Ethiopian Journal of Environmental Studies & Management 10(9): 1106 – 1118, 2017.
ISSN:1998-0507 doi: https://ejesm.org/doi/v10i9.1
Submitted: May 11, 2017 Accepted: November 8, 2017

INDOOR AIR QUALITY MONITORING IN SOME LOCAL GOVERNMENT AREAS OF LAGOS STATE, NIGERIA

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Abstract
*The indoor air quality of four Local Government Areas of Lagos State, Nigeria (Eti-Osa, Ikeja, Surulere, and Apapa) were monitored in this study. Six sample locations in each of the selected Local Government Areas were assessed for Particulate Matter ($PM_{2.5}$ and PM_{10}), Temperature, Relative Humidity, Hydrogen Sulphide (H_2S), Noise level, Carbon Monoxide (CO), Volatile Organic Compounds (VOCs), Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2), and Ammonia (NH_3); by using handheld testers which were verified before use for quality assurance. Results across the four Local Government Areas show that the levels of $PM_{2.5}$ (4-37μg/m^3), PM_{10} (7-77 μg/m^3), relative humidity (63-99%), noise level (41.8-81.8dBA), CO (001-138ppm), VOCs (-2 to 12ppm), SO_2 (0.0-0.6ppm) exceeded the regulatory limits of various organizations including WHO, NAAQS, OSHA. Furthermore, results obtained show that two sample points in Ikeja Local Government Area had CO value that is significantly higher than the regulatory limits ($P<0.001,0.01,0.05$) with values of 138 and 122ppm as against the permissible standard of 11ppm on an 8-hour exposure. Eti-Osa also had a very significant concentration of $PM_{2.5}$ (37*μg/m^3*) and SO_2 (0.6ppm) in two of its sampling points respectively which exceeded the acceptable NAAQS limits of 15* μg/m^3 and *0.38ppm respectively. It is evident from the results obtained in the study that there are dangers posed by poor indoor air we are exposed to on daily basis and as such, public awareness is pertinent; because we spend more time indoor than outdoor. The evidence therefore suggests that; with the introduction of the monitoring of indoor ambient air parameters, would be an accompanied reduction in air pollution related health conditions.*

Key Words*:* *Pollutants, Indoor air quality, Concentration, Sampling point, Local Government Areas*

Introduction

Indoor air is the surrounding air within an enclosed area. We tend to think of air pollution as something outside, but the air inside homes, offices and within other enclosed places can be more polluted than the air outside. The use of solid fuels for cooking and heating is likely to be the largest source of indoor air pollution on a global scale. Nearly half of the world continues to cook with solid fuels such as dung, wood, agricultural residues and coal. When used in simple cooking stoves, these fuels emit substantial amounts of toxic pollutants (Beelen *et al.,* 2013). These pollutants, called "solid-fuel smoke" include respirable particles, carbon monoxide, oxides of nitrogen and sulfur, benzene, formaldehyde and polyaromatic compounds. Pollutants are added in the atmosphere from various sources that change its composition and affect the biotic environment. The concentration of air pollutants depend not only on the quantities that are emitted from air pollution sources, but also on the ability of the atmosphere to either absorb or disperse these emissions (Senguputa *et al.,* 2003). Air pollutants are often unevenly dispersed in the environment; in many cases the areas with higher concentrations are near the sources of pollution (WHO, 2010). Asides the form of pollutants generated as a result of daily activities within homes and other enclosed areas; outdoor pollution can also find its way to indoor environment (and vice-versa) from ventilation systems, due to the ability of gas molecules to move freely and diffuse randomly away from point of emissions. When a building is not properly ventilated, pollutants can accumulate and reach concentrations greater than those typically found outside. This problem has received media attention as "Sick Building Syndrome" (Daly and Zannetti, 2007). Also, when bacteria die, they release endotoxins into the air, which can cause adverse health effects. Some pollutants arrive via a new mattress or furniture, carpet cleaners, or a coat of paint on the walls; other common sources can include heating, cooking, smoking tobacco products, emissions from furniture, office equipment and building materials, pets, and releases from household cleaning products (Naeher *et al*., 2000); therefore ventilation is important when cooking, cleaning, and disinfecting in a building.

Air quality has both environmental and health impacts and the evaluation of these impact is important for assessing population exposure to air pollution and predicting the magnitude of the health risks to the population (Yusuf *et al.,* 2013a). Human exposure to air pollution may result in a variety of health effects, depending on the types of pollutants, the magnitude, duration and frequency of exposure and the associated toxicity of the pollutants of concern (Brown, 2002). Typical health effects of polluted air observed by studies include: reduced lung functioning, asthma attacks, respiratory symptoms, restricted activity, increased medication use, increased hospital admissions, increased emergency room visits, development of respiratory diseases, premature death (WHO, 1999).

People with asthma, children, and the elderly may be especially sensitive to indoor pollutants, but other effects on health may appear years later, after repeated exposure (Titos *et al.,* 2015). Indoor allergens and irritants have become much more important in recent decades because we spend more time indoors and because modern homes are becoming more airtight due to over population in urban areas like Lagos state. People living in polluted areas tend to get sick more often or for longer periods than do people in areas with less pollution; exposure to elevated levels of pollution has also been linked to premature mortality (WHO, 2011). Air quality assessment is frequently driven by the need to determine whether a standard has been exceeded (Foscue and Simpson, 2010), it should include links with population exposure and with the pollution sources; this is why the locations assessed in this study were selected because they are highly populated.

Previous studies have concentrated on outdoor air quality, overlooking the fact that we spend more time indoor than outdoor. This study is aimed at enlightening the public that our domestic and anthropogenic activities have a lot of negative impact on quality of air we breathe and as such individuals, industries and regulatory agencies have a role in ensuring the air we breathe is less polluted. Data generated from this study will be of importance to policy, decision-makers and regulatory agencies. Therefore laws can be promulgated to ensure that the air in our environment both indoor and outdoor is of better quality and is less polluted.

Materials and Methods

Study Area

Four Local Government Areas in Lagos Metropolis, Nigeria were selected for this study. The Local Government Areas selected have high level of industrial activities and are highly populated. Fig 1 shows the Map of Lagos state pointing out the four Local Government Areas selected for this study.

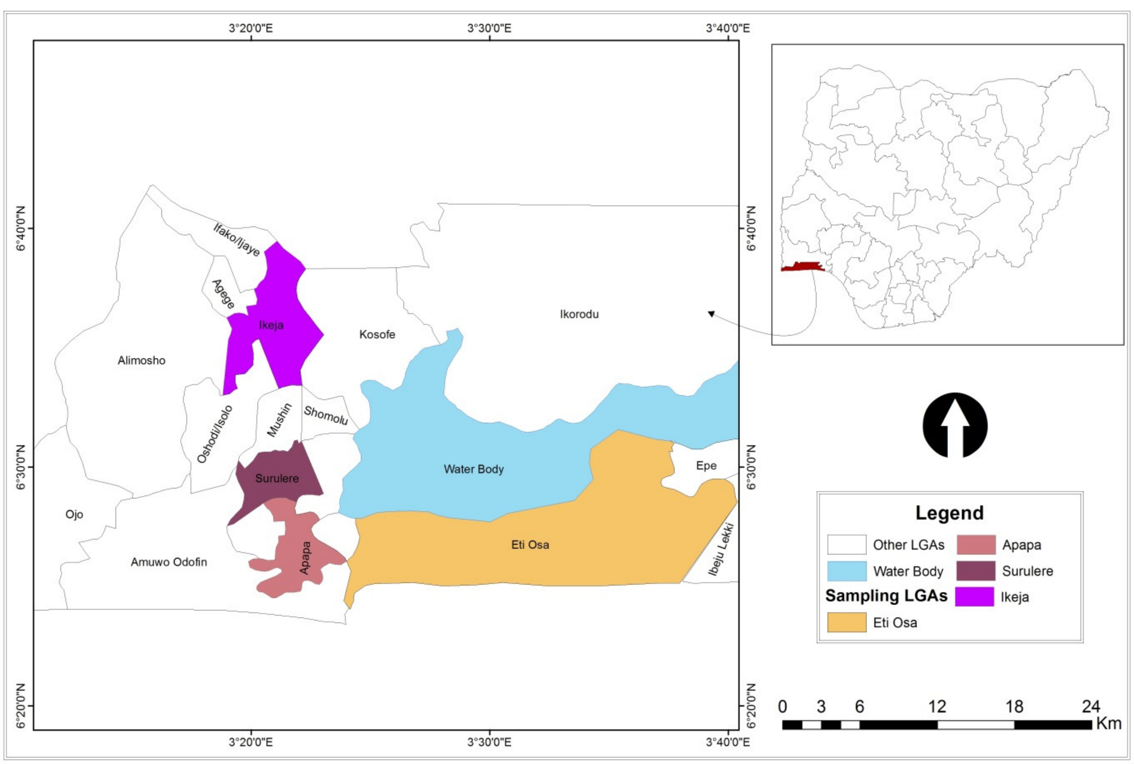

Fig 1: Map of Lagos state showing the four Local Government Areas of sampling

Description of Sample Locations

The indoor sampling points were randomly selected to comprise of vehicles, offices, classes, shops, malls and homes in each of the selected Local Government Areas.

Preliminary Site Inspection

Prior to the assessment of the air quality, physical inspection of the indoor points in the LGAs selected for air quality measurement were visited. This was to determine acceptance by the occupants whose indoor sampling points were to be used for the study.

Methodology

In each of the sampling points of the four Local Government Areas, eleven air quality monitoring parameters; Particulate Matter ($PM_{2.5}$ and PM_{10}), Temperature, Relative Humidity, Hydrogen Sulphide (H_2S), Noise level, Carbon Monoxide (CO), Volatile Organic Compounds (VOCs), Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2), and Ammonia (NH_3) were determined using a series of handheld air quality monitoring equipment and meters that were properly calibrated before use for quality assurance.

PM 10, PM 2.5, Relative Humidity and Temperature were measured using CW-HAT 200 handheld tester, 2-3times during the one-hour monitoring period in each sample point, while the values displayed on the screen were recorded at stability.

Concentrations for H_2S, NH_3, SO_2 and NO_2 were determined using the GC-310 gas detector and the value on the screen was noted at stability. Noise level was measured with a CEM-DT 805 sound level meter and a stable value displayed on the screen after the stipulated 60 seconds was read off. CO was measured using CNY 670 meter while VOC was measured with the self-regulating Gas Alert Micro5 PID meter. This study was carried out during the rainy season of July/August, 2016.

Statistical Analysis

Data obtained were subjected to the following statistical tools: Mean, Standard Deviation, Two-way analysis of variance and Tukey's multiple comparisons.

Results

Results of indoor air quality of the four Local Government Areas are presented in Tables 1-4; the values were compared with the standards in Table 5.

The least recorded value for $PM_{2.5}$ was $4µg/m^3$ in a house in Surulere and the highest value at $30µg/m^3$. The lowest value for PM_{10} was $9µg/m^3$ and the highest here was $69µg/m^3$; temperature, H_2S, VOC, NO_2, CO, NH_3 values across this Local Government Area was normal according to the standard. The lowest recorded value for relative humidity at Surulere was 63% and the highest was 96%; this axis had its lowest noise level to be 42.6dBA and its highest to be 69.4dBA.

In Ikeja Local Government Area, table 2 shows the concentration obtained from sampling; the least recorded value for $PM_{2.5}$ here was $4µg/m^3$ in a classroom and the highest was $25µg/m^3$ in an office; the lowest PM_{10} value sampled was $8µg/m^3$ and the highest was $43µg/m^3$ in a vehicle. Temperature, NO_2, CO, NH_3 values across this Local Government Area were normal according to the standard used; 0.1ppm was recorded in a house in Ikeja for NO_2 and this was the only value above zero across all Local

Government Areas, the lowest and highest concentrations for relative humidity was 79 and 97% respectively. Two extreme values of 122 and 138ppm respectively were observed for CO in a house in Ikeja.

In Eti-Osa Local Government Area, table 3 shows the values obtained from the study. Upon comparison with the standards, the least recorded value for $PM_{2.5}$ was 4µg/m^3 in a classroom and a house on this axis, while the highest value was 37µg/m^3 observed in a commercial vehicle. The lowest value for PM_{10} was 7µg/m^3 and the highest here was 77µg/m^3 seen in a private vehicle. This particular Local Government Area had the highest and lowest concentration for PM_{10} generally (7 and 77 µg/m^3 respectively); temperature, NO_2, CO, NH_3 values across this Local Government Area were normal according to the standards used. At Eti-Osa L.G.A, the lowest value for relative humidity was 74%; while the highest was 99%, which marked the highest. Furthermore; this axis had its lowest noise level as 42.6dBA, with its highest at 79.5dBA, while SO2 concentration in a classroom observed was 0.1ppm, with an exceptional value of 0.6ppm recorded in a vehicle.

In Apapa Local Government Area, table 4 shows the values obtained from the study. Upon comparison with the standards used, the values that exceeded the standards were documented, the least recorded value for $PM_{2.5}$ was 4µg/m^3 in a house on this axis and the highest value at 27µg/m^3 observed along the walkway of Apapa Mall. The lowest value for PM_{10} was 8µg/m^3 and the highest here was 56µg/m^3; temperature, H_2S, VOC, NO_2, CO, NH_3 values across this Local Government Area were normal according to the adopted standards. The lowest recorded value for relative humidity at Apapa was 61% and the highest was 90%; this axis had its lowest noise level to be 41.8dBA and its highest was 81.8dBA.

Table 1: Pollutants Level Recorded in Surulere

LOCATION		PARAMETERS (Pollutants)										
LGA	Point Locations	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)	Temp (°C)	Rel hum (%)	H_2S (ppm)	Noise (dBA)	CO (ppm)	VOC (ppm)	NO_2 (ppm)	SO_2 (ppm)	NH_3 (ppm)
	C/rm1	14.0 ±0	25.67 ±6.51	28.33 ±0.58	89.67 ±1.53	0±0	48.1 ±3.61	4.67 ±0.5	-1.33±1.1	0.10 ± 0	0.03±0.1	0±0
	C/rm2	13.00 ±5.36	26.67 ±9.07	27.0±0	92.33 ±5.51	0 ±0	55.1 ± 3.98	5.00 ± 0.0	-2.00 ± 0.00	0.03± 0.06	0 ± 0	0±0
	Office 2	6.00 ±0	15.00± 0	31.5 ±0.71	84.00 ± 0	0 ±0	45.05 ±3.32	5.50 ± 0.0	-1 ± 1.41	0.05 ± 0.07	0 ± 0	0±0
SURULERE	Veh1	18.5 ±16.27	41.00 ±39.5	30 ± 1.42	85.00 ±9.90	0 ±0	59.4± 8.70	6.00 ± 0.0	-1 ± 1.41	0.05 ± 0.07	0.10 ± 0	0±0
	Shop1	10.00± 1.42	20.5 ±2.12	28.5 ±0.71	66.00 ±4.24	0 ±0	52.05± 8.70	4.5 ± 0.71	0 ±0	0 ± 0	0 ± 0	0±0
	House1	7.00 ±4.24	15.00 ± 18.49	31.00± 1.42	80.50 ±4.96	0 ±0	66.5± 4.10	4.5 ± 0.71	-1 ± 1.41	0.05 ± 0.07	0 ± 0	0±0
	Mall 1	9.00± 1.42	17.5± 3.53	30.00 ±1.42	74.5 ±4.95	0 ±0	66.5± 4.10	5.5 ± 0.71	-1 ± 1.41	0.05 ± 0.07	0 ± 0	0±0
	Mean	10.94 ±5.91	22.44 ±13.47	29.00 ±1.78	84.39 ±10.08	0 ±0	53.44 ±7.47	5.07 ±0.69	-1.11±1.02	0.04 ± 0.05	0.02 ± 0.05	0±0

*Values are representative means of triplicates (± Standard Deviation)

Table 2: Pollutants level recorded in Ikeja

LOCATION		PARAMETERS (Pollutants)										
LGA	Point Locations	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)	Temp (°C)	Rel hum (%)	H_2S (ppm)	Noise (dBA)	CO (ppm)	VOC (ppm)	NO_2 (ppm)	SO_2 (ppm)	NH_3 (ppm)
IKEJA	C/rm1	14.00 ±2.0	17.67 ±3.06	28.67 ±1.16	80.33 ±1.53	0 ±0	58.13± 1.53	6.33 ±1.53	-1.33 ±1.15	0 ±0	0.07 ± 0.12	0 ±0
	C/rm2	5.0 ± 1.0	11.0 ±2.66	30.0 ±1.0	81.00 ±1.73	0 ±0	51.7 ±1.05	4.67± 1.15	3.33 ±2.89	0.07± 0.06	0.17 ±0.12	0 ±0
	Office1	24.0 ± 1.41	37.5 ± 0.71	31.0 ± 0	83.5 ±1.41	0 ±0	60.15 ±0.50	9 ±1.42	-1.00 ±1.42	0±0	0.05± 0.07	0 ±0
	Office2	19.0 ±1.41	37.5 ± 0.71	28.5 ±0.71	81.0 ±1.41	0 ±0	64.95 ±3.61	5.0 ±0	0 ±0	0 ±0	0 ±0	0 ±0
	Veh1	17.0± 7.07	40.5± 3.55	29.0± 2.83	85.5 ±7.78	0 ±0	68.05 ±8.84	6.00 ±1.41	-2.00 ±0	0.05 ±0.07	0.1 ±0.14	0 ±0
	Shop1	8.0 ±2.83	16.5 ±6.36	25.5 ±0.71	81.5 ±0.71	0 ±0	61.15 ±2.19	3.00 ±2.82	-2.00 ±0	0.1 ± 0	0.25 ±0.21	0 ±0
	House1	16.5± 2.12	39.5 ±0.71	27.5± 0.71	94.00 ±4.24	0.05 ±0.07	59.95 ±10.11	130.0 ±11.31	10.0 ±2.83	0.05 ±0.07	0.30 ±0.14	0 ±0
	Mall 1	14.5 ±0.71	30.0 ± 2.83	25.0± 0	91.5± 0.71	0 ±0	74.65 ±2.50	5.5 ± 0.71	-1.00 ±1.42	0 ±0	0.05 ±0.07	0 ±0
	Mean	14.16± 6.30	27.17 ±12.10	28.28± 2.14	84.33 ±5.47	0.01±0	61.51 ±7.81	19.44 ±40.40	0.78 ±4.1	0.03 ±0.05	0.12 ±0.14	0 ±0

*Values are representative means of triplicates (± Standard Deviation)

Table 3: Pollutants level recorded in Eti-Osa

LOCATION		PARAMETERS (Pollutants)										
LGA	Point Locations	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)	Temp (°C)	Rel hum (%)	H_2S (ppm)	Noise (dBA)	CO (ppm)	VOC (ppm)	NO_2 (ppm)	SO_2 (ppm)	NH_3 (ppm)
ETI-OSA	C/rm1	13±2	24.67 ±7.5	30.67± 2.3	81 ±5.3	0.03± 0.05	49.73± 2.5	5.33± 1.15	-0.67 ±1.15	0 ± 0	0.13 ±0.06	0 ±0
	C/rm2	5±1	10.67 ±3.2	26.3± 0.57	78.3 ±2.1	0 ±0	61.2± 1.4	5±0	0±0	0.03 ± 0.05	0.03 ±0.06	0 ±0
	Office1	5 ±0	11±0	30.5± 0.7	81.5 ±0.7	0 ±0	55.35± 2.6	6.5 ±0.7	0±0	0 ±0	0 ±0	0 ±0
	Office2	11± 1.41	19±2.82	28.5± 2.12	75 ±1.4	0 ±0	49.65 ±9.56	5.5 ±2.12	-1.0 ±1.4	0.1±0	0.05 ±0.07	0 ±0
	Veh1	28± 12.7	59 ±25.5	27.0± 0	99±0	0 ±0	78.9 ±0.8	7.5 ±2.12	1.5 ± 2.12	0.1±0	0.05 ±0.07	0 ±0
	Shop1	9.5± 6.37	20 ± 15.6	29± 0	86.6 ±3.5	0 ±0	54.7± 52.3	6.0 ±0	0 ±0	0.05 ±0.07	0.05 ±0.07	0 ±0
	House1	4.5± 0.71	9.0± 0	28.5	89.5± 0.7	0 ±0	52.3 ±13.7	5.5± 0.71	-1.0± 1.41	0±0	0.05 ±0.07	0 ±0
	Mall 1	5± 0	10.5 ±0.7	30.0 ±0	89 ±0	0 ±0	61.45 ±4.18	5.5± 0.71	-1.0± 1.41	0±0	0 ±0	0 ±0

*Values are representative means of triplicates (± Standard Deviation)

Table 4: Pollutants level recorded in Apapa

LOCATION		PARAMETERS (Pollutants)										
LGA	Point locations	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)	Temp (°C)	Rel hum (%)	H_2S (ppm)	Noise (dBA)	CO (ppm)	VOC (ppm)	NO_2 (ppm)	SO_2 (ppm)	NH_3 (ppm)
APAPA	C/rm1	4.3 ± 0.58	8.67 ± 1.15	28.0 ± 0	89 ± 1.0	0± 0	55.03 ± 12.4	7.0 ± 0	-2.0 ± 0	0± 0	0± 0	0± 0
	C/rm2	4.0 ± 0	8.67 ± 1.15	28.33 ± 0.58	88.0 ± 2.0	0± 0	52.6 ± 10.02	6.67 ± 0.57	-2.0 ± 0	0± 0	0± 0	0± 0
	Office1	5.5 ± 0.71	11.0 ± 2.83	29.0 ± 0	84.5 ± 2.13	0± 0	45.7 ± 0	6.0 ± 0	-2.0 ± 0	0.1± 0	0± 0	0± 0
	Office2	6.0 ± 0	14.0 ± 1.41	25.0 ± 2.83	75.5 ± 7.78	0± 0	61.55 ± 2.33	6.0 ± 1.41	0± 0	0± 0	0± 0	0± 0
	Veh1	11 ± 1.41	14 ± 4.95	30 ± 2.83	83 ± 2.83	0± 0	80.75 ± 1.48	2.5 ± 2.12	-1.0 ± 1.41	0± 0	0.15 ± 0.07	0± 0
	Shop1	6.0 ± 0	11.0 ± 0	28.0 ± 0	62.0 ± 1.41	0± 0	63.85 ± 12.66	6.5 ± 1.41	-1.0 ± 1.41	0± 0	0± 0	0± 0
	House1	5.0 ± 0	11.0 ± 0	31.0 ± 0	78.5 ± 3.54	0± 0	54.95 ± 1.77	6.5 ± 1.41	-2.0 ± 0	0± 0	0± 0	0± 0
	Mall 1	21 ± 8.48	44.5 ± 16.26	27.0 ± 0	68 ± 7.07	0± 0	68.95 ± 3.32	4.5 ± 1.41	0± 0	0± 0	0± 0	0± 0

*Values are representative means of triplicates (± Standard Deviation)

Table 5: Permissible limits/standard values for Indoor Air Quality from different organizations

Parameter	Standard value	Maximum exposure duration	Organization
$PM_{2.5}$	15µg/m^3	Annual	NAAQS/EPA (2007)
PM_{10}	20µg/m^3	Annual	WHO (2005)
Temperature	36°c	Daily	ASHRAE (1998)
Relative humidity	40-70%	Daily	OSHA (1997)
H_2S	0.1ppm	1hr	ERPG
Noise	48-52dBA	24hr	NAAQS
CO	11ppm	8hr	Canadian standard (2007)
VOC	0.05ppm	24hr	CDHS (2008)
NO_2	0.1ppm	1hr	WHO/Europe (2007)
SO_2	0.38ppm	5mins	Canadian standard (2007)
NH_3	0.28ppm	Daily	NTP (2003)

Table 6: Level of pollutants (PM2.5, PM10, RH, Noise, CO and VOC) that exceeded limits in all four study area

LGA	PARAMETERS (Pollutants)					
	$PM_{2.5}$ (µg/m^3)	PM_{10} (µg/m^3)	RH (%)	Noise (dBA)	CO (ppm)	VOC (ppm)
SURULERE	18.5	25.67,26.67,41.00,20.50, 22.44	89.67,92.33,84.00,85.00,80.50,74.50, 84.39	55.10,45.05,59.40,52.05,66.50,53.44	none	None
IKEJA	24.0,19.0,17.0,16.5	37.50,40.50, 39.50,30.00,27.17	80.33,81.00,83.50,81.00,85.50,81.50,94.00,91.50,84.33	58.13,60.15,64.95.68.05,61.15,59.95,74.65,61.51	130.00,19.44	3.33,10.0,0.78
ETI-OSA	28.00	24.67,	81.00,78.30,81.50,75.00,99.00,86.60,89.50,89.00	61.20,55.35,78.90,54.70,52.30,61.45	none	1.5
APAPA	21.00	44.5	89.00,88.00,84.50,75.50,83.00,62.00,78.50,68.00	55.03,52.60,61.55,80.75,63.85,54.95,68.95	none	None

Discussion

According to the regulatory limits in Table 5, it was observed that the most polluted area pertaining to this study is Ikeja as it had exceeded values for $PM_{2.5,}$ PM_{10} and an extreme value for CO in comparison with other LGAs as against the regulatory limits of 15µg/m^3, 20µg/m^3 and 11ppm respectively (WHO, 2005).

From the results presented in Table 1-4, measured levels of $PM_{2.5}$, PM_{10}, Relative Humidity, Noise level, CO, VOC, SO_2 in most sampled areas were above regulatory limits of 15µg/m^3, 20µg/m^3, 40-70%, 48-52dBA, 11ppm, 0.05ppm and 0.38ppm respectively except for NO_2, H_2S, Temperature, and NH_3 with limits of 0.1ppm, 0.1ppm, 36°c and 0.28ppm.

Eti-Osa had the highest level of suspended particulate matter (PM 2.5) of 37µg/m^3 (in a vehicle) which exceeded the regulatory limit of 15µg/m^3while the lowest value of 16µg/m^3 was obtained at Ikeja (in a classroom). PM_{10} varied between 21µg/m^3 as measured in Surulere-77µg/m^3 measured in Eti-Osa as against the permissible value of 20µg/m^3.

The temperature across all sampling points ranged between 27°C-31°C which was still within the acceptable limit of 36°C. The relative humidity (%) of the study area shows that the highest (99%) was measured in a commercial vehicle at Eti-Osa, while the least (71%) was in Surulere LGA which is still above the regulatory standard of 40-70%. High humidity/moisture can favor the growth of filamentous fungi (moulds) in indoor environment and promote fungal contamination. Sunil and Rakesh 2012 revealed the relationship between fungal contamination of indoor air and health problems of some residuals. Microbial pollution is a key element of indoor air pollution. It is caused by hundreds of species of bacteria and fungi, in particular filamentous fungi (mould), growing indoors when sufficient moisture is available. In indoor environments, the air and surface fungal contaminations are influenced not only by temperature, relative humidity and air flux but also by the weather conditions, hygiene standards and human activity (Ayanbimpe *et al.,* 2012). Measured levels of H_2S gas was zero across all sampling locations except for a value of 0.1ppm noted in a house in Ikeja and another 0.1ppm in a classroom in Eti-Osa LGA which were both in conformation with the regulatory limit of 0.1ppm.

The noise level measured in this study ranged between 41.8dBA-81.8dBA with the highest recorded in a noisy commercial bus at Apapa and the least also recorded at Apapa; in a classroom. The NAAQS acceptable standard of indoor noise level of 48-52dBA was exceeded in most of the sampling locations in this study which can be linked to a study carried out by Abam and Unachukwu, 2009 who established that the vehicular noise level in major cities in Nigeria is quite upsetting and disturbing. The levels of CO exceeded regulatory limits of 11ppm on an 8 hour average but the highest and most delicate value for CO (130ppm) was observed in a residential apartment in Ikeja central; this may have resulted from the use of generator sets very close to the ventilation systems of this living apartment which could be fatal because moderate exposure to CO to occupants can aggravate cardiac ailments such as the brain and the heart (Yusuf *et al.,* 2013b). Although, the levels of CO in this study are higher than the regulatory limits, much higher levels of CO have been recorded in Kenyan Masai homes (Akpofure, 2015). Carbon monoxide binds to haemoglobin in red blood cells, reducing its ability to transport and release oxygen throughout the body. CO also plays a role in the generation of ground-level ozone; it contributes to the formation of CO_2, Ozone (O_3) and greenhouse gases that warms the atmosphere (USEPA, 2007). Koku and Osuntogun, 2007 obtained high results of CO in heavy traffic points in Ibadan and Ado Ekiti; this was similar to reports from Olajire *et al.,* 2011 in a study of air pollutants in Ikeja (one of the same sampling locations in this study; and the capital of Lagos state). This axis was likewise seen to have the highest level of VOC (12.0ppm) followed by Surulere in comparison with other Local Government Areas of study.

Measured levels of NO_2, SO_2 and NH_3 in all sampled indoor locations were considered good and healthy as the values were below regulatory limits of 0.1ppm, 0.38ppm, 0.28ppm respectively across all sampling locations, except for notable values of SO_2 at 0.4 and 0.6ppm, which were above the Canadian Standards at 0.38ppm.

It can be deduced from the study that the quality of indoor air in most locations related to this study is unhealthy; especially the very alarming value of CO measured at 122 and 138ppm at a residential apartment in Ikeja LGA; this can be attributable to the fact that Ikeja is quite populated, being the capital of Lagos state and also due to its high industrial activities.

Conclusion

The results suggest that it is essential to disseminate information on air quality, proper ventilation system, environment-friendly lifestyle and activities to the public; this serves to inform, educate and raise awareness of important environmental and health issues because an informed and aware public can also contribute and assist in a meaningful way to improving the environment. This research provides a pertinent supply of information to indoor air quality studies and will be helpful in policy and decision making.

Recommendation

Public communication and education schemes are therefore recommended. Also, there is need to develop clean and renewable energy and air monitoring stations by regulatory bodies.

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