remarkably below the mean value of 98ug/m-3 reported for some selected cities in the world, this showed pronounced differenced from the annual average of 150 ug/m-3 reported by WHO for polluted air. Enrichments of Cd, Cu and Zn in the air relative to the soil are attributable to few industrial activities in the areas while that of Pb is due to vehicular emissions. Concentration of all the metals in the SPM fell within the range reported for contaminated air in Europe and North America. Akani (2008) examined the street level air temperature and quality along the traffic corridors of Lagos metropolis. The study revealed that the concentration of fine particles and gaseous pollutants (TSP, Pb, Cd, Cu, Cr, Al, Zn, As, Hg, Fe, Mn, Mg, CO_2, NO_2, SO_2 and Ozone) are higher when compared with the FEPA and WHO air quality standards. It was observed that street level pollutant concentrate more along traffic corridors than further away and that traffic density and congestion influence the instantaneous level of pollutants during the dry seasons and less during the wet season. The study concluded that there is need for traffic education, adequate land use planning and emission inventory in the metropolis. Oluwande (1977) measured the level of air pollution resulting from vehicular exhaust in Ibadan for a period of one year and noted that the level of atmospheric dust was higher in the city than in the rural suburbs, and that the level of atmospheric dusts was higher during higher heavy traffic and dry season than during the wet season. Ede et al (2006) examined the flare combustion efficiency and emissions from associated petroleum gas flare points in the Niger delta. The study concludes that there was a downward flux in the combustion efficiency for the same station except at Elenlewo flare site; it was also revealed that the mean combustion efficiency from the combined analysis was 72% for the flare points which results in emission factor of 3.10×10^{-4}. At the calculated combustion efficiency, it was estimated that about 230,431 tons of particulates have been emitted.

From the above review, it is obvious that there is abundant information about the state of the urban environment. In all these studies however, the influence of urban landuse air pollution contribution to the concentration of pollutants in the rural area was ignored. Similarly, much emphasis has been placed on urban areas at the detriment of rural areas. Specifically in Port Harcourt, emphasis has been on flare sites. In most cases air quality measurements are carried out by multinational companies solely for its consumption (see Ede et al, 2006). The public do not have access to this information and are not better educated and well informed. Most of the studies also are site specific (see Ede et al, 2006). These are the gaps in knowledge which this study intends to fill. This study is an attempt to unravel the influence of urban pollutants on the concentration levels of rural landuse pollutants in Port Harcourt and its rural surroundings.

METHODOLOGY

Air quality was measured in two stations each from the urban and rural areas examined for the study. However, to examine the urban-rural difference, an agricultural land use location (30km away from the city) having rural characteristics was examined. The collection of air quality and meteorological data for this study commenced from 2nd August to 18th September, 2010 reflecting the wet season; transition period of October 4th to November 20th, 2010 and dry season period of January 3rd to February 19th 2011. The choice of these seasons is based on rainfall distribution of

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Port Harcourt. This covered about 126 days (42 days each of the three seasons). The transition period of rainfall represents the period when rainfall begins to recede giving way to the dry season. It is also a period between the wet season and the dry season. These steps were taken in order to capture the fluctuations in pollutant concentrations in all the stations for all the seasons. In order to select the sample points which will serve as air quality monitoring stations, a land use map of the study area with the scale 1:1,000 was gridded 500 m x 500 m. All the squares of the gridded map were coded in their respective land use type and selection was made without replacement to obtain two monitoring stations representing a specific landuse to obtain four stations. The spatial variations in atmospheric pollutants concentration in this study were evaluated by analyzing the actively sampled pollution data from the different land use areas chosen in this study on daily basis. The analysis was based on the data collected throughout the seasons considered in this study. The objective is to ascertain and/or identify the mean weekly spatial variations in the concentration of atmospheric pollutants at the respective land use areas. The data were collected for seven weeks making a total of 42 day (Sunday not inclusive) during wet, transition and dry seasons. The seasonal variation in atmospheric pollutants concentration was done amongst the major landuse types (urban and rural) with a view to unraveling the difference in the concentration of atmospheric pollutants at different seasons of the year for the study area. Table 1 show the coordinates of the areas which constitute the major land use areas used for the study. However, the mean of the pollutants from all the urban landuse areas was used to represent the urban landuse data while the mean of the data from two randomly selected rural areas were used as the data representing the rural landuse which was used for the computation of two- independent sample comparison with the aid of SPSS statistical software. For all the land use types, effort was made to identify the general direction of wind. This is to enable us identify the down-wind and up-wind direction to enhance the quality and reliability of the data that was collected. The following pollutants parameters were measured using potable in situ direct reading instrumentation; Nitrogen Oxide (NO_2); Sulphur Oxide (SO_2); Carbon Monoxide (CO); Methane (CH_4) and Suspended Particulate Matter (PM_{10}, PM_7, $PM_{2.5}$, PM_1 and TSP).

Table 1: Location of monitoring stations.

Landuse	Stations	Latitudes (^{0}N)	Longitudes (^{0}E)
Industrial	Eleme	$4^0 47^1$	$7^0 6^1$
	Trans-Amadi	$4^0 48^1$	$7^0 1^1$
High density residential	Diobu	$4^0 47^1$	$6^0 59^1$
	Rumuagholu	$4^0 52^1$	$6^0 59^1$
Low density residential	GRA	$4^0 48^1$	$6^0 59^1$
	Abuloma housing estate	$4^0 46^1$	$7^0 2^1$
Commercial	Mile III Market	$4^0 48^1$	$6^0 59^1$
	Creek road market	$4^0 45^1$	$7^0 1^1$
Transport	PH-Aba exprees way	$4^0 48^1$	$7^0 0^1$
	Ikwerre road	$4^0 52^1$	$6^0 59^1$
	PH Int'l Airport	$5^0 0^1$	$6^0 57^1$
Rural	Aluu	$4^0 56^1$	$6^0 56^1$
	Egbelu-akami	$4^0 50^1$	$6^0 57^1$

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RESULT AND DISCUSSION OF FINDINGS

Comparison of pollutant concentration between urban and rural landuse areas during dry season

The comparison of the concentration of PM_{10} revealed that the value (406.7µg/m^3) at the urban areas was more than the rural area which had a value of 259.03µg/m^3. These concentrations represented 61% for urban and 38.90% for the rural. In the same manner, the concentration of Total Suspended Particulate (TSP) was more at the urban area with a value of 606µg/m^3 representing 62.20% as compared to the rural area with a value of 268.23µg/m^3 representing 37.79% during the dry season. The concentration of SO_2 was 0.56mg/m^3 at the urban areas representing 100% with none detected at the rural areas during the dry season. In the same way, NO_2 was not detected at the rural area but had a value of 3.3 representing 100% at the urban areas. In the case of carbon monoxide (CO), the rural area has a higher concentration having a value of 73.84mg/m^3 representing 55.33%. But at the urban area, the value of CO was 59.6mg/m^3 representing 44.66%. The activities such as production, refinement, transportation and storage of crude oil in addition to the processing transmission and distribution of natural gas with lands which produce methanogenic bacteria in the urban areas of Port Harcourt provides a good habitant and environment that continuously emitted more CH_4 with a value of 61.36mg/m^3 representing 100% with none detected at the rural area during the dry season. However, in order to compare the concentrations of atmospheric pollutants between the rural and urban landuse areas, during the dry season. The analysis of two independent sample comparisons of mean of the respective pollutants between the urban and rural areas was done using SPSS statistical software. The summary of the result is shown in table1

Table 2: Summary of the analysis of T-test for two-independent-samples comparison of pollutant concentrations between the urban and rural landuse areas during the dry season.

Pollutants	T-cal	T-critical	Level of significant
PM_{10}	6.73*	2.01	Significant at 99%
TSP	0.9	2.01	Not Significant
SO_2	5.70*	2.01	Significant at 99%
NO_2	1.13	2.01	Not significant
CO	0.60	2.01	Not Significant
CH_4	9.85*	2.01	Significant at 99%

*Significant at 99% significant level

The analysis of the difference between the means of the atmospheric pollutants between the rural and urban landuse areas (table 7.1) revealed that there was significant difference in the concentration of PM_{10}, SO_2 and CH_4 during the dry season with the computed T-values of 6.73, 5.70, and 9.85 respectively which were more than the T-critical value of 2.01 at 99% confidence level. Similarly, the study further revealed that there was no significant difference in the concentrations of TSP, NO_2 and CO during the dry season having T- Calculated values less than the T-critical value of 2.01. This result means that the concentrations of TSP, NO_2 and CO between both rural and urban areas do not vary significantly. The implication of this is that the activities

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that generate these pollutants and the meteorological variables in both the urban and rural areas do not differ. The reason for this result is that in the rural areas especially during the dry season, bush burning is a common phenomenon which arises because of slashes and burn method of farm preparation. Also, fuel wood is used for cooking which generate lots of smoke from local kitchens,. These are common feature which can be observed that produces soot in the rural areas. In addition to this is the absence of paved surfaces which encourage natural windblown dust from bear ground surfaces at the rural areas. These activities generate large volumes of TSP, NO_2 and CO into the atmosphere of the rural areas during the dry season. The graphs below (fig. 1-3) however support the result of this analysis.

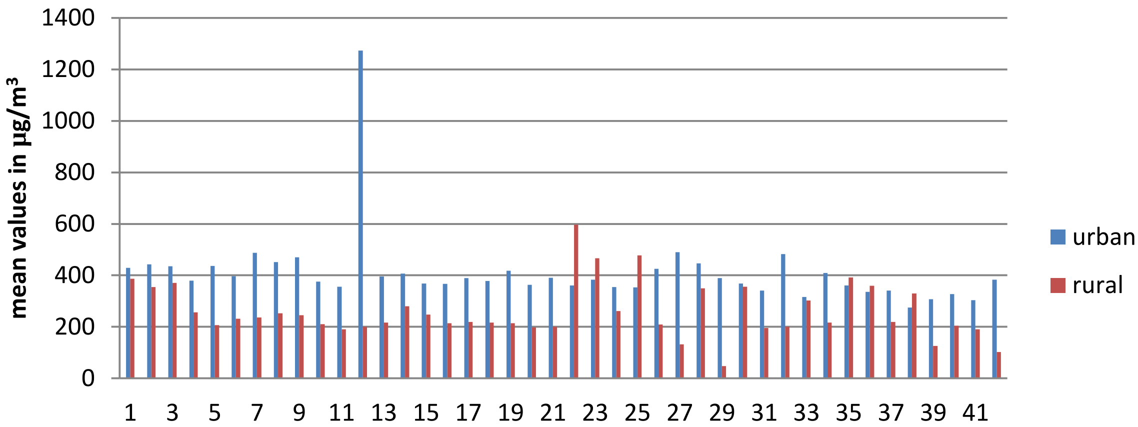

Fig.1: Mean daily values of PM_{10} concentrations between Urban and Rural Landuse areas during dry season.

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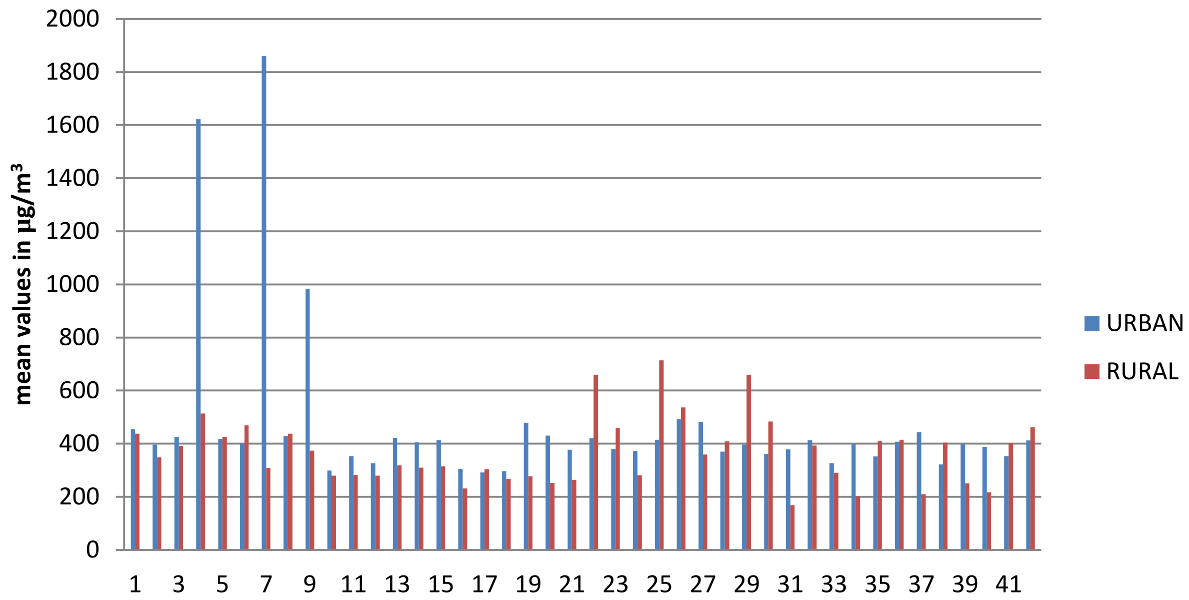

Fig 2: Mean daily TSP concentration between urban and rural landuse areas during the dry season.

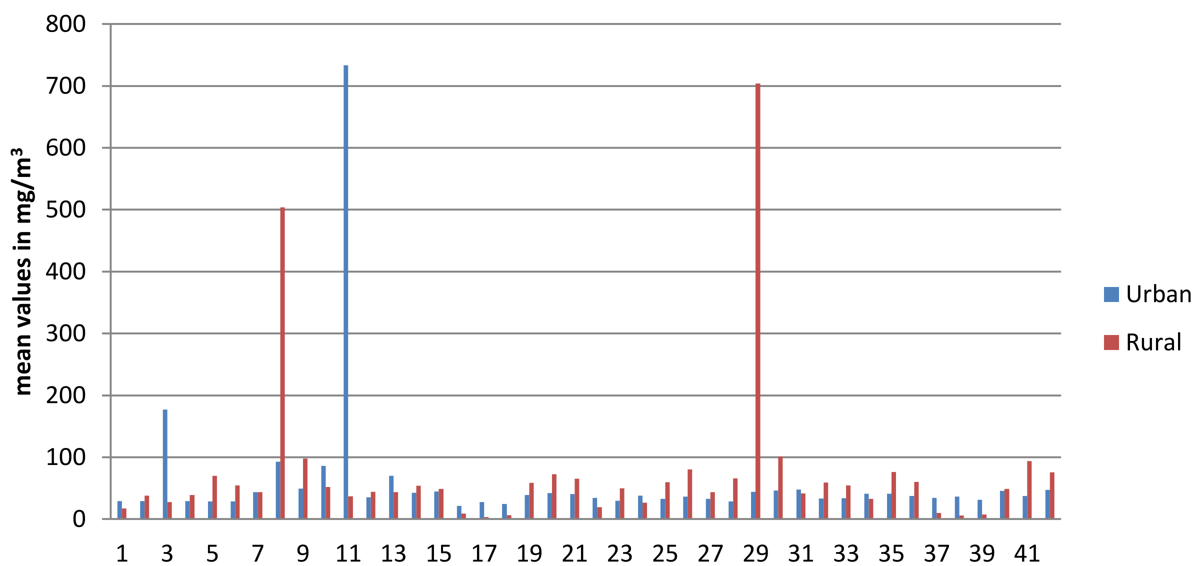

Fig. 3: Mean values of CO between Urban and Rural landuse areas during the dry season.

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Comparison of atmospheric pollutant concentration between urban and rural landuse areas during wet season.

The concentrations of the pollutant between the urban and rural areas during the wet season revealed that PM_{10} concentration was higher with a value of 100.6μg/m^3 representing 75% at the urban areas and at the rural area, the value was 33.52μg/m^3 representing 24.90% with a mean difference of about 67.08μg/m^3. The concentration of TSP also showed that the value (222.04μg/m^3) was more at urban areas representing 84% and rural value of 42.33μg/m^3 representing 15% with a mean difference of about 179.71μg/m^3 for the wet season. However for the concentration of sulphur oxide (SO_2), it was observed that the rural areas had relatively higher value (0.25mg/m^3) representing 51% of the SO_2 concentration. At the case of Nitrogen oxide (NO_2) the value was 6.04 mg/m^3 representing 100% of the concentration in the urban area. None was detected at the rural area during the wet monoxide (CO) revealed the rural area had more concentration with a value of 26.23mg/m^3 accounting for 52.68% and 23.56mg/m^3 representing 47.30mg/m^3 at the urban areas during the wet season. As shown in figure 7.1, the concentration of methane was similarly higher at the rural areas with a value of 1.06mg/m^3 representing 70.60% while at the urban areas, the value of methane was 0.44mg/m^3 representing 29.33% during the wet season.

The analysis above revealed that PM_{10} TSP and NO_2 concentrations were higher representing 75%, 84% and 100% of the concentrations respectively. But at the rural areas, SO_2, CO and CH_4 concentrations were higher than the urban concentrations representing 51%, 52.68% and 70.33% during the wet season. The significance of the difference between the means of the atmospheric pollutant between the rural and urban landuse areas shown in table 2, reveal that there was significant difference in the concentrations of PM_{10}, TSP, NO_2 and CO during the wet season with the computed T-values of 12.74, 11.32, 2.08 and 4.07 respectively which were more than the T-critical value of 2.01 at 99% confidence level. Similarly, the study further revealed that there was no significant difference in the concentrations of SO_2 and CH_4 during the same wet season with the calculated T-values of 1.54 and 1.02 respectively which were less than the T-critical value of 2.01.

Table 3: Summary of the analysis of T-test for two – independent-sample comparision of atmospheric pollutant concentrations between the urban and rural landuse area during the wet season.

Pollutants	**T-cal**	**T-crit.**	**Level of significance**
PM_{10}	12.74*	2.01	Significant at 99%
TSP	11.32*	2.01	Significant at 99%
SO_2	1.54	2.01	Not Significant
NO_2	2.08*	2.01	Significant at 99%
CO	4.07*	2.01	Significant at 99%
CH_4	1.02	2.01	Not Significant

*Significant at 99% significant level

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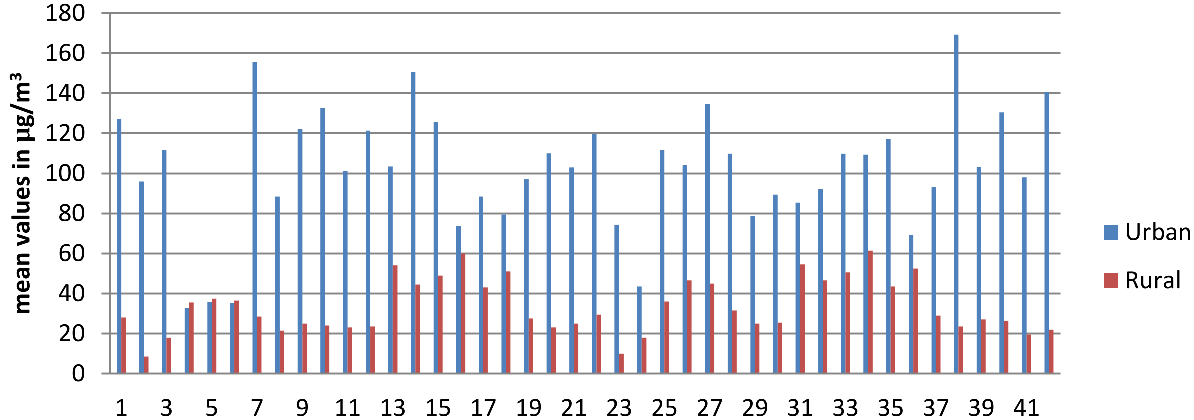

Fig. 4: Mean daily values of PM_{10} concentration between Urban and Rural landuse areas during the wet season

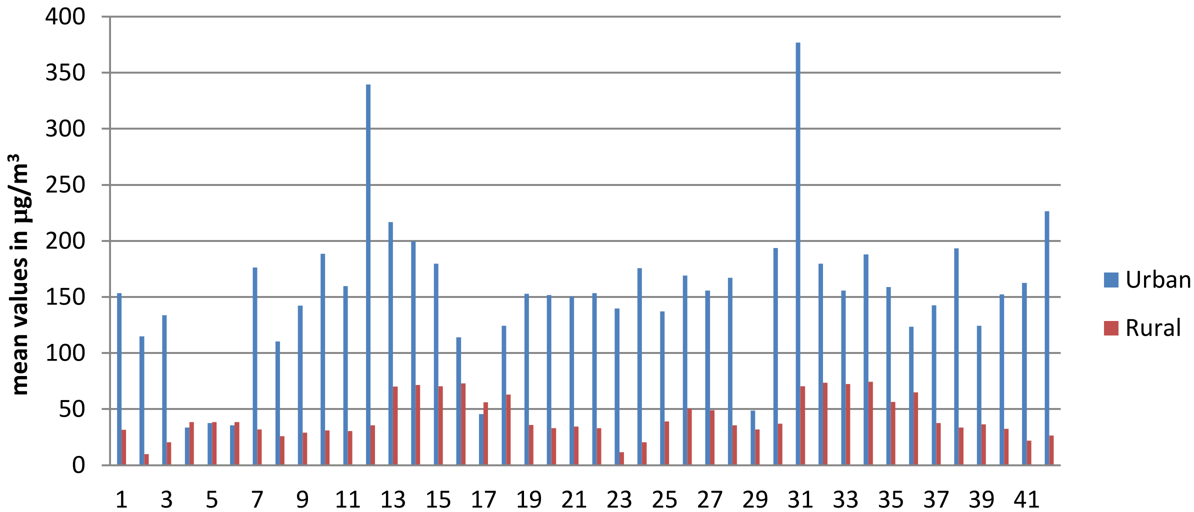

Fig. 5: Mean daily values of TSP concentrations between the Urban and Rural areas during the wet season.

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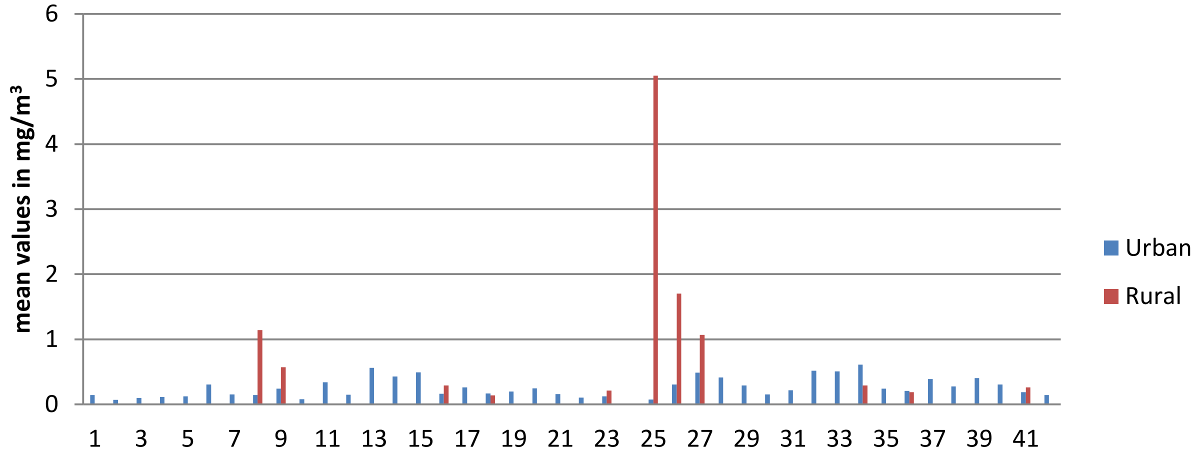

Fig 6: Mean daily values of SO_2 concentrations between Urban and Rural areas during wet season.

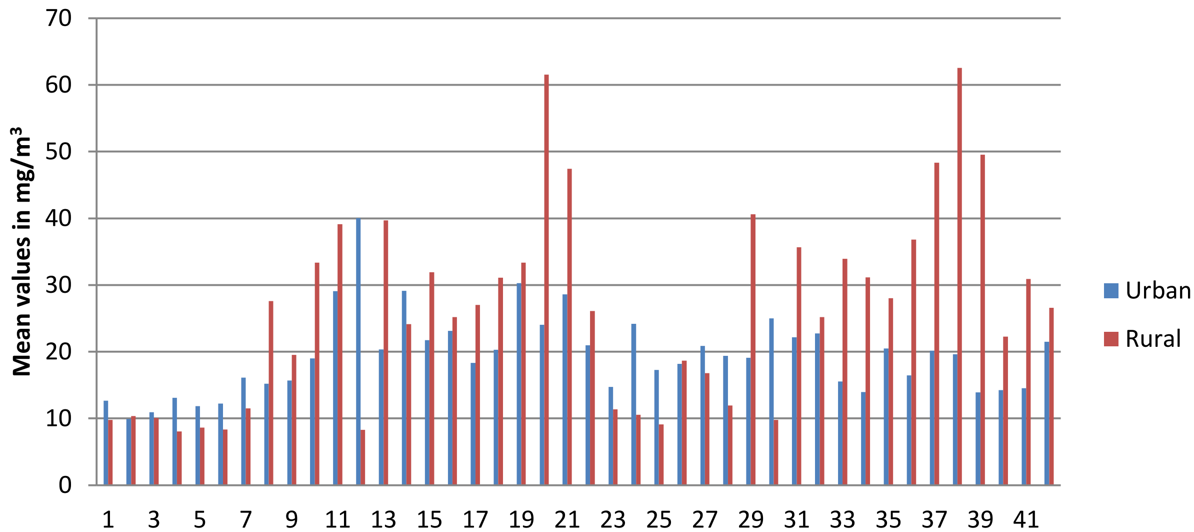

Fig. 7: Mean daily values of CO concentrations between Urban and Rural landuse areas during the wet season

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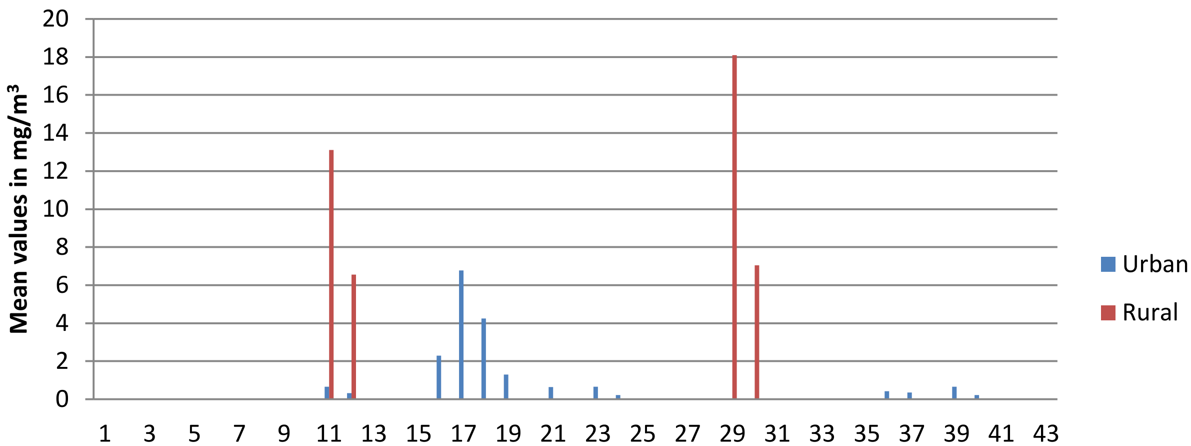

Fig. 8: Mean daily values of CH_4 concentrations between Urban and Rural landuse areas during the wet season

Comparison of atmospheric pollutants concentration between urban and rural landuse areas during transition period.

The concentration of PM_{10} during the transition period revealed that the values (215.71µg/m^3) were high at the urban areas as compared to the rural area with a mean value of 14,621µg/m^3. Both the urban and rural areas represented 59.60% of the concentration of PM_{10} respectively during the transition period. In the case of Total Suspended Particulate (TSP), the concentration of TSP was similarly higher at the urban areas with a value of 287.71µg/m^3 accounting for 58.43%. At the rural areas, the value of TSP was 204.62µg/m^3 representing 41.56% during the transition period. For Sulphur oxide (SO_2), the value was 9.15mg/m^3 representing 100% because none was detected at the rural area. Similarly Nitrogen Dioxide (NO_2) had a value of 2.12mg/m^3 representing 100% of the concentration when compared to the rural areas that had no values during the transition area that had no values during the transition. The concentration of carbon monoxide (CO) also showed a positively shared concentration towards the urban area with a value of 46.23mg/m^3 representing 56.8% and the rural area having the value of 35.06 representing 43.12%. Similarly for the concentration of methane (CH_4), the activities in the urban area, enhanced the concentration of methane more with a value of 20.53mg/m^3 representing 95.48%, while the rural area had a value of 0.97mg/m^3 representing 4.51%. In order to compute the difference of mean test for the comparison of the concentration of pollutants at both the rural and urban landuse areas, table 4 show the summary of the test of difference between the concentrations of pollutants during the transition.

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Table 4: Summary of the analysis of T-test for two-independent-sample comparison of atmospheric pollutant concentrations between the urban and rural landuse area during the transition period.

Pollutants	T-cal	T-crit.	Level of Significance
PM10	4.62*	2.01	Significant at 99%
TSP	2.82*	2.01	Significant at 99%
SO2	1.06	2.01	Not Significant
NO2	18.75*	2.01	Significant at 99%
CO	0.98*	2.01	Not Significant at 99%
CH4	6.63*	2.01	Significant at 99%

*Significant at 99% significant level

The analysis of the difference between the means of the atmospheric pollutant between the rural and urban landuse areas shown in table 3 reveal that there were significant differences in the concentrations of PM_{10}, TSP, NO_2 and CH_4 during the transition period with the computed T-values of 4.62, 2.82, 18.75 and 6.63 respectively which were more than the T-critical value of 2.01 at 99% confidence level. Similarly, the study further revealed that there was no significant difference in the concentrations of SO_2 and CO during the same transition period with the calculated T-values of 0.98, and 0.98 respectively which were less than the T-critical value of 2.01. The bar graphs of the concentration of the pollutants during the transition period are shown in fig 9-12

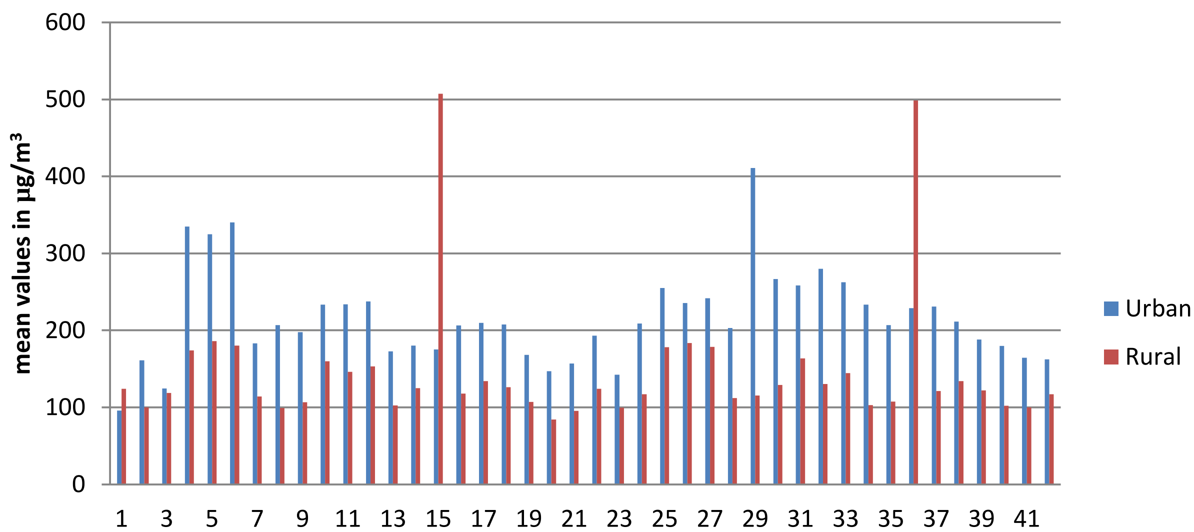

Fig. 7.13: Mean daily values of PM_{10} concentrations between Urban and Rural landuse areas during the transition period.

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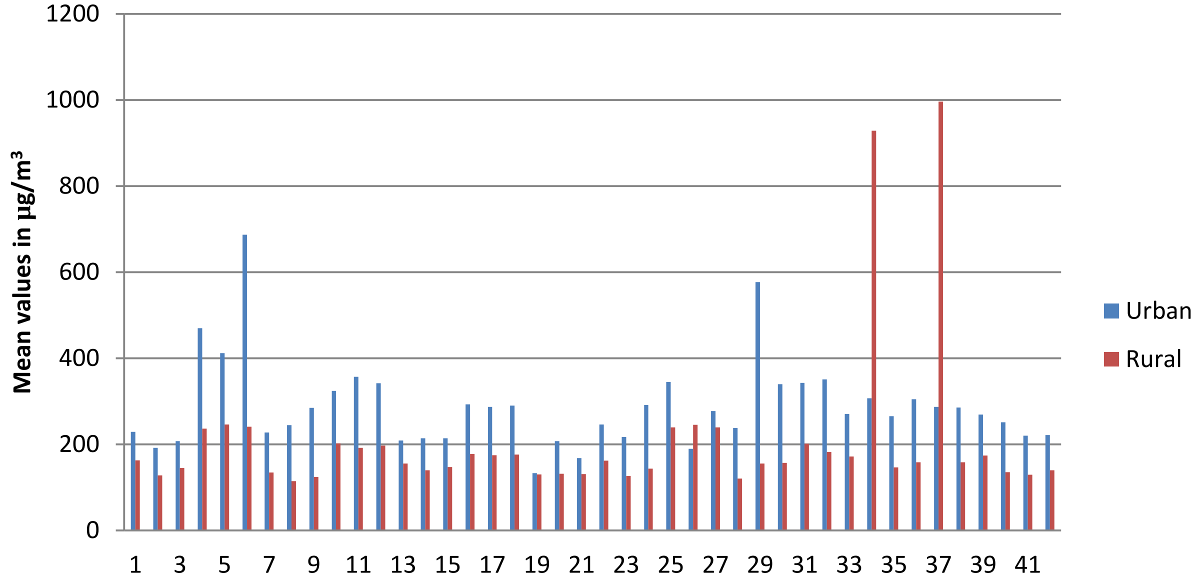

Fig. 7.14: Mean daily values of TSP concentrations between Urban and Rural landuse areas during the transition period

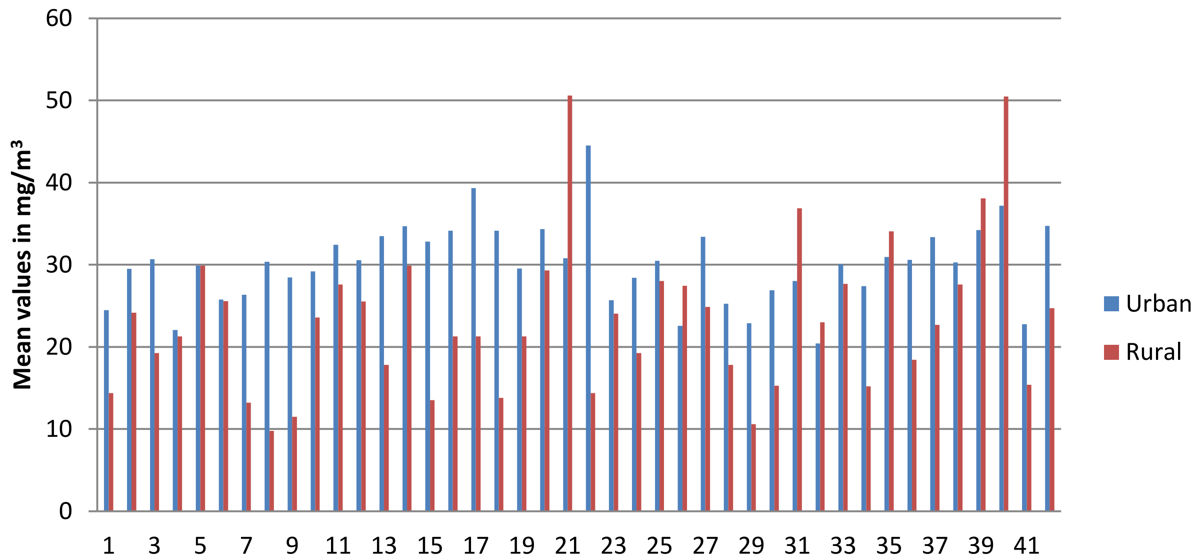

Fig. 7.17: Mean daily values of CO concentrations between Urban and Rural landuse areas during the transition period

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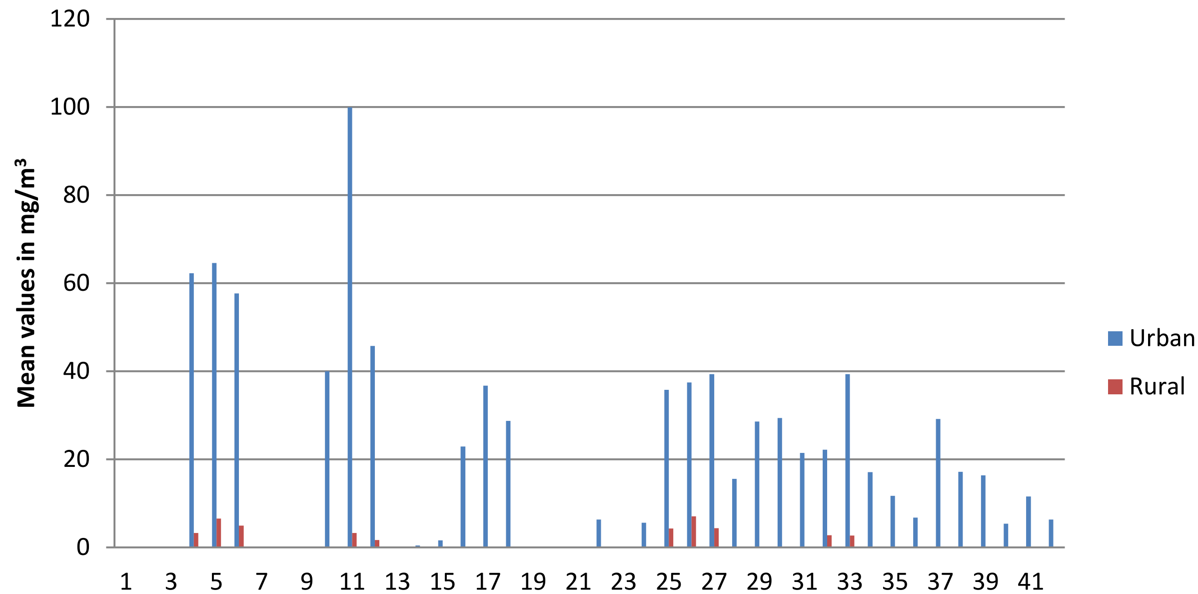

Fig. 7.18: Mean daily values of CH_4 concentrations between Urban and Rural landuse areas during the transition period

CONCLUSION

The study has shown that the rural areas of Port Harcourt region are not free from atmospheric pollutants which threaten human comfort and existence especially during the dry season. The study showed that there was significant difference in the concentration of PM_{10}, SO_2 and CH_4 during the dry season. Similarly, there was no significant difference in the concentrations of TSP, NO_2 and CO during the dry season. This result means that the concentrations of TSP, NO_2 and CO between both rural and urban areas do not vary significantly. The implication of this is that the activities that generate these pollutants and the meteorological variables in both the urban and rural areas do not differ. The reason for this result is that in the rural areas especially during the dry season, bush burning is a common phenomenon which arises because of slashes and burn method of farm preparation in addition to the prevalence of hydrocarbon industrial facilities in the region and absence of paved surfaces which encourage natural windblown dust form bear ground surfaces at the rural areas. During the period of investigation, the atmospheric loading of pollutants (SO_2, CO, TSP, $PM_{10,}$ and CH_4) was highest during the dry season, followed by the transition and wet seasons.

RECOMMENDATION

There is need for regular monitoring of atmospheric pollutants around the Port Harcourt region to forestall the potential health and atmospheric related impacts of such air toxics in the region.

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REFERENCES

Akani, C.O (2008) Analysis of street level air temperature and quality along the Traffic corridors of Lagos metropolis. An Unpublished Ph.D thesis. University of Ibadan.

Akeredolu, F.A; Oluwole, A.F; Beliku E.A; Ogunsola, O.J. (1994) 'Modelling of carbon monoxide concentration for motor vehicles travelling near roadway intersections in Lagos, Nigeria' the 2nd int'l conference on air pollution. Part 2 (of 2), Barcelonia

Ayoade, J.O. (2004) Introduction to Climatology for the Tropics. Revised edition John Wiley, London.

Bamgboye, O.A. (2006) "Chemistry, the melting pot for sustainable development" 19th Inaugural lecture 2006. Lagos State University, Lagos, Nigeria.

Baumbach G. et al (1995) Air pollution in a large Tropical city with high traffic density. Result of measurement in Lagos Nigeria. The science of total environmental 169. 25-31.

Botkin D B and Keller E A (1998). Environmental Science. Earth as a Living Planet (2ed). New York, John Willey and Son Inc.

Ede P.N. (2000) Estimation of atmospheric pollutants: a comparison of two methods. Journal of Innovation and Discovery. 2, 24-32

Efe, S I (2006). Particulate Pollution and its Health Implications in Warri Metropolis, Delta State Nigeria. *Env. Anal.* 11, 1339-1351.

Galloway, J.N. (1996) Anthropogenic Mobilization of Sulphur and Nitrogen: Immediate and Delayed Consequences. *Annu. Rev. Energy Environ.*, 21,261-292.

Guttikunda, S.K.; Carmichael, G.R.; Calori, G.; Eck, C.; Woo, J.H. (2003) The Contribution of Megacities to Regional Sulfur Pollution in Asia. *Atmos. Environ.*, 37(1), 11-22.

Miller G T (1994). Living in the Environment: Principles, Connections and Solution (3rd) Belmont Wadsworth Pub. Company.

Moore C (1995). Poisons in the Air. *International Wildlife*, 25, 38 – 45.

Obioha, I.B (1994) Inventory and emission Projections in relation to various Transport modes in Nigeria. (Mimeo)

Obioha, I.B (2005) "Chemical Characterization of Suspended Particulates along Air Corridors of Motorways in Two Nigerian Cities" In Journal of applied Science 5(2) Pp. 347-350.

Oguntoyinbo, J.S. (1973) "Temperature and humidity Traverses in Ibadan" Annual Conference of the Nigerian geographical Association, University of Lagos.

Ogubguaja. V.O and Barisisa L.Z. (2001) 'Atmospheric pollution in North –East Nigeria: measurement and analysis of suspended particulate matter' Bulletin of chemical Society of Ethiopa. Vol 15. No 2.

Ojo, S.O. (1981) "Land use energy balance relationships and planning in metropolitan Lagos" in Oyeleye, D.A. (ed) Spatial Expansion and Concomitant problems occasional paper, No. 1 Department of Geography, University of Lagos.

Oke, T.R. (1974)"Review of Urban Climatology 1968-73". W.M.O. Tech Note No 134.

Okecha S A (2000). Pollution and Conservation of Nigeria's Environment. Ekpoma T' Afriqu Inter ass W.A.

Oliver, J.E. (1973) Climate of Man's Environment. John Wisley and sons, New York.

ISSN 2056-7537(print), ISSN 2056-7545(online)

Olurin, O. (1991) "Environment, Health and Fortune". Text of 5th Alhaja Sidikat Mosunmola Balogun Memorial Lecture. Ogun State University, Ago-Iwoye.

Oluwande, P.A. (1997) 'Automobile traffic and air pollution in a developing country (An example of an affluence-caused environmental problem). Environ. Studies, 10, Pp 197-203.

Ono, M; Murakami, M; Nitta H; Nakai, S; Meada, K. (1990) Epidemiological studies of air pollution and health effects in area near roadways with heavy traffic in Tokyo". Jpn J. Public Health 37: Pp321-332.

Oni, S.I. (1998): "Transport Induce Air pollution and Health in Metropolitan Lagos". The eight Annual conference of the Environment and behavior Association of Nigeria (EBAN) University of Port Harcourt 17th- 19th Nvenber, 1998.

Owens, N.J.P.; Galloway, J.N.; Duce, R.A. (1992) Episodic Atmospheric Nitrogen Deposition to Oligotrophic Oceans. *Nature*, 397-399.

Smith, K. (1975) Principles of Applied Climatology. McGrawHill Book Co. Ltd. London. Chp. 2

Taiwo, O. (2005) "The case of Lagos Air Quality Improvement Project" Website: http://www.cleanairnet.org/ssa/1414/article-69320Taiwopdf. Pp 1-15.

ISSN 2056-7537(print), ISSN 2056-7545(online)