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Assessment of Respiratory Health Impact of Fuel-Wood Utilization on Exposed Rural Women in Odeda, Southwestern, Nigeria

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Abstract- This study monitored the concentration of seven air pollutants and examined the concentration of Carbon monoxide (CO) and Carboxylhaemoglobin (COHb) in human breath and blood among the exposed rural women. A total of 12 villages were purposively selected from the list of villages in Odeda Local government area, (Southwestern Nigeria). Active air samplers were used to monitor air quality at the cooking points in houses selected through systematic random sampling. Air monitoring was observed in replicates between November 2012 and January 2013. In order to elicit information on energy utilization and occurrence of air pollution related health problems among the rural dwellers, one questionnaire was administered to the available female in each selected house. The mean±SD (ppm) concentrations of pollutants monitored across the villages were CO: 15.18±4.29; CO_2: 44.09±10.74; NO_2: 0.59±0.12; SO_2: 2.05±0.65; CH_4: 0.58±0.51; PM_{10}: 98.64±9.22 and PM2.5: 43.81±11.11 at average wind speed of 3.11±0.57 m/s. The overall means of Breath CO (ppm) and % COHb were 2.17±0.58 and 1.47±0.37 respectively.

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Strictly as per the compliance and regulations of :

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Abstract- This study monitored the concentration of seven air pollutants and examined the concentration of Carbon monoxide (CO) and Carboxylhaemoglobin (COHb) in human breath and blood among the exposed rural women. A total of 12 villages were purposively selected from the list of villages in Odeda Local government area, (Southwestern Nigeria). Active air samplers were used to monitor air quality at the cooking points in houses selected through systematic random sampling. Air monitoring was observed in replicates between November 2012 and January 2013. In order to elicit information on energy utilization and occurrence of air pollution related health problems among the rural dwellers, one questionnaire was administered to the available female in each selected house. The mean±SD (ppm) concentrations of pollutants monitored across the villages were CO: 15.18±4.29; CO_2: 44.09±10.74; NO_2: 0.59±0.12; SO_2: 2.05±0.65; CH_4: 0.58±0.51; PM_{10}: 98.64±9.22 and $PM_{2.5}$: 43.81±11.11 at average wind speed of 3.11±0.57 m/s. The overall means of Breath CO (ppm) and % COHb were 2.17±0.58 and 1.47±0.37 respectively. PM_{10} had the highest mean concentration. There were no significant differences (P>0.05) in the mean concentration of air pollutants across the selected communities except for CH_4. However, there was significant negative correlation between $PM_{2.5}$ and Breath CO ($p \leq 0.05$). Health problems frequently experienced in the study area were catarrh, eye irritation, cough, sneezing, dry throat and nausea, shortness of breath, headache, dizziness and skin irritation.

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I. Introduction

Although fuel-wood is an important source of energy for domestic use in rural areas but is also a major source of air pollutants such as carbon monoxide, particulate matters, Polycyclic aromatic hydrocarbons (PAHs) and others which are detrimental to human health.

Poverty, lack and/or inadequacy of alternative energy sources have promoted the use of fuel-wood which creates high levels of air pollutants (Zafar *et al.*, 2010). Exposure to these substances leads to increased risk of a variety of diseases including pneumonia, chronic respiratory diseases and lung cancer (Bruce *et al.*, 2002).

Biomass fuel smoke has been classified as a probable human carcinogen and coal smoke as a proven human carcinogen (Straif and IARC Monograph Working Group, 2006), mutagens (WHO, 1997) and is as dangerous to health as breathing in emissions from a car exhaust or tobacco smoke (Koning *et al.*, 1985). Comparison of the burden of illness and premature death from solid fuel use (e.g. fuel-wood) with other major risk factors, including outdoor air pollution, tobacco smoking and hypertension indicated that solid fuel use may be responsible for 800,000 to 2.4 million premature deaths each year (Ezzati *et al.*, 2002; Smith *et al.*, 2004). Inhaled air pollutants have diverse effects on people that are exposed, depending on body constitution, lifestyle, nutritional status and age. Studies have shown that women and children, who are the most exposed and vulnerable to the pollutants, are two to six times at risk of contracting serious respiratory infections (WHO, 1997; Jones, 1999). Interest in respiratory health impacts of air pollutants from fuel-wood utilization has been increasing rapidly probably as a result of high cases of illnesses recorded. Traynor *et al.*, (1985) among rural women and children observed that long time exposure to biomass combustion results in chronic obstructive lung diseases, heart diseases, acute respiratory infections, low birth weight, eye disorder, conjunctivitis, blindness and cancer (Edokpa and Ikelegbe, 2012). Children strapped on their mothers' back while cooking with open cook stoves contracted pneumococcal infections 2.5 times higher than non-exposed ones (WHO, 1997; Mac, 2009). Epidemiological studies in developing countries have also linked exposure to air pollutants from dirty (biomass) fuel to Acute Respiratory Infection (ARI) in children; chronic obstructive lung diseases such as asthma and chronic bronchitis; lung cancer; and still-births and other related problems which include irritation of the skin, eyes, nose and throat; dizziness, nausea and long-term chronic health effects (Ayars, 1997). Furthermore, studies have found strong links between chronic lung diseases in women and exposure to smoke from open cook stoves due to high concentration of NO_2 (Frampton, *et al.*, 1991; Goldstein, *et al.*, 1988 and

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Jones, 1999) and SO_2 (Oin *et al.*, 1993) while another found a strong correlation between the high elemental concentration of aerosol particles, high mortality and high morbidity in biomass users (Maloni *et al.,* 2002). Owning to the predominant use of fuel - wood for cooking in rural parts of Ogun state and the potential respiratory health hazards that may result. There is paucity of data relating to the concentration, levels of air pollution from sources such as fuel-wood combustion in Nigeria, hence the need for the constant monitoring and assessment of air pollutants from fuel-wood utilization, this paper therefore assessed air quality at the cooking points, CO concentration in breath and % COHb in selected villages in order to ascertain the level of some gases, in selected villages of Odeda Local Government Area of Ogun state, Nigeria.

II. The Study Area

Odeda local government area (LGA) with headquarters at Odeda is one of the 20 local government areas in Ogun State, southwest Nigeria. It lies on the North-eastern zone of the State, on longitude $7^{0}12^{1}$ to $7^{0}31^{1}$ and latitude $3^{0}15^{1}$and $3^{0}45^{1}$ (Figure 1). The local government area shares boundary with Abeokuta south local government area on the West, Obafemi-Owode local government area on the South, on the North and East with Akinyele and Ibarapa Local government of Oyo state. The population figure was 109,449 (NPC, 2006) and a land area of about 1,554 km^2.

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. There are approximately 438 settlements/communities spread across the three zonal divisions in the local government namely Odeda, Opeji and Ilugun.

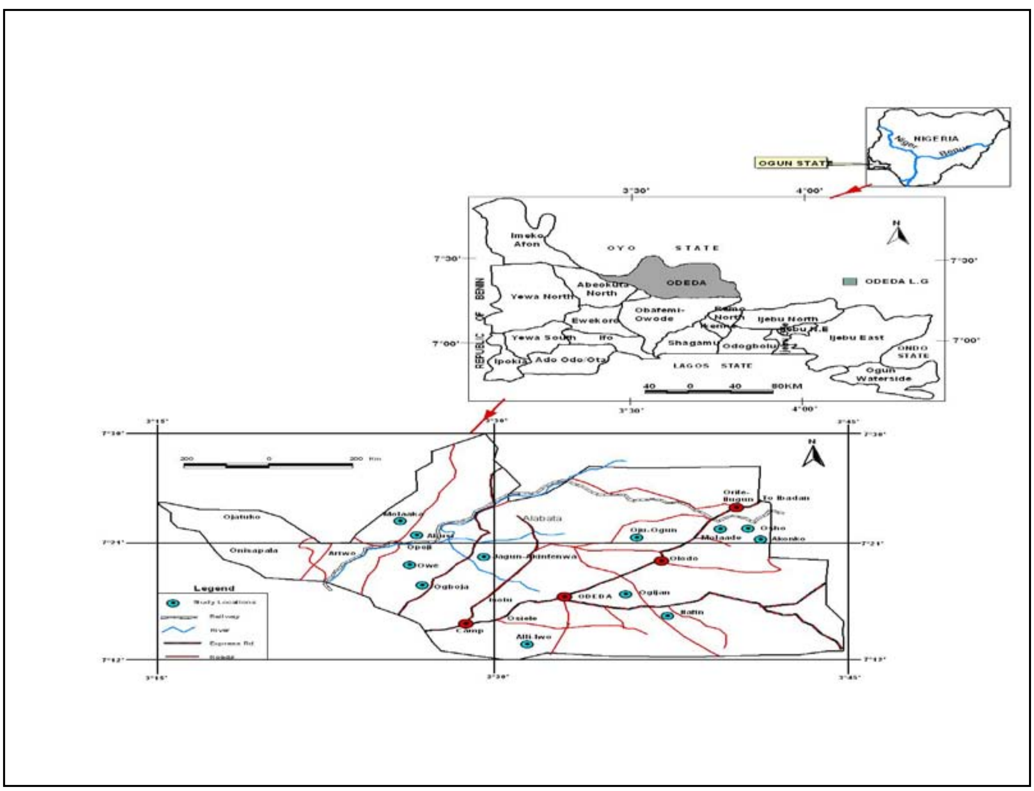

Figure 1 : Map of study area

III. Research Methodology

Data collection for this research work adopted a multi-staged procedure involving three (3) phases. A pre-sampling survey was conducted to select communities for the research, including needed permission for community entry. However, this research work is gender specific hence the target audiences were married women who dominate cooking using fuel-wood.

a) Sample Size and Sampling Procedure

Communities sampled were drawn purposively and based on exclusive criteria such as absence of social amenities (such as tarred roads, electricity supply and other modern facilities) and 2 km distance from any known major road (these criteria were paramount in order to prevent interference from vehicular emission and to allow air pollutant dispersion respectively). A total of 12 communities were selected after considering the criteria earlier mentioned. The 12 are Iwo-Alli, Jagun Akinfenwa, Ilafin, Ogijan (Odeda zone), Ogboja, Abusi, Owe, Molaaka (Opeji zone), Molaade, Akonko, Osho and Oju-ogun (Ilugun zone). Ten (10) houses were randomly selected from each of the 12 sampled villages for both air quality monitoring and questionnaire survey.

b) Stage One: Questionnaire Administration

A pretested structured questionnaire was administered to elicit information on the sources of energy, source of wood, type of wood used for cooking, location of cooking points, number of cooking points, hours of cooking per day, problems encountered in energy sourcing, commonly treated health problems and the experience of some selected ailments. A total of 120 copies of questionnaire were administered.

c) Stage Two: Air quality monitoring

The preliminary results from the first stage (i.e. questionnaire survey) were used to identify the households where air quality monitoring were conducted. Hence, random selections of 10 households were sampled in each community making a total of 120 households in all. Wind vane was used to determine the wind direction; 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); the $QRAE^+$ was used to monitor Lowest Explosive Limit (LEL i.e. CH_4), Kanomax Anemometer was used to monitor wind speed and velocity while Dust track II Aerosol monitor R11593 for measuring suspended particulate matter (PM_{10}, $PM_{2.5}$). These gases are emitted during wood combustion and are known to induce or cause respiratory disease in exposed humans and also contribute to the problem of global warming (NO_2 and CO_2 being greenhouse gases). These gases were monitored in replicates, in each of the communities between November, 2012 and January, 2013.

d) Stage Three: Respiratory Health Status Assessment

Carboxyl-haemoglobin level and carbon monoxide concentration in the breath of respondents that fully complete their questionnaire and voluntarily agree to participate were assessed using Oximeter (Breath Analyzer).

IV. Data Analysis

The data collected from the three sources were subjected to descriptive, one-way ANOVA and correlation analyses using the statistical package for Social Sciences (SPSS version 17.0.1 and Microsoft Excel, 2007).

V. Results and Discussion

a) Household Survey

Table 1 shows the socio-demographic characteristics of the respondents. About 40 % of the rural women were 50 years old and above and have had between four and six children 51.7 %. Many of them have no formal education or just primary school education (42.5 %). About 45 % of these women are farmers, while others are engaged in selling of farm produce (35 %). These results were supported by a similar study by Oguntoke *et al.*, (2010).

Over 80 % of the respondents depend on fuel-wood for their energy provision (Table 2), while 15 % use both kerosene and fuel-wood, utilization of fuel-wood is closely linked to its availability and affordability (46.7 %). Also, this choice may be due to the attitude of the rural dwellers to want to retain rural habits in relation to energy use, even though other sources exist (Cline-cole, 1988).

Over 80 % of the respondents spend an average 4 hours daily using fuel-wood stove (Table 3); while majority of the respondents (87.5 %) of the respondents have spent above 10 years cooking with fuel-wood. Taking critical consideration, 4hrs daily intake of air pollutants for a period of ten years may have impacted negatively on the respiratory system of the fuel-wood users.

In all the villages about 68 % of the respondents have their cooking cited outdoor; 13.3 % have their cooking points inside and 18.3 % have both indoor and outdoor locations. Most outdoor cooking points are in close proximity to the dwelling units. More than 33.3 % of the respondents have their outdoor cooking points at a distance of not more than 5 m to the house. This may be a source of fuel-wood smoke penetration into houses thereby impairing the Indoor Air Quality (IAQ) according to the study by Oguntoke *et al.*, (2010). Majority of the respondents have minimum of two cooking points (50.8 %) which could possibly double the concentration of air pollutants when the two are been used simultaneously.

Concerning treated illnesses due to air pollutant, table 4 shows that catarrh (85.83 %) topped the list of frequently treated diseases, followed by eye irritation (81.67 %), cough (53.33 %), sneezing (50 %) and nausea (42.50 %). However, for occasionally experienced ailments, it is in order of shortness of breath (51.67 %), headache (50%) and skin irritation (46.67 %) while dizziness is rarely experienced.

Most of the respondents did not consider these respiratory ailments suffered by them as a serious problem probably because health problems from air pollution are known to be subtle (Mac, 2009) and serious outcomes take a fairly long latency period. The respiratory diseases may have become quite frequent that the respondents might have developed means of coping with or they live by them Oguntoke *et al.*, (2010). A critical consideration of health problems suffered by these respondents showed that ailments closely associated with human exposure to air pollutants are prevalent among the respondents (Oin, *et al*; 1993; Frampton, *et al*; 1991 and Jones, 1999; Theuri, 2009).

b) Air quality measurement

The mean concentration of CO among the villages ranged between 8.70±0.31 and 21.79±1.13 ppm with an overall mean value of 15.18±4.29 ppm, which is within the permissible limit (10 - 20 ppm) allowed by WHO (WHO, 2005), Carbon dioxide (CO_2) ranged between 25.21±2.07 and 65.34±0.22 ppm with an overall mean value of 44.09±10.74 ppm, while NO_2 ranged between 0.31±0.00 and 0.78±0.00 ppm with an overall mean value of 0.59±0.12, which were higher than the WHO limit of 0.06 ppm (WHO, 2005), SO_2 ranged between 1.45±0.01 and 3.67±0.00 ppm with an overall mean value of 2.05±0.65. Methane (CH_4) concentration monitored in the selected villages ranged between 0.00 and 1.00±0.01 ppm, with an overall mean value of 0.58±0.51 ppm and these exceeded the limit of 0.06 ppm set by WHO (WHO, 2005). Particulate Matter i.e. PM_{10} have mean concentration that ranged between 81.00±3.17 and 111.20±9.86 ppm, an overall mean of 98.64±9.22, $PM_{2.5}$ ranged between 27.00±1.33 and 61.50±1.08 ppm, and an overall mean value of 43.81±11.11 ppm. Also on the same table 5 shows the mean values of CO concentration in breath which among the villages ranging between 0.78±0.49 and 2.58±2.69 ppm and overall mean value of 1.51±0.49 ppm. The COHb in blood ranged between 0.33±0.23 and 2.64±2.88, with an overall mean value of 1.04±0.62, which falls within the 1 – 3 % permissible limit of WHO, 2005. It is to be noted that CO does not accumulate in the body because once an exposure ends, the lungs exhale CO and COHb reverts back to oxyhaemoglobin, the form of hemoglobin that can carry oxygen. Half of the CO in the blood will be removed in approximately 5 hours (MIOSHA, 1974).

The mean value of CO observed in this study was lower unlike Oguntoke *et al.*, (2010), however the trend is not the same for NO_2, SO_2 and CH_4. This trend may not be unconnected to some phenomenon that may affect pollutants' concentration in an outdoor environment. Such factors include temperature inversion, atmospheric stability, lapse rate and mixing height. Table 6 shows that there is no significant variation ($p>0.05$) in air pollution among the villages except for CH_4. This may not be unconnected to the common wood been used, common activities and the variation in CH_4 may be due to addition of supplement materials such as polythenes, pet bottles, biofuels e.g. cow dung, plant residues such as "iha" and "eesan" for quick burning (Zafar et al., 2010). A significant negative correlation exists between $PM_{2.5}$ and Breath CO. which implies that as one increase the other decreases as shown on Table 7.

VI. Conclusion

Utilization of fuel-wood as a source of energy is a major source of air pollution in the study area. Apart from the fact that these gases affect human health negatively, their eventual release into the ambient environment is capable of increasing the concentration of air pollutants in the already polluted atmosphere.

Hence, the reduced concentration of air pollutants in breath and blood should not be assumed to mean that the population is totally free from respiratory problems as a result of their fuel-wood utilization. Further studies that will encompass other respiratory health assessment should be encouraged to further ascertain this fact. Reasonable distances should be given between cooking points and dwelling houses in order to protect the indoor air quality. A sustainable alternative source of energy that is readily available should be developed for the use of rural dwellers. Cooking stove with efficient combustion design should be introduced into the rural communities so as to minimize the emission of pollutants during cooking process. Environmental awareness and education should be embarked upon in the rural areas to sensitize the residents to the health problems associated with exposure to high level air pollutants within the house.

Table 1 : Socio-demographic characteristics of respondents from the study area

Demographic characteristics	No. of Respondents	Percent
Age-group		
21 – 30	14	11.7
31 – 40	27	22.5
41 – 50	31	25.8
> 50	48	40.0
Total	120	100.0
No. of children		
≤ 3	31	25.8

4 – 6	62	51.7
> 6	27	22.5
Total	120	100.0
Educational background		
No formal education	51	42.5
Primary education	51	42.5
Secondary education	17	14.2
Tertiary education	1	0.8
Total	120	100.0
Occupation		
Petty trading	17	14.2
Farming	54	45.0
Artisan (e.g. local hairdresser, carpenter etc)	5	4.2
Civil servants	2	1.7
Petty trading and farming	42	35.0
Total	120	100.0

Table 2 : Cooking energy source, reason for choice, hours of cooking and years of utilization by the respondents in the study area

	No. of Respondents	Percent
Energy source		
Kerosene	2	1.7
Firewood	98	81.7
Charcoal	2	1.7
Kerosene and Firewood	18	15.0
Total	120	100.0
Reason for choice of fuel-wood		
Easy to source	43	35.8
Cooks faster	21	17.5
Available and cheap	56	46.7
Total	120	100.0
Hours of cooking		
≤ 1hr	4	3.3
2 - 4hrs	20	16.7
> 4 hrs	76	80.0
Total	120	100.0
Years of fuel-wood utilization		
< 5 years	4	3.3
5 - 7 years	6	5.0
8 - 10 years	5	4.2
> 10 years	105	87.5
Total	120	100.0

Table 3 : Kitchen location and distance to cooking point in the study area

	No. of Respondents	Percent
Kitchen location		
Indoor	16	13.3
Outdoor	82	68.3
Indoor and Outdoor	22	18.3
Total	120	100.0
No. of cooking points		
1	6	5.0
2	61	50.8
3	49	40.8
4	4	3.3
Total	120	100.0
Distance to cooking points		
Indoor	16	13.3
≤5m	40	33.3
6 - 10m	37	30.83
11 - 20m	20	16.67
> 20m	7	5.83
Total	120	100.0

Table 4 : Frequency of health problems in fuel-wood users

Health problem	Frequently (%)	Occasionally (%)	Rarely (%)
Eye irritation	98 (81.67)	15(12.5)	7(5.83)
Dry throat	58(48.33)	42(35)	20(16.67)
Headache	26(21.67)	61(50.83)	33(27.5)
Sneezing	60(50)	49(40.83)	12(9.17)
Skin irritation	18(15)	56(46.67)	47(38.33)
Shortness of breath	29(24.17)	62(51.67)	29(24.17)
Cough	64(53.33)	38(31.67)	18(15)
Dizziness	25(20.83)	47(39.17)	48(40)
Nausea	51(42.50)	26(21.67)	43(35.83)
Catarrh	103(85.83)	17(14.17)	0.00(0)

Table 5 : Mean values of parameters monitored in the selected villages

VILLAGES	CO (ppm)	CO_2 (ppm)	NO_2 (ppm)	SO_2 (ppm)	CH_4 (ppm)	PM_{10} (ppm)	$PM_{2.5}$ (ppm)	CO BREATH	% COHb
Iwo-Alli	10.21±0.32	25.21±2.07	0.62±0.00	1.45±0.01	1.00±0.01	105.45±5.21	60.40±1.68	0.92±0.98	0.49±0.49
Ogijan	15.86±0.12	51.34±1.32	0.31±0.00	1.75±0.11	0.00	100.5±9.21	61.50±1.08	2.58±2.69	1.15±0.72
Jagun Akinfenwa	21.79±1.13	45.32±1.00	0.63±0.18	3.67±0.00	1.00±0.00	111.20±9.86	60.20±2.14	0.78±0.49	0.94±1.24
Ilafin	19.30±0.04	52.99±2.36	0.59±0.19	1.59±0.00	0.00	88.40±4.76	38.20±1.98	1.16±0.88	0.33±0.23
Ogboja	18.40±0.09	34.09±2.19	0.54±0.00	1.89±0.02	1.00±0.00	88.00±3.78	36.00±3.10	1.48±1.08	1.28±0.84
Owe	17.80±0.23	39.01±1.10	0.38±0.00	1.67±0.13	0.00	81.00±3.17	38.40±1.93	1.81±1.48	0.71±0.76
Molaaka	19.71±0.32	65.34±0.22	0.55±0.19	1.46±0.21	1.00±0.00	96.80±4.52	27.00±1.33	1.63±1.38	0.93±1.17
Abusi	10.10±0.02	41.98±2.07	0.63±0.12	2.19±0.13	1.00±0.00	99.10±3.81	38.20±0.32	1.29±0.93	1.14±1.11
Molaade	14.10±0.11	51.45±1.27	0.54±0.00	2.78±0.29	1.00±0.00	94.90±5.77	40.50±1.74	1.75±1.38	1.59±0.96
Osho	13.80±0.13	34.98±1.61	0.72±0.00	2.45±0.19	0.00	108.20±6.07	40.20±2.45	1.76±1.39	0.67±0.66
Oju-ogun	8.70±0.31	38.19±1.20	0.66±0.00	1.98±0.02	0.00	107.00±3.91	46.97±2.19	1.16±0.87	2.64±2.88
Akonko	12.40±0.22	49.19±2.26	0.78±0.00	1.69±0.01	1.00	103.10±5.01	38.17±1.04	1.74±1.38	0.55±0.49
Mean±Stdev	15.18±4.29	44.09±10.74	0.59±0.12	2.05±0.65	0.58±0.51	98.64±9.22	43.81±11.11	1.51±0.49	1.04±0.62
Permissible Limit	10.0 - 20.0	NA	0.04 - 0.06	0.01 - 0.1	0.06	NA	NA	NA	1-3

**NA- Not Available*

Table 6 : Variations in air pollutants' concentration between villages ($p < 0.05$)

Pollut -ants	Locations grouping											
CO	Iwo-Alli[a]	Ogijan[a]	Jagun Akinfenwa[a]	Ilafin[a]	Ogboja[a]	Owe[a]	Molaaka[a]	Abusi[a]	Molaade[a]	Osho[a]	Oju-ogun[a]	Akonko[a]
CO_2	Iwo-Alli[a]	Ogijan[a]	Jagun Akinfenwa[a]	Ilafin[a]	Ogboja[a]	Owe[a]	Molaaka[a]	Abusi[a]	Molaade[a]	Osho[a]	Oju-ogun[a]	Akonko[a]
SO_2	Iwo-Alli[a]	Ogijan[a]	Jagun Akinfenwa[a]	Ilafin[a]	Ogboja[a]	Owe[a]	Molaaka[a]	Abusi[a]	Molaade[a]	Osho[a]	Oju-ogun[a]	Akonko[a]
NO_2	Iwo-Alli[a]	Ogijan[a]	Jagun Akinfenwa[a]	Ilafin[a]	Ogboja[a]	Owe[a]	Molaaka[a]	Abusi[a]	Molaade[a]	Osho[a]	Oju-ogun[a]	Akonko[a]
CH_4	Ogijan[a]	Ilafin[a]	Owe[a]	Osho[a]	Oju-ogun[a]	IwoAlli[ab]	Jagun Akinfenwa[ab]	Molaaka[ab]	Abusi[ab]	Molaade[ab]	Akonko[ab]	Ogboja[b]
PM_{10}	Iwo-Alli[a]	Ogijan[a]	Jagun Akinfenwa[a]	Ilafin[a]	Ogboja[a]	Owe[a]	Molaaka[a]	Abusi[a]	Molaade[a]	Osho[a]	Oju-ogun[a]	Akonko[a]
$PM_{2.5}$	Iwo-Alli[a]	Ogijan[a]	Jagun Akinfenwa[a]	Ilafin[a]	Ogboja[a]	Owe[a]	Molaaka[a]	Abusi[a]	Molaade[a]	Osho[a]	Oju-ogun[a]	Akonko[a]

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

Table 7 : Relationship between air pollutant concentration and human body concentration

VARIABLES	CO	CO_2	NO_2	SO_2	CH_4	PM_{10}	$PM_{2.5}$	BREATH CO	% BLOOD CO
CO	1.00	0.46	-0.36	0.22	0.02	-0.36	-0.13	-0.03	0.53
CO_2		1.00	-0.24	-0.03	0.06	-0.16	-0.38	0.09	-0.25
NO_2			1.00	0.18	0.26	0.46	-0.24	-0.07	-0.41
SO_2			0.18	1.00	0.22	0.44	0.31	-0.53	0.03
CH_4					1.00	0.15	-0.10	-0.36	-0.16
PM_{10}						1.00	0.53	-0.38	-0.21
$PM_{2.5}$							1.00	-.598*	0.54
BREATH CO								1.00	-0.27
% BLOOD CO									1.00

**Correlation is significant at the 0.05 level*

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