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ASSESSMENT OF AIR QUALITY INDICES AND ITS HEALTH IMPACTS IN ILORIN METROPOLIS, KWARA STATE, NIGERIA.

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Abstract: In most of the African studies, PM concentrations exceed WHO limits. In this study, assessment of air quality indices and its health impacts in Ilorin metropolis, Kwara State, Nigeria was assessed. Interestingly, what's more, the ambient air quality measurement was done with respect to Particulate Matter ($PM_{2.5}$ and PM_{10}), Volatile Organic Compound (VOC), Combustible (LEL), Formaldehyde, Temperature, Relative Humidity and Oxygen (O_2)in Temidire Irewolede community at twenty-four (24) locations for eight weeks. The air pollution measurements were carried out using direct reading, automatic in-situ gas monitors; Hand held mobile multi-gas monitor with model AS8900 (Combustible (LEL), and Oxygen (O_2)), BLATN with model BR – Smart Series air quality monitor (PM_{10}, Formaldehyde) and air quality multimeter with model B SIDE EET100 (Dust ($PM_{2.5}$), VOC, Temperature and Relative Humidity). The results showed the mean concentrations of $PM_{2.5}$(64.9), PM_{10}(43.2), Combustible (LEL) (5.4) and Formaldehyde (0.3) are generally lower and within acceptable range of National and International regulatory standards for air quality indices. There are however, few exceptions such as mean concentrations of VOC, Oxygen and Formaldehyde respectively high compared to National and International standards. These high values were attributed to the amount of pollutants present in the air because of anthropogenic activities from the industries. Hence, air pollution in Ilorin Metropolis were however found to be relatively polluted. It can therefore be concluded that drastic efforts must be made to reduce air pollution levels. Comprehensive air quality monitoring and adequate measures should be implemented. There is also a need for the continuous monitoring and auditing of $PM_{2.5}$ and PM_{10} in the community to safeguard the health of the public and the environment.

Keywords: Air quality index, Health Impact, Particulate Matter ($PM_{2.5}$ and PM_{10}), Combustible (LEL) and Formaldehyde.

Introduction

Air pollution represents a thoroughly social problem, global issues, threat multiplier as too its resolution and the nature of air pollution is changing **(**Smith and Ezzati, 2005).Air pollution is one of the great killers of our age. Polluted air was responsible in 2015 for 6.4 million deaths worldwide: 2.8 million from household air pollution and 4.2 million from ambient air pollution **(**Prüss-Üstun*et al.,* 2016). In the same year, tobacco caused 7 million deaths, AIDS 1.2 million, tuberculosis 1.1 million, and malaria0.7 million **(**Frumkin*et al.,* 2004). In the absence of aggressive control, ambient air pollution is projected by 2060 to cause between 6 million and 9 million deaths per year**(**Organisation for Economic Co-operation and Development, 2016). Non-communicable diseases account for 70% of air pollution deaths, and air pollution is a major, insufficiently appreciated cause of non-communicable disease **(**Prüss-Üstun*et al.,* 2016). Air pollution was responsible in 2015 for 19%of all cardiovascular deaths worldwide, 24% of ischemic heart disease deaths, 21% of stroke deaths, and 23% of lung cancer deaths. **(**Frumkin*et al.,* 2004) Additionally, ambient air pollution appears to be an important although not yet quantified risk factor for neurodevelopment disorders in children **(**Grandjean and Landrigan, 2014).and neurodegenerative diseases in adults(Kioumourtzoglou*et al*., 2015).To evaluate the impacts of air pollution in developing countries especially Nigeria, thisaims at assessing ambient air quality of Temidire Irewolede Community of Ilorin Metropolis, Kwara State, Nigeria by determine air quality index for all the various parameters, examine the relationship between the air quality parameters**,** compare the air quality with the international and national standards and make the necessary recommendations to the residents of Temidire Irewolede Community and the general public.

MATERIALS AND METHODS

Ilorin, the state capital of Kwara State is located on latitude 8º30’ and 8º50’N and longitude 4º20’ and 4º35’E of the equator (Figure 3.1), with a population of over one million people (NPC, 2006).Ilorin city occupies an area of about 468sqkm and it is situated in the transitional zone within the forest and the guinea savannah regions of Nigeria. It is about 300 kilometres away from Lagos and 500 kilometres away from Abuja the Federal Capital of Nigeria. Its elevation ranges from 250 to 400m above sea level. It is also the headquarters of the Ilorin West Local Government Area (LGA) which is surrounded by other LGAs of the state. This gives her roles as the commercial and administrative capital of the State, the headquarters of Ilorin West LGA, and together with Ilorin East, Ilorin South, Asa and Moro LGAs they constitute the Ilorin Emirate.

Ilorin has diverse ethnic groups of mainly Yoruba, Fulani, Hausa, Kambari, Gobir, and Nupe, that constituted it. The multi-linguistic and multi-cultural nature of the people could be traced to their historical background. Ilorin is said to be founded as hamlets in 17th century by an itinerant farmer called Ojo from Gambe near Oyo-Ile. The hitherto existing hamlets were in 1830s consolidated under the sovereignty of Fulani hegemony by Abdul-Salam, the son of Sheikh Alimi. The total population of Ilorin West LGA is 365,221 in 2006. This is comprised of 180,387 males and 184,834 females; being the most populous LGA in Kwara State that has 3.0% as its growth rate (NPC, 2006).

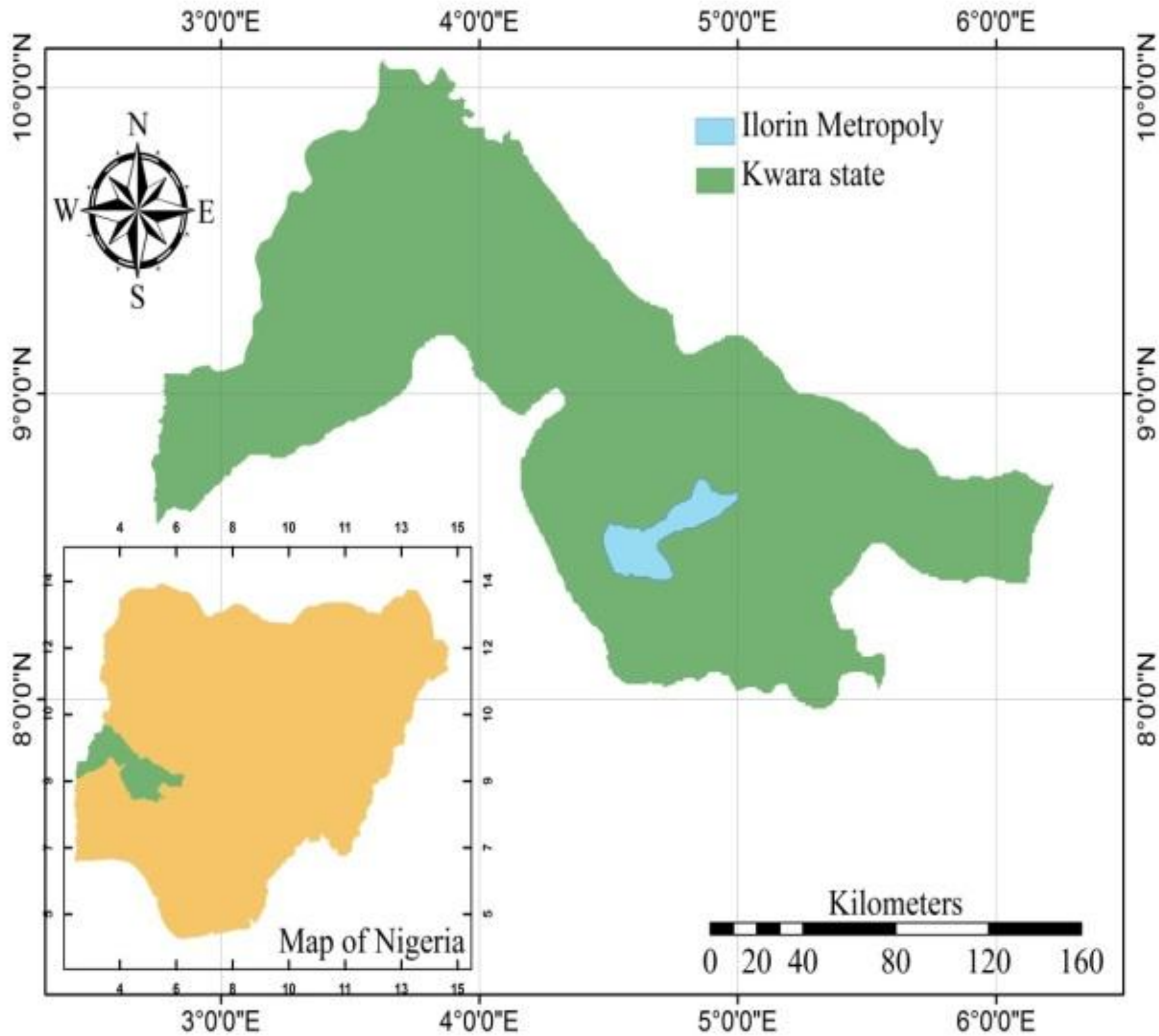

Figure 3.1: Map of Kwara State Showing the Study Area

Sample Collection

Sample collections were limited to air quality. Air quality sources were randomly selected within the vicinity of the study area, but at different distances from each other. Also, the samples were collected at different locations. The monitoring exercises were taken in the daytime, between 9.00am and 6.00pm. Night samples were not collected. Sampling was carried out between 1st April 2018 through 31st of May 2018 within Temidere Irewolede community each day for a period of eight (8) weeks on an alternate day.

Equipment Employed

Hand held mobile multi-gas monitor with model AS8900 (Carbon Monoxide (CO), Hydrogen Sulphide (H_2S),Combustible (LEL), and Oxygen (O_2)), BLATN with model BR – Smart Series air quality monitor (PM_{10}, Formaldehyde) and air quality multimeter with model B SIDE EET100 (Dust ($PM_{2.5}$), VOC, Temperature and Relative Humidity) equipment were used to detect the presence and precise quantity of the following individual gases viz: Carbon Monoxide (CO), Particulate Matter ($PM_{2.5}$ and PM_{10}), Hydrogen Sulphide (H_2S), Volatile Organic Compound (VOC), Combustible (LEL), and Oxygen (O_2).

Global Positioning System (GPS)

Spatial positioning of different locations in TIC was collected using a hand held Global Positioning System. The GPS was helpful in obtaining the selected areas in the community and data obtained was used to produce a digital map through the Arc view GIS software.

Statistical Analysis

Data analysis and computations of results were done using the Statistical Package for Social Sciences (SPSS version 22.0). Mean, standard deviation and coefficient of variation were computed for each of the parameter. Pearson correlation was used to establish relationship among the parameters. Levels of these parameters relative to their respective FMEV and WHO standards were compared for statistical significance using one sample t-test. Statistical significance was established at 0.05 level of significance with $p<0.05$ signifying statistical significance.

RESULTS AND DISCUSSION

Results

Table 4.1: Air Quality Index (AQI) for the study area.

Parameters	**FMEV**		**WHO**	
	Mean	Remarks	Mean	Remarks
Oxygen	97.65	Moderate	86.84	Moderate
VOC (ppm)	240.80	Very unhealthy	240.80	Very unhealthy
$PM_{2.5}$(ug/m^3)	56.15	Moderate	43.05	Good
PM_{10}(ug/m^3)	28.81	Good	17.29	Good
LEL (%)	107.23	Unhealthy for sensitive group	1.028	Good
Formaldehyde (mg/m^3)	2570.65	Hazardous	34.59	Good

Table 4.1 shows the Air Quality Index (AQI) in the study area. Based on Federal Ministry of Environment standard, the level of Oxygen was moderate while in terms of VOC, $PM_{2.5}$, PM_{10}, LEL and Formaldehyde it was very unhealthy, moderate, good, unhealthy for sensitive group and hazardous respectively. For WHO classification, $PM_{2.5}$, PM_{10}, LEL and Formaldehyde were good while VOC, Oxygen levels were very unhealthy and moderate respectively.

Table 4.2: Correlation matrix for the air quality indices

Parameters	1	2	3	4	5	6
1. Oxygen	1					
2. VOC (ppm)	-0.021 (0.890)	1				
3. $PM_{2.5}$(ug/m^3)	0.142 (0.342)	-0.066 (0.659)	1			
4. PM_{10}(ug/m^3)	0.102 (0.499)	-0.158 (0.295)	0.374* (0.010)	1		
5. LEL (%)	0.063 (0.677)	0.4960** (<0.0001)	0.1260 (0.4030)	0.043 (0.776)	1	
6.Formaldehyde (mg/m^3)	-0.605** (<0.0001)	0.5110** (<0.0001)	-0.1690 (0.2560)	-0.0380 (0.801)	0.372 (0.110)	1
7.Temperature^{o}C	-0.008 (0.959)	0.1330 (0.3740)	-0.308* (0.035)	-0.199 (0.184)	-0.434** (0.003)	-0.024 (0.874
8. Relative humidity (%)	-0.223 (0.132)	-0.1220 (0.4160)	0.2560 (0.082)	0.190 (0.2070)	0.4180** (0.004)	0.088 (0.558

*significant at 5% ($p<0.05$), **significant at 1% ($p<0.01$).

nship between the parameters. Result shows significant negative relationship between the level of Oxygen and Formaldehyde (r =-0.605, p<0.0001), $PM_{2.5}$ and temperature (r = -0.434, p =0.003), relative humidity and temperature (r=-0.756, p<0.0001). Result also reveals significant positive relationship between the level of VOC and combustible(LEL) (r=0.4960, p<0.0001), $PM_{2.5}$ and PM_{10} (r =0.374, p =0.010), relative humidity and LEL

Table 4.3: Comparison in Oxygen, VOC, $PM_{2.5}$, PM_{10},LEL,Formaldehyde, temperature and relative humidity levels with that of FMEV and WHO standards

Parameters	Range	Mean	SD	FMEV	WHO	p-value for FMEV	p-value for WHO
Oxygen	9.66-21.10	20.41	1.85	20.9	> 23.5	0.075	<0.0001**
VOC (ppm)	0.00-9.50	1.20	2.11	0.500	0.500	0.027*	0.027*
$PM_{2.5}$(ug/m^3)	54.00-108.00	64.58	15.25	115	150-230	<0.0001**	<0.0001**
PM_{10}(ug/m^3)	5.00-89.00	43.22	22.24	150	250	<0.0001**	<0.0001**
LEL (%)	0.00-50.00	5.36	9.77	5	15.5	0.801	<0.0001**
Formaldehyde (mg/m^3)	0.01-3.00	0.31	0.66	0.012	30	0.004**	<0.0001**
Temperature^{o}C	33.30-41.80	37.64	2.13	-	-	-	-
Relative humidity (%)	42.40-64.00	52.50	5.87	-	-	-	-

- Not applicable, *significant at 5% (p<0.05), **significant at 1% (p<0.01).

Result in Table 4.3 reveals that the level of Oxygen obtained in the study area was not significantly different from that of FMEV standard (p=0.075, p>0.05) but significantly above that of WHO standard (p<0.0001). The result also shows that the level of LEL was significantly less than that of WHO acceptable value (p<0.0001) but not significantly difference from that of FMEV standard (p=0.801, p>0.05). The level of VOC was significantly above that of FMEV standard (p=0.027) and that of WHO standard (p=0.027) while both $PM_{2.5}$ and PM_{10} were both significantly lower than their respective FMEV and WHO standards (p<0.0001). The mean level of Formaldehyde was found to be significantly higher than FMEV standard (p=0.004) but significantly lower than WHO standard (p <0.0001).

Discussion

The Air Quality Index (AQI) was calculated for all sampling locations using the daily average concentration of the measured parameters. Local air quality affects how we live and breathe. Like the weather, it can change from day to day or even hour to hour. The AQI is an index for reporting daily air quality. It tells us how clean or polluted the air is, and corresponding health effects. Our results show the Air Quality Index (AQI) in the study area. Based on Federal Ministry of Environment standard, the level of VOC, LEL and Formaldehyde can be described as unhealthy and hazardous for sensitive group such as children, women and elderly and people with respiratory diseases such as asthma. This implies high value of the index represents a highest value of environmental pollution, and, of course a highest health risk. It was observed that VOC, LEL and Formaldehyde may have posed serious health risks to individuals who spent long hours at these locations. Sensitive groups such as asthmatics, children and the elderly, people with heart or lung diseases were at highest risk. For WHO classification, VOC levels were very unhealthy. Sensitive people should consider limiting their stay outside especially during production time of the industry.

VOCs are important outdoor air pollutants are often divided into separate categories of methane (CH_4) and no methane (NMVOCs). Methane is an extremely efficient greenhouse gas which contributes to enhance global warming. Other hydrocarbon VOCs are also significant greenhouse gases via their role in creating ozone and in prolonging the life of methane in the atmosphere, although the effect varies depending on local air quality. Within the NMVOCs, the aromatic compounds benzene, toluene and xylene are suspected carcinogens and may lead to leukaemia through prolonged exposure. 1, 3-butadiene is another dangerous compound which is often associated with industrial uses.

Bivariate relationship between Air Quality Parameters

The result of the Pearson's correlation coefficient of air quality parameter as shown in tables 2 revealed no general pattern of relationship between the variables in the sample.There exists significantly strong positive correlation between PM_{10}concentration and $PM_{2.5}$concentration (0.010)between combustible (LEL) concentration and volatile organic compound (VOC) concentration ($p<0.01$)between the concentration of Formaldehyde and volatile organic compound (VOC) concentration ($p<0.01$)between Relative humidity concentration and combustible (LEL) concentration($p<0.05$) respectively. This result implies that as PM_{10} in the air increases, the $PM_{2.5}$ increases significantly, As LEL increases volatile organic compound (VOC) increases significantly. This may be because of pollutants reaction or interplay in the planetary boundaries. However, there were significantly negative correlation between Formaldehyde concentration and oxygen concentration ($p<0.01$), and between temperature concentration and $PM_{2.5}$ concentration ($p<0.05$). this implies that, as formaldehyde increases, volatile organic compound (VOC) increases significantly while oxygen decreases significantly. This may be attributed to the toxic nature of these pollutants. The result of bivariate relationship also reveals that significantly negative correlation between temperature concentration and combustible (LEL) concentration ($p<0.01$) between relative humidity concentrations and temperature ($p<0.01$).Implying that as temperature increases $PM_{2.5}$ and combustible (LEL) decreases significantly. Also, as relative humidity increases combustible (LEL) increases significantly, however, for temperature, the reverse was the case such that as the relative humidity increases, temperature decreases significantly.

Comparison of Air Quality with the International and National Standards

The analysis of oxygen obtained in the study area was not significantly different from that of FMEV standard but significantly above that of WHO standard. The result also shows that the level of LEL was significantly less than that of WHO acceptable value but not significantly different from that of FMEV standard. The level of VOC was significantly above that of FMEV standard and that of WHO standard. This could be because of a wide range of finely divided solids that may be dispersed into air from combustion process, industrial activities or natural sources This could also be attributed to urban sources as well as planned burns and it could be referenced against known events (Raimi, 2008).These VOCs react with primary anthropogenic pollutants-specifically, NOx, SO_2 and anthropogenic organic carbon compounds-to produce haze of secondary pollutants (Janice, 2002). The mean concentration of VOC in the air is 1.20. This could be attributed to soot and smoke from the stacks of the Olak Roofing Nigeria Limited industry and therefore poses a problem to the health of the people in the area and also to environmental sustainability. This finding agrees with highly significant values recorded by Tawari and Abowei (2012) in their studies. The actual health damage caused by dust particles depends upon its nature and composition (Binder *et al.,* 1976). According to the Health Care Institute of India, there is an alarming rise in number of patients in Delhi hospitals with respiratory problems (Indian Express, 1996).

Also, the mean $PM_{2.5}$ and PM_{10} concentrations in the studied samples were 64.58 and 43.22 respectively.$PM_{2.5}$ and PM_{10} were both significantly lower than their respective FMEV and WHO standards, thus the air has met the “low health category” and posing no threat to the health and environment. This means that the levels of $PM_{2.5}$ and PM_{10}particles in the air can be considered healthy for the resident of the communities and everyone. Although it should be closely monitored because the present concentration could be due to anthropogenic activities of Olak Roofing Nigeria Limited industry

Present in the study area. The concentration of $PM_{2.5}$ and PM_{10} measured may seem insignificant, cumulative effect might be harmful to health. Interestingly, sources of particulate matter can be manmade or natural. Some particulates occur naturally, originating from volcanoes, dust storms, forest and grassland fires, living vegetation and sea spray. Human activities, such as the burning of fossil fuels in vehicles, power plants and various industrial processes also generate significant amounts of aerosols. Averaged over the globe, anthropogenic aerosols those made by human activities-currently account for about 10% of the total amount of aerosols in our atmosphere. Increased levels of fine particles in the air are linked to health hazards such as heart disease (Molles, 2005) altered lung function and lung cancer. Persistent free radicals connected to airborne fine particles could cause cardiopulmonary disease (Bronwen, 1999).

Conclusion

It can be concluded that the mean concentrations of $PM_{2.5}$, PM_{10} and other assessed parameters such as Combustible (LEL) and Formaldehyde etc are generally lower and within acceptable range of National and International regulatory standards for air quality indices. There are however, few exceptions such as mean concentrations of volatile organic compounds, oxygen and formaldehyde respectively high compared to National and International standards. This high value was attributed to the amount of pollutant present in the air because of input of influents from the industries. Hence, air pollution in Ilorin metropolis were however found to be relatively polluted. It can therefore be concluded that drastic efforts must be made to reduce air pollution levels. Reducing air pollution saves and improves the quality of lives. It can help to reduce the incidence of acute and chronic respiratory infections such as pneumonia and asthma among children. Reducing air pollution would reduce complications during pregnancy and childbirth for the resident of the communities, as well as improve community development, helping them to live longer and more productive lives, and benefit sustainable development and climate change mitigation.

Recommendation

Generally, this research could serve as a vital tool to assist in monitoring concentration of pollutants viz a viz environmental pollution. To improve on the current air quality monitoring and assessment programmes in Ilorin metropolis there is need to embark on the following:

i. Olak Roofing Nigeria Limited industry should be mandated to extend the height of their stack, to be tall enough to reduce the particulate concentration by dispersing smoke over a relatively broad area.
ii. State and local government should actively disseminate health warning so that communities can better protect themselves from air pollution.
iii. Raise awareness of the harm pollutants cause communities including children, pregnant women and the elderly.
iv. Limit exposure of vulnerable people to air pollution when levels are high around the community.
v. Develop monitoring mechanisms, regulations and enforcement measures.
vi. Institute planning policies to minimize pollution that may be caused by future development. Government agencies such as the Kwara State Ministry of Environment should collaborate with other multinationals and stakeholders in air pollution management to come up with a comprehensive AQM scheme for the region.
vii. There should be a focus on the reduction of pollution levels from industry to permissible levels as defined in national and international standards.
viii. There is a need to engage in renewable energy, clean energy and cleaner air initiatives.
ix. Usage of emissions abatement control mechanisms by polluters should be enforced.

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