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Seasonal and Spatial Analysis of Air Pollutants Emissions from Fuel-Wood Utilization in Selected Rural Communities within Odeda Lga, Nigeria

Oyebanji, F. F. [α], Oguntoke, O. [σ], Ojekunle, O. Z. [ρ], Adeofun, C. O. [ω], Adedeji, O. H. [¥], Ekpo, U. F. [§] & Adekunle, M. M. [χ]

Abstract- The effects of fuel-wood utilization on spatial and temporal concentration of air pollutants were assessed in 12 purposively selected rural communities in Odeda Local Government Area of Ogun state. Carbon (II) oxide (CO), Carbon (IV) oxide (CO_2), Sulphur (IV) oxide (SO_2), Nitrogen (IV) oxide (NO_2), Methane (CH_4) and Particulate Matter of 2.5 ($PM_{2.5}$) and 10 (PM_{10})were monitored at 0, 2 and 5 m away from the cooking points using active air samplers in dry and wet seasons. Data collected were subjected to descriptive, ANOVA and Correlation statistics at 0.05 significant level. The mean±SD concentration (ppm) of pollutants monitored at 0, 2 and 5 m respectively across the villages were CO: 37.42±5.10, 26.00±3.86, 15.27±3.65;CO_2: 21.30±6.72, 10.71±1.31, 5.63±4.31; NO_2: 0.50±0.12, 0.16±0.05, 0.14±0.18; SO_2: 1.60±0.76, 1.10±1.52, 0.24±0.24; CH_4: 0.50±0.52, 0.33±0.49, 0.08±0.29; PM_{10}: 77.18±8.47, 35.99±3.78, 12.74±1.59; and $PM_{2.5}$: 28.93±4.24, 17.92±4.33, 8.87±3.32 at average wind speed of 2.52±0.25m/s in the wet season; while CO: 15.18±4.29, 6.57±3.53, 1.17±1.40;CO_2: 44.09±10.74, 21.60±7.78, 9.78±3.10; NO_2: 0.59±0.12, 0.17±0.11, 0.08±0.08; SO_2: 2.05±0.65, 0.80±0.38, 0.26±0.26; CH_4: 0.58±0.51, 0.33±0.49, 0.08±0.29; PM_{10}: 98.64±9.22, 48.53±7.63, 17.64±8.98 and $PM_{2.5}$: 43.81±11.11, 16.44±3.71, 7.81±1.78 at average wind speed of 3.11±0.57 m/s in the dry season. PM_{10} had the highest mean concentration for both wet and dry seasons. The mean concentrations of CO and CH_4 reduced from wet to dry seasons, while CO_2, SO_2, NO_2, $PM_{2.5}$ and PM_{10} increased from wet to dry seasons. There were no significant differences ($p > 0.05$) in the mean concentration of air pollutants across the communities for both seasons except for CH_4. The overall mean values of NO_2 (0.25±0.06 and 0.28±0.09)and SO_2 (0.84±0.36 and 1.03±0.36)for wet and dry seasons respectively were above the National Environmental Standards and Regulations Enforcement Agency (NESREA) air quality standards; NO_2: 0.04 – 0.06 ppm and SO_2: 0.01 ppm. This study concludes that although fuel-wood utilization affects the quality of air,concentration reduces and changes over space and time respectively.

Keywords: dirty energy, ambient environment, air quality, spatio-temporal concentrations.

I. Introduction

There had been a notion that rural air is free from contaminations because the areas are often devoid of fumes that is emitted from vehicle exhausts, the tiny particles released by diesel engines and majorly the various air pollutants released during industrial activities. This notion has been proved wrong by various authors.

However, either one lives in the rural or urban area, air in good quality and quantity is one of the necessities of life upon which man's existence and sustenance are pivoted. Meanwhile its availability and variability in space and time is dependent on the activities going on around such area and critical issues that must be taken into consideration are exposure and health related studies. This is because some epidemiological studies have used available ambient air monitoring data to predict exposure of the population of their interest (Briggs *et al*., 2000).

It should not be assumed that pollutants even when released from a point source would be homogenously distributed in terms of quality in space and time. According to Jerrett *et al*., 2005 and Miller *et al*., 2007, some epidemiological studies have shown the importance of intra-urban air pollution concentration variability, which often results in inconsistent comparisons for air quality data within different sites and consequently inconsistent actions to control.

In this study we investigated the rural air pollution distribution with respect to space and timeas it relates to air pollutants emitted during combustion of wood as fuel in the selected rural communities of Odeda, Ogun state, Nigeria.

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II. The Study Area

Odeda is quite a large town and is one of the 20 local government areas within Ogun State, southwest of Nigeria. It lies on the North-eastern zone of the State, on longitude 7°12' to 7°31' and latitude 3°15'and 3°45'(Figure 1).This Local Government Area (LGA) shares boundary with Abeokuta south and north local government areas to the West, Obafemi-Owode local government to the South, whereas to the North and East, Odeda shares boundary with Akinyele and Ibarapa Local government of Oyo state respectively. The population figure is 109,449 (NPC, 2006) and covers a land area of about 1,554 km^2.

The mean monthly rainfall and temperature of the area are about 900.3mm and 33.3°C (Akanni, 1992). The LGA falls largely within the derived savanna vegetation which dominated the northernmost part of Ogun state. Nevertheless, pockets of forest vegetation which have not been degraded by human activities still exist. Generally, the floristic composition includes both true forest and savanna species. Important tree species found in this vegetation type include *Lophira lanceslate*, *Daniellia oliverri* and *Afzolia Africana* (Gbadegesin, 1992) among others. Odeda LGA is predominantly a rural community with numerous villages. Apart from farming which is the major occupation of the residents, people also engage in trading of farm produce, which is done on the periodic market days and hunting. Fuel-wood utilization still remains the highly patronized energy source in the study area where even people in the youthful age resides. The major occupation is farming and fuel-wood is used to prepare farm produce for sale. There is no preference for any particular specie of wood, the type of wood used depends on availability, and hence different species and sizes of woods are used in combination to generate an efficient heat needed and it is often collected from nearby forest (Oyebanji*et al.,* 2013). This local government has approximately 438 settlements/communities spread across the three zonal divisions in the local government namely Odeda, Opeji and Ilugun.

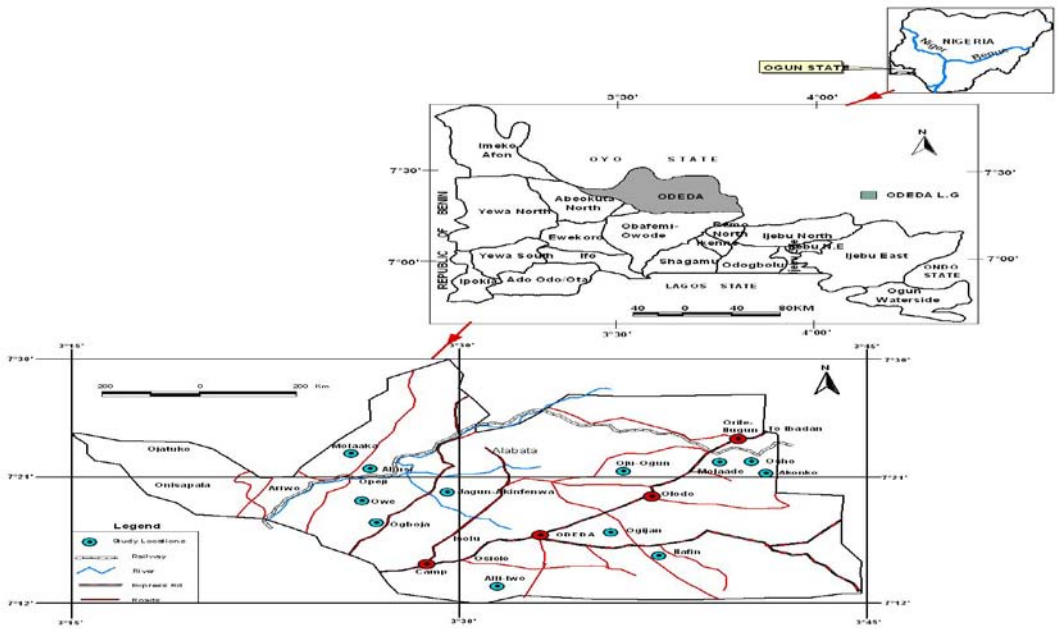

Figure 1 : Map of study area

III. Methodology

Communities sampled were drawn purposively and based on exclusion criteria that is: absence of social amenities (such as tarred roads, electricity supply and other modern facilities) and 2km distance from any known major road (these criteria were paramount in order to prevent interference from vehicular emission and allowance for pollutant dispersion respectively).

Odeda is divided into three (3) zones namely Odeda, Opeji and Ilugun. A total of 12 communities were selected after considering the criteria earlier mentioned. The 12 communities are Iwo-Alli, JagunAkinfenwa, Ilafin, Ogijan (Odeda zone), Ogboja, Abusi, Owe, Molaaka (Opeji zone), Molaade, Akonko, Osho and Oju-ogun (Ilugun zone).Ten (10) sampling points where fuel-wood is used for cooking were randomlyselected from each of the 12 sampled communities for air quality monitoring making a total of 120 points in all. Wind vane was used to determine the wind direction (in order to determine the best location for mounting air samplers); the MultiRAE lite QRAE systems multigas sampler was used to monitor the concentration of Nitrous oxide (NO and NO_2), carbon monoxide (CO), Carbon dioxide (CO_2), Sulphur dioxide (SO_2), Temperature (°C) and humidity (%); the QRAE$^+$ was

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used to monitor Lowest Explosive Limit (LEL i.e. CH_4), Kanomax Anemometer was used for measuring wind speed and velocity while Dust track II Aerosol monitor R11593 for measuring suspended particulate matter (PM_{10} and $PM_{2.5}$).

These gases were monitored in replicates, in each of the communities between November and January for dry season and June to October. Point source air quality monitoring was taken at the cooking points 0 m, 2m and 5 m away from the cooking points along the wind direction.

The data collected were subjected to descriptive (mean and standard deviation), ANOVA and Correlation analyses using the statistical package for Social Sciences (SPSS version 17.0.1 and Microsoft Excel, 2007).

IV. Results and Discussion

Figure 2 shows the mean values of meteorological data for both the wet and dry seasons. Temperature ranged from 29.67±3.82°C to 37.57±5.50°C and from 26.93±0.10 °C to 31.50±0.45°C for wet and dry season respectively. Humidity ranged from 70.00±0.70% to 85.00±0.12% and 56.37±0.75% to 68.13±0.84% for wet and dry season respectively, wind speed ranged from 1.98±0.31 to 2.91±0.61 and 2.13±0.15m/s to 3.86±0.19m/s for wet and dry season respectively. Various air pollution studies either in urban or rural areas has always taken into consideration major weather parameters, which include temperature, humidity and wind speed. This is because temperature and humidity affect the concentration of air pollutants in the atmosphere specifically; wind speed influences the rate of air pollutant dispersal as well as atmospheric mixing. High humidity and low wind speed will increase the concentration of air pollutants in the atmosphere with short and long term implications for human health according to Oin *et al.,* 1993.Research have shown that air pollution gets worse during the dry season as pollutants remain suspended and concentrated in the atmosphere due to lack of rain to wash and dissolve them (WMO, 1999; Gunnar *et al*., 2002). This may suggest the general increase noticed in the concentration of some pollutants during the dry season. Also, if there is a temperature inversion, dispersal of pollutants may be highly difficult concentrating the pollutants to a particular area.

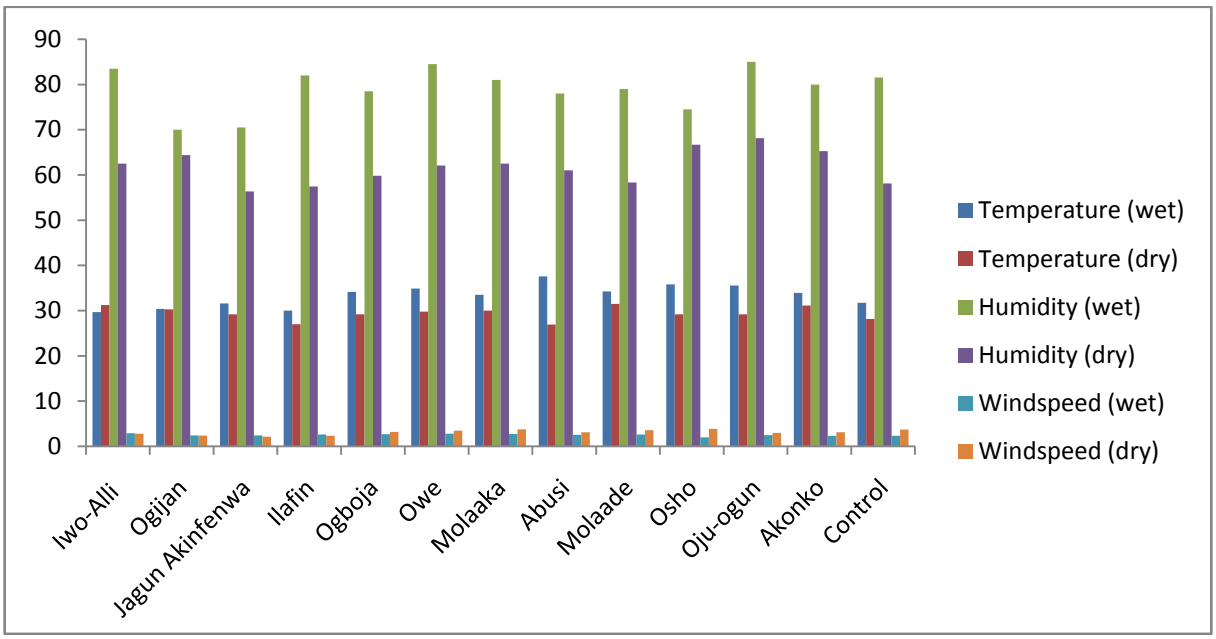

Figure 2 : Meteorological parameters monitored during wet and dry season

The change in mean concentration of air pollutants with 0, 2, and 5 m distances is shown on Figures 3 to 9 for CO, CO_2, NO_2, SO_2, CH_4, $PM_{2.5}$ and PM_{10}in the wet and dry seasons respectively. Naeher *et al*., (2007) states that inorganic gases including CO, O_3, inhalable coarse and fine particles are transported over a long distance. However, particles in micron size range are not easily removed by gravitational settling and therefore can be transported over long distances (Echalar *et al*., 1995). The transport of biomass combustion particles over hundreds of kilometers has been extensively documented (Andrae *et al*., 1988). Haze layers with elevated concentrations of CO, carbon dioxide (CO_2), Ozone (O_3), and Nitric oxide (NO) have been observed. During transport, many of the gaseous species are converted to other gases or into particles. As pollutants are dispersed, there is atmospheric mixing and hence concentration reduces as shown in this study. The "black carbon" from biomass emissions contributes to regional and global climate change as

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well as adverse health effects in some parts of the world (Venkataraman *et al*., 2005; Koch & Hansen,2005). All the air pollutants (smoke) tend to disperse away from the point source generation area especially on high wind intensity days (EPA, 2010 and Oren, 2001) and this suggests their dispersion.

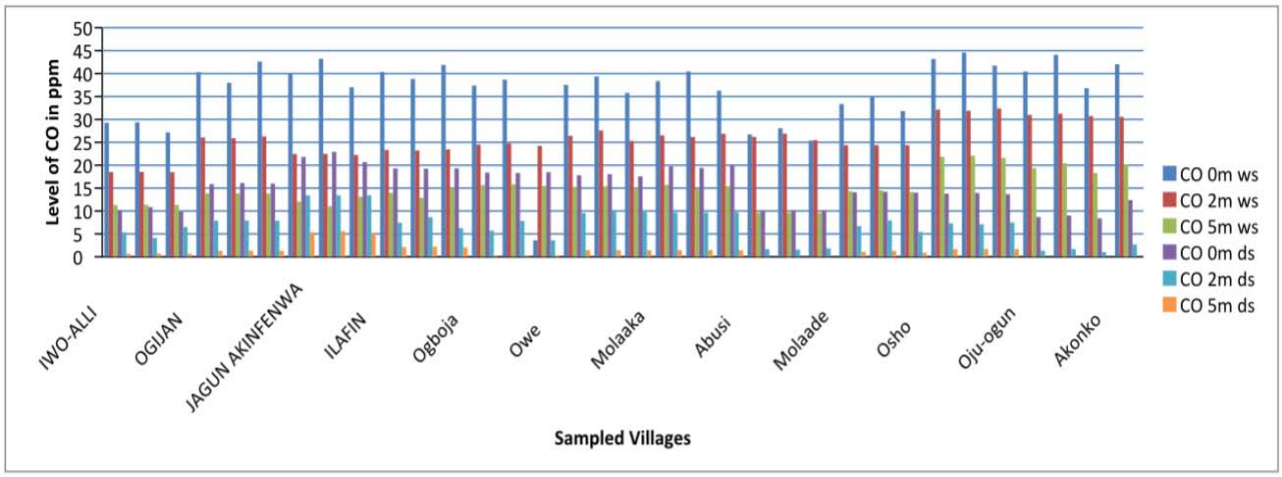

Figure 3 : Concentration of CO at distances to the cooking point between villages during wet and dry seasons

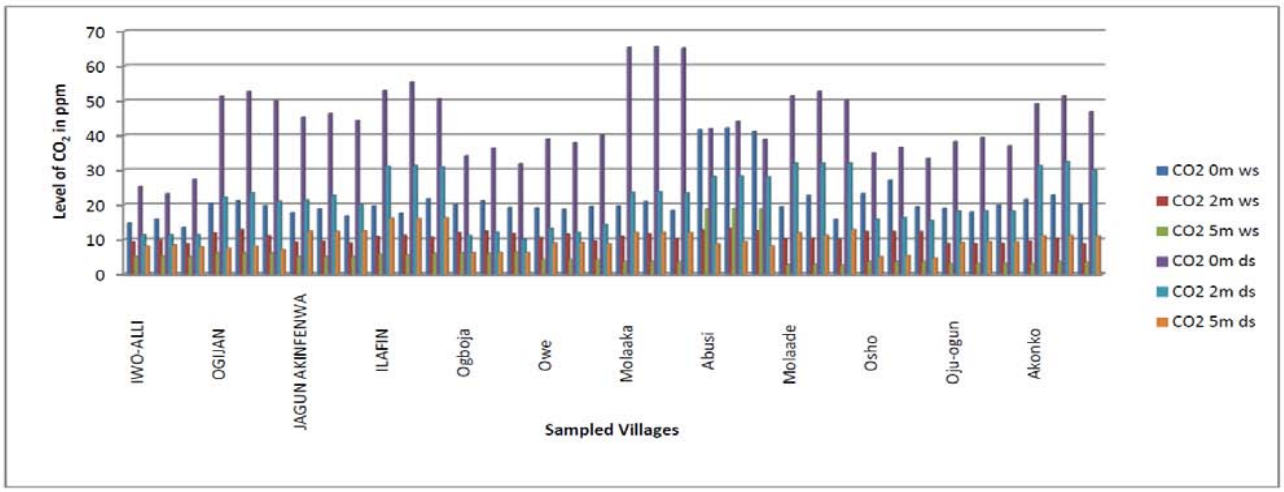

Figure 4 : Concentration of CO_2 at distances to the cooking point between villages during wet and dry seasons

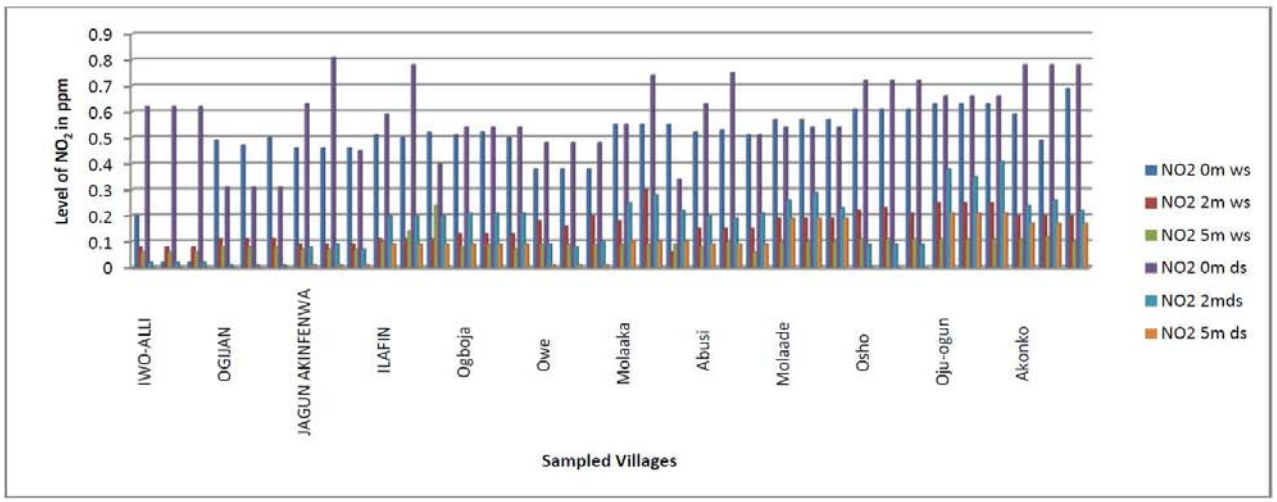

Figure 5 : Concentration of NO_2 at distances to the cooking point between villages during wet and dry seasons

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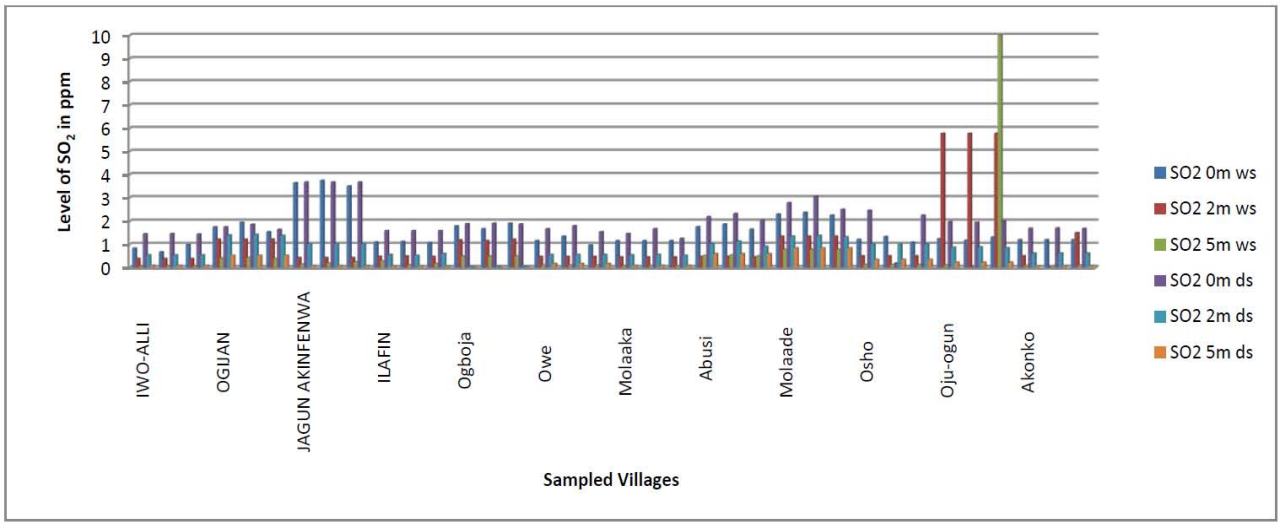

Figure 6 : Concentration of SO_2 at distances to the cooking point between villages during wet and dry seasons

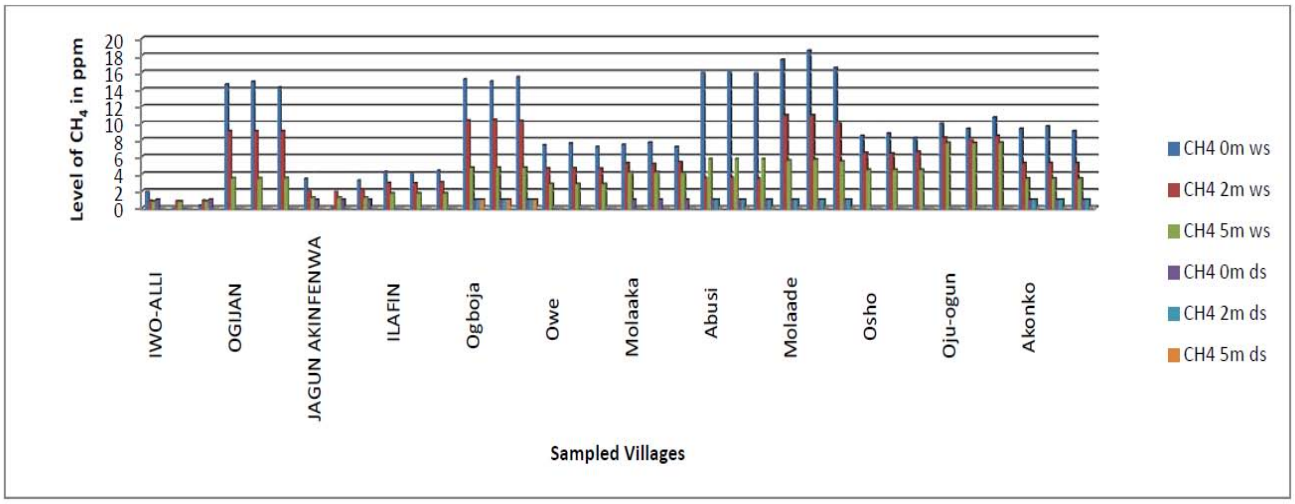

Figure 7 : Concentration of CH_4 at distances to the cooking point between villages during wet and dry seasons

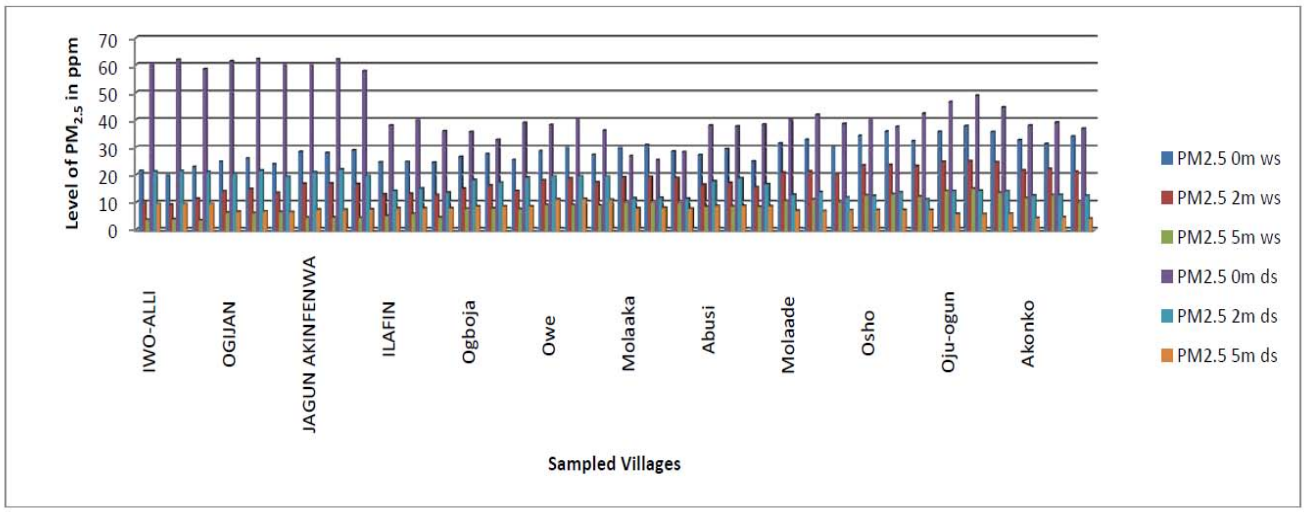

Figure 8 : Concentration of $PM_{2.5}$ at distances to the cooking point between villages during wet and dry seasons

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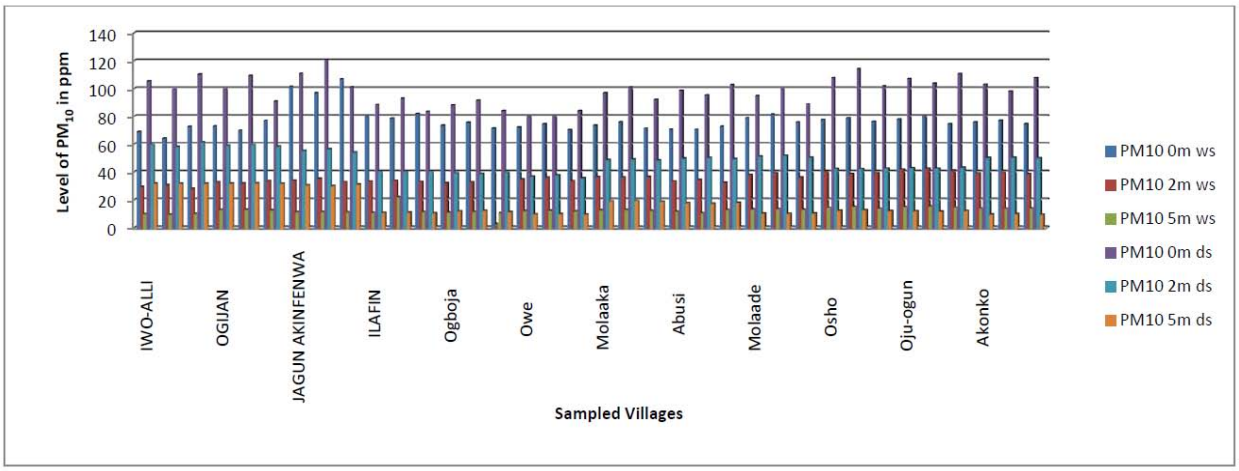

Figure 9 : Concentration of PM_{10} at distances to the cooking point between villages during wet and dry seasons

The disparity recorded in the concentration of CO between the two seasons may not be far from the fact that CO is yielded from incomplete combustion (Naeher, *et al*., 2007) and it is expected that wood during the wet season may have high moisture content which produces lower energy and heat output because the heat produced will be used to vapourize moisture thereby producing thick smoke with high CO concentration (DEC, 2009). In the dry season, wood are very dry and hence yield complete combustion and give high mean CO_2 concentration during the dry season as observed in thetable 3, but the atmospheric concentration of CO_2 has been a major concern in this era of climate change. The trees that are supposed to help sequester CO_2 were cut for fuel without replanting (Odii and Mokwunye, 2003). However, the mean concentrations for NO_2, SO_2, $PM_{2.5}$ and PM_{10} increased during the dry season except for CH_4 whose mean concentration reduced as shown by Figure 7.It is expected that during the wet season the mean concentration of the aforementioned air pollutants will be higher than that of the dry season because of the burning of supplement materials like polythene bags, plastic bottles, “iha”, “oguso”, “eesan” etc as explained by the respondents to compensate for the low amount of dry wood (Zafar *et al*., 2010). Gases that have been dispersed into the atmosphere would remain suspended and concentrated during the dry season until they are washed down onto the earth surface by rain and thereby react with rain water to form new compounds hence reducing the concentration of the pollutant gases in the air. Some weather parameters affect the ambient concentration and dispersion rate of air pollutants, depending on wind speed air pollutants can travel very far and respect no boundary. During the dry seasons the mean concentration of CO_2, NO_2, SO_2, $PM_{2.5}$ and PM_{10} increase but that of CO and CH_4 reduce and vice versa.

Table 1 shows the overall mean concentrations of air pollutants for both wet and dry seasons respectively. There is no significant variation ($p < 0.05$) between the mean concentrations of pollutants among the villages except for CH_4 which shows significant variation in the two seasons monitored.There is no significant difference between the mean concentrations of air pollutants measured in the selected communities except for CH_4($p < 0.05$), this may because most of them burn the same kind of wood for the same kind of activity and hours of cooking. However, only the kind of supplement material added may be different (Zafar *et al*., 2010).

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Table 1 : Variation in air pollutants between villages during both seasons ($p < 0.05$)

VILLAGES	CO (wet)	CO (dry)	CO_2 (wet)	CO_2 (dry)	SO_2(wet)	SO_2(dry)	NO_2 (wet)	NO_2 (dry)	CH_4 (wet)	CH_4 (dry)	$PM_{2.5}$ (wet)	$PM_{2.5}$(dry)	PM_{10} (wet)	PM_{10}(dry)
Iwo-Alli	19.70±9.02^{a}	5.40±4.77^{a}	9.73±4.83^{a}	14.89±9.08^{a}	0.42±0.39^{a}	0.69±0.69^{a}	0.11±0.08^{a}	0.21±0.35^{a}	1.22±0.68^{a}	0.33±0.58^{ab}	23.11±39.65^{a}	65.95±37.04^{a}	12.05±8.91^{a}	30.57±26.47^{a}
Ogijan	28.74±13.24^{a}	8.36±7.28^{a}	12.86±7.15^{a}	27.02±22.29^{a}	1.12±0.68^{a}	1.22±0.63^{a}	0.23±0.23^{a}	0.11±0.18^{a}	9.12±5.5^{bcd}	0.00±0.00^{a}	24.96±41.83^{a}	64.03±34.43^{a}	15.27±9.32^{a}	29.60±28.49^{a}
JagunAkinfenwa	24.88±14.18^{a}	13.53±8.23^{a}	10.67±6.45^{a}	26.36±17.02^{a}	1.37±1.95^{a}	1.59±1.86^{a}	0.21±0.22^{a}	0.24±0.34^{a}	2.33±1.1^{ab}	0.33±0.58^{ab}	34.07±58.61^{a}	66.00±41.09^{a}	16.67±11.84^{a}	29.59±27.38^{a}
Ilafin	25.89±13.38^{a}	9.63±8.79^{a}	12.07±6.97^{a}	33.43±18.51^{a}	0.55±0.52^{a}	0.74±0.78^{a}	0.23±0.24^{a}	0.29±0.26^{a}	3.07±1.24^{abc}	0.00±0.00^{a}	27.14±46.54^{a}	46.83±38.98^{a}	14.35±9.71^{a}	20.20±15.94^{a}
Ogboja	25.84±10.94^{a}	8.16±9.27^{a}	12.79±6.97^{a}	17.14±14.86^{a}	1.16±0.65^{a}	0.66±1.07^{a}	0.24±0.24^{a}	0.28±0.23^{a}	10.14±5.20^{cd}	1.00±0.00^{b}	25.17±42.14^{a}	46.70±38.39^{a}	16.61±9.53^{a}	20.91±13.89^{a}
Owe	26.42±11.14^{a}	9.60±8.18^{a}	11.27±7.44^{a}	20.38±16.29^{a}	0.58±0.54^{a}	0.80±0.78^{a}	0.22±0.15^{a}	0.19±0.26^{a}	5.01±2.29^{abcd}	0.00±0.00^{a}	24.39±41.75^{a}	42.82±35.76^{a}	18.72±9.65^{a}	23.17±13.84^{a}
Molaaka	26.87±13.33^{a}	10.28±9.15^{a}	11.39±8.00^{a}	33.66±28.03^{a}	0.56±0.54^{a}	0.70±0.70^{a}	0.27±0.24^{a}	0.30±0.23^{a}	5.69±1.63^{abcd}	0.33±0.58^{ab}	24.79±42.49^{a}	55.23±38.90^{a}	19.77±9.78^{a}	15.52±10.12^{a}
Abusi	20.84±9.72^{a}	3.94±5.40^{a}	24.39±15.23^{a}	26.27±16.70^{a}	0.92±0.73^{a}	1.27±0.83^{a}	0.25±0.24^{a}	0.31±0.29^{a}	9.15±7.78^{bcd}	0.67±0.58^{ab}	23.97±40.67^{a}	55.83±40.75^{a}	17.47±9.43^{a}	21.58±15.05^{a}
Molaade	24.02±9.53^{a}	7.30±6.52^{a}	10.74±8.28^{a}	31.81±19.72^{a}	1.48±0.77^{a}	1.66±1.01^{a}	0.29±0.25^{a}	0.33±0.19^{a}	11.39±5.98^{d}	0.67±0.58^{ab}	27.00±44.93^{a}	52.37±42.16^{a}	21.18±10.52^{a}	20.17±17.84^{a}
Osho	32.37±10.68^{a}	7.60±6.06^{a}	13.06±9.76^{a}	18.63±15.17^{a}	0.61±0.55^{a}	1.27±1.08^{a}	0.31±0.26^{a}	0.27±0.39^{a}	6.56±2.02^{abcd}	0.00±0.00^{a}	26.05±44.58^{a}	54.63±48.83^{a}	23.49±10.79^{a}	20.01±17.67^{a}
Oju-ogun	30.27±10.55^{a}	3.35±4.68^{a}	10.26±8.0^{a}	21.82±14.88^{a}	0.71±0.57^{a}	1.02±0.89^{a}	0.33±0.27^{a}	0.42±0.23^{a}	8.68±1.19^{bcd}	0.00±0.00^{a}	27.92±43.35^{a}	54.27±48.29^{a}	25.16±10.77^{a}	22.47±21.64^{a}
Akonko	30.90±10.92^{a}	5.03±6.52^{a}	11.34±9.32^{a}	30.49±19.08^{a}	0.60±0.56^{a}	0.79±0.82^{a}	0.30±0.26^{a}	0.40±0.33^{a}	6.09±2.97^{abcd}	0.67±0.58^{ab}	25.51±43.67^{a}	34.56±59.36^{a}	22.13±59.36^{a}	18.47±17.54^{a}

Means with the same superscript column-wise are not significantly different according to Duncan Multiple Range test

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On a general note, considering the relationship between all measured parameters during the wet season (using the Pearson's correlation at 5% significant level)were positive and significant relationship exist between air pollutants CO_2 at cooking point and 2 m, CO at 5 m and cooking point, NO_2 at point and 2 m, NO_2 at 5 m and CH_4 at 2 m, SO_2 at 5 m and CH_4 at 5 m, CO at 2 m and CH_4 at 5 m, SO_2 at 2 m and CH_4 at 5 m, CH_4 at 2 m and CH_4 at 5 m, CH_4 at 5 m and PM_{10} at 2 m, SO_2 at 2 m and PM_{10} at 5 m, CH_4 at 5 m and PM_{10} at 5 m, CH_4 at 5 m and $PM_{2.5}$ at point, CH_4 at 5 m and $PM_{2.5}$ at 2 m, whereas negative significant relationship exist between CO_2 at 5 m and CO at point and between CO at 5 m and CO_2 at 5 m ($p < 0.05$) as shown on Table 2.In the same vein, during the dry season some air pollutant measured both positive and negative significant relationship, however, the strongest positive relationships were displayed between CO_2 at all the points, CO_2 at 2 m and SO_2 at point, $PM_{2.5}$ at 2 m and PM_{10} and $PM_{2.5}$ at 5 m and PM_{10} at 2 m ($p < 0.05$). Negative significant relationships were displayed between NO_2 at 2 m, $PM_{2.5}$ at 5 m and PM_{10} at 2 m, and between NO_2 at 5 m and PM_{10} at 2 m as displayed on Table 3.

Table 2 : Correlation Matrix of air pollutants and particulates with five factor (Wet season)

VARIABLES	CO (P)	CO (2M)	CO (5M)	CO_2 (P)	CO_2 (2M)	CO_2 (5M)	NO_2 (P)	NO_2 (2M)	NO_2 (5M)	SO_2 (P)	SO_2 (2M)	SO_2 (5M)	CH_4 (P)	CH_4 (2M)	CH_4 (5M)	$PM_{2.5}$ (P)	$PM_{2.5}$ (2M)	$PM_{2.5}$ (5M)	PM_{10} (P)	PM_{10} (2M)	PM_{10} (5M)
CO (P)	1.00	0.55	0.747	-0.45	-0.14	-0.648*	0.50	0.32	0.43	0.01	0.18	-0.46	-0.22	0.24	-0.02	0.40	0.53	0.52	0.47	0.44	0.33
CO (2M)		1.00	0.820	0.26	0.17	-0.14	0.791	0.865	0.893	-0.24	0.39	-0.09	0.30	0.41	0.648*	-0.11	0.859	0.905	0.847	0.854	0.884
CO (5M)			1.00	-0.26	-0.10	-0.608*	0.606*	0.764	0.814	-0.35	0.35	-0.29	0.00	0.39	0.37	-0.04	0.803	0.792	0.768	0.763	0.774
CO2 (P)				1.00	0.628*	0.895	0.28	0.13	0.08	0.03	-0.14	0.39	0.50	-0.06	0.41	-0.24	0.02	0.05	0.06	0.07	0.15
CO2 (2M)					1.00	0.57	0.19	-0.06	0.00	-0.10	-0.38	0.44	0.52	0.26	0.21	-0.38	-0.20	-0.08	-0.18	-0.16	-0.03
CO2 (5M)						1.00	-0.08	-0.28	-0.35	0.10	-0.21	0.34	0.34	-0.25	0.14	-0.21	-0.39	-0.34	-0.34	-0.34	-0.26
NO2 (P)							1.00	0.701*	0.762	0.10	0.40	0.22	0.48	0.57	0.719	0.18	0.789	0.772	0.784	0.772	0.738
NO2 (2M)								1.00	0.968	-0.31	0.53	0.03	0.30	0.46	0.760	-0.19	0.922	0.895	0.921	0.937	0.993
NO2 (5M)									1.00	-0.18	0.48	0.11	0.38	0.576*	0.740	-0.10	0.939	0.948	0.941	0.957	0.976
SO_2 (P)										1.00	-0.08	0.31	0.16	0.08	-0.08	0.804	-0.09	-0.12	0.03	0.00	-0.28
SO_2 (2M)											1.00	0.03	0.20	0.44	0.676*	0.00	0.50	0.578	0.52	0.51	0.53
SO_2 (5M)												1.00	0.900	0.663*	0.49	-0.22	-0.09	0.01	-0.02	0.01	0.07
CH_4 (P)													1.00	0.793	0.720	-0.32	0.16	0.32	0.23	0.26	0.36
CH_4 (2M)														1.00	0.691*	-0.18	0.37	0.52	0.42	0.44	0.51
CH_4 (5M)															1.00	-0.26	0.622*	0.700*	0.679*	0.696*	0.796
$PM_{2.5}$ (P)																1.00	0.14	-0.01	0.18	0.12	-0.20
$PM_{2.5}$ (2M)																	1.00	0.941	0.974	0.972	0.918
$PM_{2.5}$ (5M)																		1.00	0.917	0.929	0.913
PM_{10} (P)																			1.00	0.997	0.928
PM_{10} (2M)																				1.00	0.944
PM_{10} (5M)																					1.00

**Correlation is significant at the 0.05 level*

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Table 3 : Relationship between air pollutant concentration at the varied distances (Dry season) using Pearson's correlation co-efficient

VARIABLES	CO (P)	CO (2M)	CO 5M	CO_2 (P)	CO_2 (2M)	CO_2 (5M)	NO_2 (P)	NO_2 (2M)	NO_2 (5M)	SO_2 (P)	SO_2 (2M)	SO_2 (5M)	CH_4 (P)	CH_4 (2M)	CH_4 (5M)	$PM_{2.5}$ (P)	$PM_{2.5}$ (2M)	$PM_{2.5}$ (5M)	PM_{10} (P)	PM_{10} (2M)	PM_{10} (5M)
CO (P)	1.00	0.862	0.716	0.46	0.00	0.39	-0.36	-0.24	-0.35	0.22	-0.22	-0.36	0.02	-0.25	0.24	-0.36	-0.18	0.09	-0.13	0.11	0.19
CO (2M)		1.00	0.868	0.30	-0.14	0.26	-0.38	-0.51	-0.579*	0.39	0.07	-0.19	-0.04	-0.49	-0.07	-0.10	0.09	0.36	0.18	0.27	0.29
CO (5M)			1.00	0.20	0.01	0.38	-0.09	-0.41	-0.47	.662*	0.21	-0.19	-0.02	-0.47	-0.20	0.22	0.18	0.41	0.36	0.29	0.08
CO_2 (P)				1.00	0.712	0.648*	-0.24	0.30	0.31	-0.03	0.24	0.15	0.06	0.01	-0.29	-0.16	0.07	-0.08	-0.38	-0.48	-0.39
CO_2 (2M)					1.00	0.692*	0.14	0.39	0.52	0.14	0.42	0.41	0.17	0.38	-0.42	0.01	0.16	-0.23	-0.25	-0.50	-0.54
CO_2 (5M)						1.00	0.07	0.31	0.34	0.08	0.01	-0.12	0.12	-0.07	-0.36	-0.17	0.02	-0.10	-0.16	-0.25	-0.18
NO_2 (P)							1.00	0.37	0.33	0.18	-0.23	-0.29	0.26	0.21	-0.12	0.46	-0.15	-0.35	-0.24	-0.45	-0.34
NO_2 (2M)								1.00	0.936	-0.06	-0.16	0.04	0.12	0.39	0.12	-0.08	-0.42	-0.655*	-0.596*	-0.687*	-0.44
NO_2 (5M)									1.00	-0.04	-0.01	0.19	0.20	0.52	0.04	-0.03	-0.21	-0.590*	-0.44	-0.644*	-0.56
SO_2 (P)										1.00	0.50	0.30	0.22	0.10	-0.08	0.44	0.19	0.16	0.31	0.11	-0.18
SO_2 (2M)											1.00	0.808	-0.19	-0.06	0.00	0.43	0.49	0.29	0.43	0.00	-0.35
SO_2 (5M)												1.00	-0.02	0.34	-0.30	0.04	0.26	-0.03	0.06	-0.12	-0.11
CH_4 (P)													1.00	0.598*	0.25	0.15	0.42	0.20	-0.10	0.02	-0.02
CH_4 (2M)														1.00	0.43	-0.19	-0.04	-0.40	-0.37	-0.22	-0.21
CH_4 (5M)															1.00	-0.36	-0.35	-0.19	-0.22	0.14	0.15
$PM_{2.5}$ (P)																1.00	0.598*	0.49	0.53	-0.01	-0.53
$PM_{2.5}$ (2M)																	1.00	0.832	0.690*	0.37	-0.22
$PM_{2.5}$ (5M)																		1.00	0.784	0.673*	0.11
PM_{10} (P)																			1.00	0.720	-0.04
PM_{10} (2M)																				1.00	0.53
PM_{10} (5M)																					1.00

**Correlation is significant at the 0.05 level*

The implication of the positive significant relationship is that there exists direct proportional relationships between the parameters although at different significant level which corroborates the study of the associations between $PM_{2.5}$ and lung function decrements in children (Koenig *et al*., 1993), visits to emergency departments for asthma (Norris *et al.,* 1999), hospitalizations for asthma (Sheppard *et al*., 1999), and increases in asthma symptoms in children (Yu and Lumley, 2000), as well as increase in exhaled Nitric oxide (Koenig *et al.,* 2003, 2005). High PM concentrations results in the condensation of gases when they are combusted (Naeher*et al*., 2007) this may also explain the positive correlation shown by PM and almost all the other monitored gases.

V. Conclusions

Finally, the various values observed, meets with the World Health Organization (WHO), Air Quality Guidelines, 2005 but when compared with National Environmental Standards and Regulation Enforcement Agency (NESREA) standards for ambient air, SO_2 and NO_2 exceed the limit. It should be noted that Nigerian Air Quality Standards have notactually considered fuel-wood sources and there are no set standards and limits for this activity.

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