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RISK ASSESSMENT OF TOXICITY POTENTIAL FOR CRITERIA AMBIENT AIR POLLUTANTS IN SELECTED AREAS OF LAGOS STATE, NIGERIA

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Abstract

The quality of ambient air is determined by the extent of pollution of the environment. The United States Environmental Protection Agency identifies six pollutants namely particulate matter, ground level ozone, carbon monoxide, sulphur oxides, nitrogen oxides and lead exposure as toxic and injurious because of their potentials to cause or trigger various human health problems. This study examines the toxicity potential of criteria ambient air pollutants in selected areas of Lagos State, Nigeria. The data for the study include five-year data of criteria pollutants for selected areas of Lagos and World Health Organization (WHO) guideline values of criteria pollutants. Data analysis adopted the use of Toxicity Potential Model for the calculation of the toxicity potential of the criteria pollutants. GIS procedure was employed to produce a map showing the spatial pattern and hotspot areas of criteria pollutants. Criteria pollutants in the study area were also compared with the WHO standards with a view to determining areas of excessive pollution and toxicity potential in the area. The study reveals that $PM_{2.5}$, $PM_{10,}$ SO_2 and NO_2 in Lagos areas clearly exceeded the benchmark set by WHO. Furthermore, CO and O_3 are well below the WHO standards. The toxicity potential values for $PM_{2.5}$, $PM_{10,}$ SO_2 and NO_2 in the area of study are greater than unity while the values for CO and O_3 are lesser than unity which indicates that such concentration has a tendency of causing harm to people and hence should be avoided. The study recommends that governments, and other stakeholders in health should harmonize efforts, resources and ideas towards effective planning, monitoring, and provision of facilities that could control and ameliorate the presence of these pollutants to which urban residents are exposed thereby reducing the health effects from such exposures.

Keywords: Ambient air, Pollution, Health, Toxicity, Criteria pollutants

Introduction

The quality of ambient air is determined by the extent of pollution of the environment. Pollution on the whole is caused principally by human activities, though it can also be a natural process (Dara, 2004). The United States Environmental Protection Agency (USEPA, 2012) classified air pollutants into two groups: criteria and hazardous air pollutants. The criteria pollutants are those that can have adverse effect on health and the environment. They include particulate matter, oxides of nitrogen, oxides of sulphur, carbon (II) Oxide and lead. Criteria pollutants are toxic and injurious to health. Apart from their natural presence in air, they can be introduced into the air by various types of anthropogenic activities such as incomplete combustion from engines, bush-burning, electricity generating plants, decaying of accumulated organic and domestic wastes, and other industrial processes (Raheem and Amole, 2015).

Air quality can be a critical reflection of the ambient atmospheric pollution, relative to the potential to inflict harm on the environments (WHO, 2002). Air is said to be polluted when there is 'the presence in the outdoor atmosphere of one or more contaminants such as dust, fumes, gas, mist, odour, smoke, or vapour in such a characteristics and duration as to make them actually or potentially injurious to human, plant or animal life, or property or which interferes with the comfortable enjoyment of life and property' (World Bank, 1978). Human health is threatened with diseases and early mortality particularly in emerging economies facing rapid industrialization and urbanization like Lagos. Epidemiological studies of occupational diseases on the working population had shown negative effects of the environment on people working in a contaminated environment over a lifetime of employment (The MACBETH project 1999, and Samoli, E. 2003). According to WHO (2014), by reducing air pollution levels, countries can reduce the burden of disease from stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma. Moreover, reduction in outdoor air pollution also reduces emissions of CO_2 and short-lived climate pollutants such as black carbon particles and methane, thus contributing to the near and long-term mitigation of climate change (WHO, 2014).

Air quality has a strong link to human health and wellbeing as shown in many studies (Zhu *et al*. 2002, Parakash, *et al*. 2006). The rapid expansion, population increase and transformation of the Lagos city, one of the most industrialized cities in the world have contributed to its present polluted states. Akinola *et al*. (2014) posited that the increasing human activities, especially industrial and vehicular emissions are posing great environmental challenges that have resulted in loss of life and destruction of properties in the state. The overall effects of air pollution on Lagos residents and environments contribute to drag in the efforts for its most sustainable programs (Akinola *et al.* 2014).

Statement of the problem

According to Brunekreef (2005), ambient particulate matter levels in cities of developing countries including Nigeria are generally much higher than in developed countries because of dispersed heating with small-scale solid fuel use, uncontrolled industrial emissions, and the large numbers of non-catalyst two-stroke engine vehicles. Ediagbonya *et al*. (2012) posited that atmospheric environmental problems, had previously received scanty attention in Nigeria but have become a subject of increasing importance. Air pollution is a major threat to human life and most people inhale pollutants while at home or commuting to work irrespective of the mode of transportation (Ekpenyong *et al*. 2012). Depending on the dose and the exposure time, these pollutant gases have the potential to cause far reaching adverse health effects in man, but principally affect the respiratory and cardiovascular systems.

The World Health Organization (2002), argued that about 2.4 million people worldwide (including about 93,700 Nigerians) die each year from causes directly attributable to air pollution. Akinola *et al*. (2014) posited that studies have shown that in Lagos state Vehicular Emissions are the highest point source contributors of carbon dioxide (CO_2) into the environment, followed by the manufacturing industries. Unending traffic jams in Lagos metropolis results in commuters spending several unproductive hours in traffic and increased avoidable emissions of CO_2 and other pollutants. A study conducted by the Lagos Metropolitan Transport Management Authority (LAMATA) on air quality between 2003 and 2007 indicated that vehicular emission contribute approximately 43% ambient air pollution in Lagos. The continuous expansion, population increase and transformation of the Lagos city have contributed to its present polluted states. However, assessment of the effect of air pollution in developing countries is difficult because of a lack of cohesive air quality policies in combination with poor environmental monitoring and a paucity of disease surveillance data (Briggs, 2003). Therefore, this study becomes imperative in examining the hotspot areas and toxicity potential for criteria ambient air pollutants in selected area of Lagos State.

Study Area

Lagos State is located between latitudes 6º.35N to 6.58ºN and longitudes 3º.45'E to 3.75ºE of the Greenwich meridian in the south western part of Nigeria. The state has a tropical wet and dry climate with an all year-round precipitation in many parts of the state. Wet season is characterised by a double maximum of rainfall usually from March to July and the other in late August to early September. A dry spell may occur from late September to early November. The annual mean rainfall is between 1381.7mm and 2733.4mm in recent time from one location to another. The maximum temperature ranges between 29°C - 34°C, the lowest being in the month of July and the highest in February and a minimum temperature varies between 24°C -28°C. The relative humidity varies seasonally with an average of 70% throughout the year.

The vegetation of the study area is made up of two types namely; swamp forest of the coastal belt and dry lowland rain forest. The swamp forest is a combination of mangrove forest and coastal vegetation developed under the brackish conditions of the coastal areas, swamp fresh water lagoons and estuaries. Lying to the north of the swamp forest is the lowland (tropical) rain forest zone and stretches from Ikeja through Ikorodu. The economic valuable trees such as teak, tripochiton, seletrocylon (arere), banclea diderrichil (opepe) and terminahia (idigbo) can be to be found in some parts of the study area. Lagos State occupies an area of 3,577 square kilometres, which represents 0.4% of Nigeria landmass with a marine shoreline of about 180km extending inland to a maximum distance of about 32km. Lagos is the most populous city in Nigeria, the second fastest-growing city in Africa and the seventh in the world (www.lagosstate.gov.ng). The NPC (2016) estimates of the population of Lagos state was 21 million, making Lagos the largest city in Africa.

The study area accounts for over 60% of the federation's total industrial investment and the largest concentrations of industries can be found in Ikeja, Alimosho and Kosofe local government areas (www.lagosstate.gov.ng). Other specific locations of numerous industries include Apapa, Surulere, Shomolu, Mushin, Oshodi-Isolo, Agege, Amuwo Odofin, and Ikorodu among others. See fig. 1 for the map of the study area.

Aim and objectives

The aim of the study is to identify the hotspot areas and toxicity potential for criteria ambient air pollutants in selected area of Lagos State. To achieve this aim, the specific objectives are to: compare criteria pollutants in Lagos area with the WHO standard for the pollutants and identify hotspot areas and toxicity potential for criteria pollutants based on deviations from the WHO benchmark.

Materials and Methods

Data required and sources

The US Environmental Protection Agency (USEPA, 2012) identifies six common air pollutants also known as criteria pollutants. This are particulate matter ($PM_{2.5}$, PM_{10}), ground level ozone, carbon monoxide, sulphur oxides, nitrogen oxides and lead. These pollutants are critical because of their implications for human health and the environment. Out of the six, particulate matter and ozone are the most widespread health threats because of their association with Asthma, Chronic Obstructive Pulmonary Disease (COPD) and respiratory diseases as prominent air pollution related diseases (WHO, 2014).

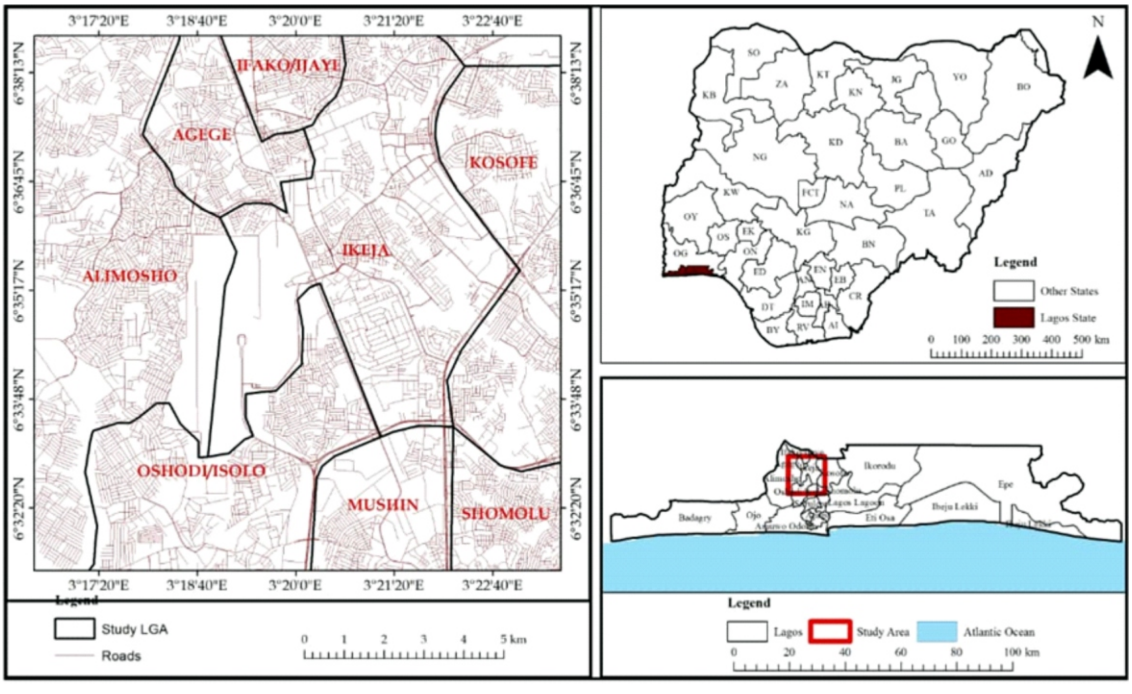

Figure 1. Lagos State showing sample areas with Nigeria as inset

Based on the foregoing the data required and sources of data for this study are both primary and secondary. The primary sources includes the coordinates of the sample sites. The secondary data includes five (5) years data of criteria pollutants, the pollutants are Particulate matter ($PM_{2.5}$, PM_{10}), Ground level (O_3) Nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and carbon dioxide (CO), WHO Guidelines for $PM_{2.5}$, PM_{10}, SO_2, NO_2, CO and Ground level O_3, maps, and statistical data obtained from WHO published works.

Table 1: Showing Study Sites Distribution within the Study Area.

LANDUSE TYPE	LOCATIONS/SITES
RESIDENTIAL	Agege Housing Estate; Oko-oba
	Ikeja G.R.A: SoboArobiodu street.
	Magodo Estate: CMD Road, Shangisha
	Ogba Staff Quarters; Ogba
	Secretariat; Alausa: front of Skye bank
HIGH TRAFFIC	Maryland Junction, Ikeja
	General Hospital: Frontage of LASUTH
	Ojodu-Berger: Berger Roundabout
	Iyana-Ipaja: Under Bridge
	Oshodi B/Stop: Oshodi
INDUSTRIAL	Specomil: Inside Ikeja Industrial Estate
	Wemabod: Adjacent Guinness Nigeria PLC office
	Wempco: Industrial Estate Ogba
	Ize-Iyamu
	Matori

Source: Author's Fieldwork, 2016

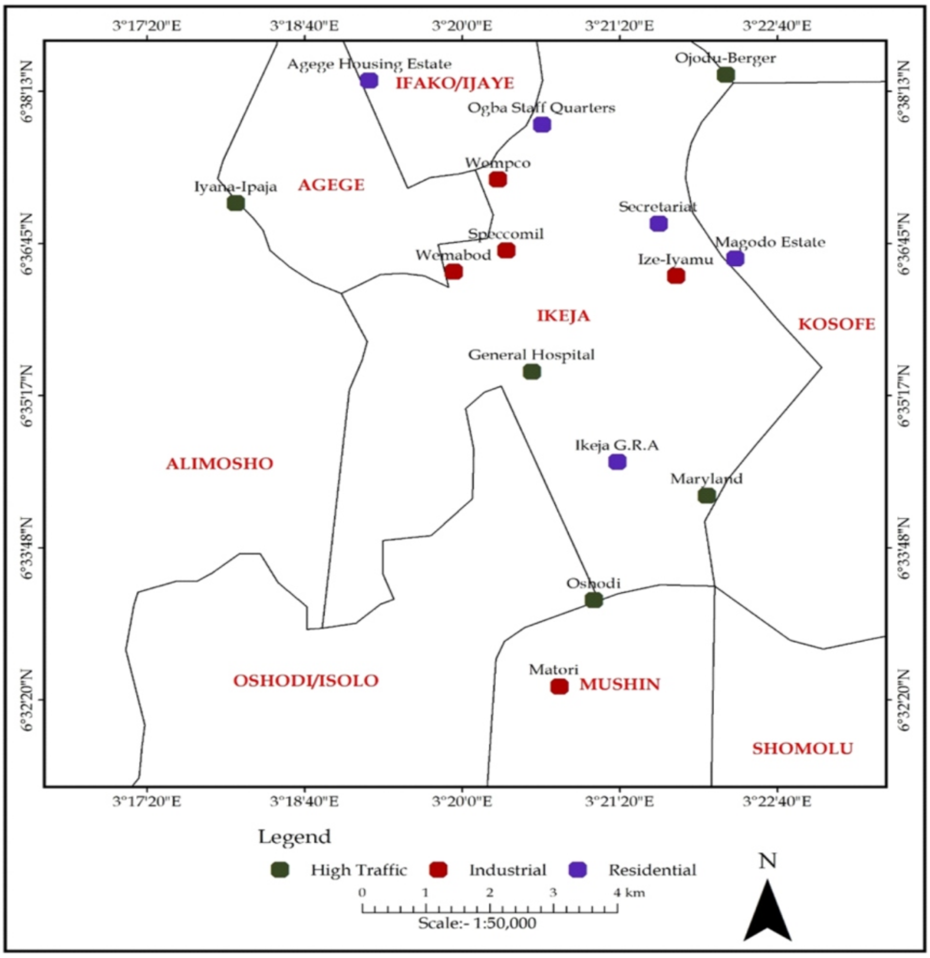

Figure 2: Sampling Sites in the Study Area
Source: Author's Fieldwork, 2016

Methods of Data Collection

Study sites were selected with a view to giving a holistic representation of air quality status of the study area. The study area was categorised into three (3) base on the predominant landuse types. Thus, Lagos was divided into high traffic, industrial and residential areas. Residential areas were defined as landuse types in which housing predominates. In the light of the above, State Government staff quarters and Estates owned by private agencies were considered. The high traffic areas are the major road intersections where high volumes of traffic are experienced during the working hours of the day while areas with high concentration of industries were considered as industrial areas. It must be noted that this categorisation is not water tight as these characteristics may occur in all areas with varying intensities (Laro, 2016)

Geographic coordinates: Direct measurement of coordinates of fifteen (15) sample sites from the field with the aid of the global positioning system (GPS).

Data on Criteria pollutants: The data on criteria pollutants was obtained from Ministry of Environment, Lagos State. The data are particulate matter ($PM_{2.5}$ and PM_{10}), Ground level Ozone (O_3), Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2) and Carbon monoxide (CO).

Guideline value for criteria pollutants: The data was sourced from the WHO air quality guideline book. The data are annual, daily and 8 hours mean of $PM_{2.5}$, PM_{10}, SO_2, NO_2, CO and ground level (O_3).

Methods of Data Analysis

Descriptive statistics was employed to compare Criteria Pollutants in Lagos area with the WHO standard**.** For the purpose of this study, WHO Values which are presented in $\mu g/m^3$ are converted to mg/m^3 using gas detection calculator (www.gasdetection calculator.com). This was because the data on criteria pollutants collected from Lagos state Ministry of Environment were presented in mg/m^3. Hotspot areas and toxicity potential for Criteria Pollutants were obtained as deviations from the WHO Guidelines and Standard defining the permissible level of each criteria pollutants

Toxicity Potential is expressed as the ratio of measured ambient pollutants concentration to the statutory limit of ambient concentration (Sonibare *et al*. 2005). It is useful in assessing the deleterious effects of air pollutants emissions on human health. It was computed using Eqn (1) taking into consideration the ambient air quality standards of World Health Organisation (WHO) as reported in WHO Air quality guidelines (2005).

The toxicity potential of the pollutants measured was computed using the following equation:

$$TP_i = \frac{Ci(t)}{Sli(t)} \qquad \text{.....................eq. (1)}$$

Where TP represents the toxicity potential of pollutant 'i'

This equation takes into consideration the ambient air quality standard of WHO as reported in WHO air quality guidelines (2005)

In the same vein, the use of tables was employed to identify the hotspot areas in ArcGIS environment. The discussion and interpretation of the results are presented in the section below.

Results and Discussion

Benchmarking criteria pollutants in Lagos

The WHO (2005) air quality guidelines book presents revised guideline values for the four most common air pollutants - particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide, sulphur dioxide and ozone based on a recent review of the accumulated scientific evidence. The rationale for selection of each guideline value is supported by a synthesis of information emerging from research on the health effects of each pollutant. Based on the foregoing, these guidelines are apply globally (WHO, 2005). The details of the WHO Air Quality guidelines is as shown in table 2

As shown in Table 3, Ambient $PM_{2.5}$ and PM_{10} level in the study area were observed to be higher than the internationally permitted standard of 0.01 mg/m^3 and 0.02 mg/m^3 respectively over an annual average period (WHO, 2005). The ambient level of carbon monoxide (CO) in the study area were observed to be lower than the statutory standard of 10 ppm. Also, $PM_{2.5}$ and PM_{10} level in the study area are higher than the WHO recommended value of 0.02 ppm and 0.01 ppm respectively except for Agege housing estates, which is a residential area where 0.01 ppm was recorded for both pollutants. Ambient ground level ozone (O_3) concentration in the study area were observed to be lower than the WHO statutory standard of 0.05 ppm over an eight (8) hours averaging period.

Hotspot areas for criteria pollutants and toxicity potentials in Lagos Metropolis

As indicated in Table 4, the hotspot areas are where there was high concentration of criteria pollutants in the area of study. These areas deviate above the recommended WHO standard, the areas were highlighted in 'reds' signifying hotspot areas. The table also reveals that a minimum of two (2) and maximum of four (4) pollutants across different landuse in the study area exceeds the statutory recommended value.

The minimum toxicity potential with WHO standard for $PM_{2.5}$ was 8 computed for Agege housing estate, a residential area, while the maximum was 33 in Ojodu Berger, a high traffic area (see Table 5). The minimum toxicity potential for PM_{10} was 7 in Ogba Staff quarters which is a residential area, while the maximum was 23 in Iyana-Ipaja, a high traffic area. Also, the minimum toxicity potential for CO was 0.01 in Ogba Staff quarters and Secretariat, a residential area, while the maximum was 0.18 in Ojodu Berger which was a high traffic area. The minimum toxicity potential for NO_2 was 0.5 ppm in Agege housing estate, a residential area, while the maximum was 17.5 ppm in Ojodu Berger a high traffic area. The minimum toxicity potential for SO_2 was 1 in Agege, a residential area, while the maximum is 43 in Ojodu Berger a high traffic area. Minimum toxicity potential for O_3 was 0.08 in Ikeja GRA, a residential area, while the maximum is 0.6 in General Hospital and Iyana-Ipaja a high traffic areas, and Ize-Iyamu and Matori, an industrial areas. It follows therefore that high traffic areas recorded the highest values of criteria pollutants, followed by industrial and residential areas for instance 33, 19 mg/m^3 and 17.5, 43ppm was recorded for $PM_{2.5}$, PM_{10} and NO_2, SO_2 respectively in Ojodu Berger. By implications, High traffic and industrial areas as indicated in Table 5 has the highest toxicity level of criteria pollutants.

Table 2: Conversion of WHO Guideline values for pollutants from microgram ($\mu g/m^3$) to milligram (mg/m^3)

Pollutants	Guideline value in ($\mu g/m^3$/ ppm)	Value in (mg/m^3/ ppm)
Particulate matter ($PM_{2.5}$)	10 $\mu g/m^3$ (annual mean)	0.01 mg/m^3
Particulate matter (PM_{10})	20 $\mu g/m^3$ (annual mean)	0.02 mg/m^3
Nitrogen dioxide (NO_2)	40 $\mu g/m^3$ (annual mean)	0.02 ppm
Sulphur dioxide (SO_2)	20 $\mu g/m^3$ (daily mean)	0.02 ppm
Ozone (O_3)	100 $\mu g/m^3$ (8hr mean)	0.05 ppm
Carbon monoxide (CO)	10 ppm (8hr mean)	10 ppm

* Conversion factor: gasdetectioncalculator.com

Source: Authors computation, 2016.

Table 3: Criteria Pollutants and International Standards

Landuse type		$PM_{2.5}$ (mg/m^3)	PM_{10} (mg/m^3)	CO (ppm)	No_2 (ppm)	So_2 (ppm)	O_3 (ppm)
Residential Areas	Ogba S/Qtrs	0.12	0.14	0.12	0.03	0.03	0.01
	Secretariat	0.14	0.10	0.14	0.03	0.02	0.01
	Magodo	0.14	0.13	0.24	0.06	0.05	0.01
	Ikeja GRA	0.16	0.14	0.20	0.04	0.04	0.004
	Agege H/Estate	0.08	0.09	0.09	0.01	0.01	0.01
High Traffic Areas	Maryland	0.22	0.11	0.85	0.22	0.30	0.02
	Oshodi	0.26	0.27	1.10	0.26	0.36	0.02
	Ojodu Berger	0.33	0.38	1.76	0.35	0.43	0.02
	Gen.Hospital	0.25	0.19	0.87	0.23	0.34	0.03
	Iyana-Ipaja	0.30	0.46	1.16	0.40	0.38	0.03
Industrial Areas	Specomil	0.26	0.28	0.49	0.06	0.09	0.02
	Wemabod	0.17	0.15	0.37	0.04	0.07	0.02
	Wempco	0.17	0.19	0.35	0.09	0.11	0.02
	Ize-Iyamu	0.23	0.26	0.73	0.13	0.12	0.03
	Matori	0.23	0.19	0.70	0.07	0.09	0.03
Int. Standard	**WHO**	**0.01**	**0.02**	**10**	**0.02**	**0.01**	**0.05**

Source: Author's Computation, 2016

Table 4: Hotspots in the Three Land use Areas

Locations		$PM_{2.5}$ (mg/m³)	PM_{10} (mg/m³)	CO (ppm)	No_2 (ppm)	So_2 (ppm)	O_3 (ppm)
Residential Areas	Ogba S/Qrtrs	0.12	0.14	0.12	0.03	0.03	0.01
	Secretariat	0.14	0.10	0.14	0.03	0.02	0.01
	Magodo	0.14	0.13	0.24	0.06	0.05	0.01
	Ikeja GRA	0.16	0.14	0.20	0.04	0.04	0.004
	Agege H/Estate	0.08	0.09	0.09	0.01	0.01	0.01
High Traffic Areas	Maryland	0.22	0.11	0.85	0.22	0.30	0.02
	Oshodi	0.26	0.27	1.10	0.26	0.36	0.02
	Ojodu Berger	0.33	0.38	1.76	0.35	0.43	0.02
	Gen.Hospital	0.25	0.19	0.87	0.23	0.34	0.03
	Iyana-Ipaja	0.30	0.46	1.16	0.4	0.38	0.03
Industrial Areas	Specomil	0.26	0.28	0.49	0.06	0.09	0.02
	Wemabod	0.17	0.15	0.37	0.04	0.07	0.02
	Wempco	0.17	0.19	0.35	0.09	0.11	0.02
	Ize-Iyamu	0.23	0.26	0.73	0.13	0.12	0.03
	Matori	0.23	0.19	0.70	0.07	0.09	0.03
Int. Standards	WHO	0.01	0.02	10	0.02	0.01	0.05

*Reds signifies hotspot areas

Source: Authors Computation, 2016.

Table 5: Computed Toxicity Potential of the Criteria Pollutants

		$PM_{2,5}$ (mg/m³)	PM_{10} (mg/m³)	CO (ppm)	No_2 (ppm)	So_2 (ppm)	O_3 (ppm)
Locations		TP_{WHO}	TP_{WHO}	TP_{WHO}	TP_{WHO}	TP_{WHO}	TP_{WHO}
Residential Areas	Ogba S/Qrtrs	12	7	0.01	1.5	3	0.2
	Secretariat	14	5	0.01	1.5	2	0.2
	Magodo	14	6.5	0.02	3	5	0.2
	Ikeja GRA	16	7	0.02	2	4	0.08
	Agege H/Estate	8	4.5	0.09	0.5	1	0.2
High Traffic Areas	Maryland	22	5.5	0.09	11	30	0.4
	Oshodi	26	13.5	0.11	13	36	0.4
	Ojodu Berger	33	19	0.18	17.5	43	0.4
	Gen. Hosp.	25	9.5	0.09	11.5	34	0.6
	Iyana-Ipaja	30	23	0.12	20	38	0.6
Industrial Areas	Specomil	26	14	0.05	3	9	0.4
	Wemabod	17	7.5	0.04	2	7	0.4
	Wempco	17	9.5	0.04	4.5	11	0.4
	Ize-Iyamu	23	13	0.07	6.5	12	0.6
	Matori	23	9.5	0.07	3.5	9	0.6

*Reds signifies toxicity potential values above unity

Source: Author's Computation, 2016

It must be noted that toxicity potential values greater than unity indicates that such concentration has a tendency of causing harm to people that are exposed to it in such an environment and hence should be avoided. The toxicity potentials values highlighted in Table 5 are areas with concentration of criteria pollutants that has a potential for harmful effects to people. Fig. 3 shows the map of the hotspot areas.

Subsequently, Figure 3 shows the hotspot areas with high toxicity potential, these areas pose a serious health threat to the inhabitants around the areas and major road user's. For instance, Burnnet *et al* (1998) found a 4.3% increase in all-cause mortality for an increase in 24-hour average NO_2 levels 47μgm-^{3}. Dennison *et al* (2002) summarises the health effects of associated with exposure to Ozone as increase in daily Mortality, Respiratory and Cardiovascular diseases such as High blood Pressure, Cough, Phlegm and wheeze.

Long-term exposure to $PM_{2.5}$ is associated with an increase in the long-term risk of cardiopulmonary mortality by 6–13% per 10 μg/m^3

of $PM_{2.5}$ (Pope, C.A. III, 2002). Susceptible groups with pre-existing lung or heart disease, as well as elderly people and children, are particularly vulnerable. For example, exposure to PM affects lung development in children, including reversible deficits in lung function as well as chronically reduced lung growth rate and a deficit in long-term lung function (WHO, 2011). Dennison *et al* (2002) concludes that because of the correlations between SO_2 and other contaminants in the air it is difficult to confidently attribute the observed effects in the epidemiological studies to SO_2 alone.

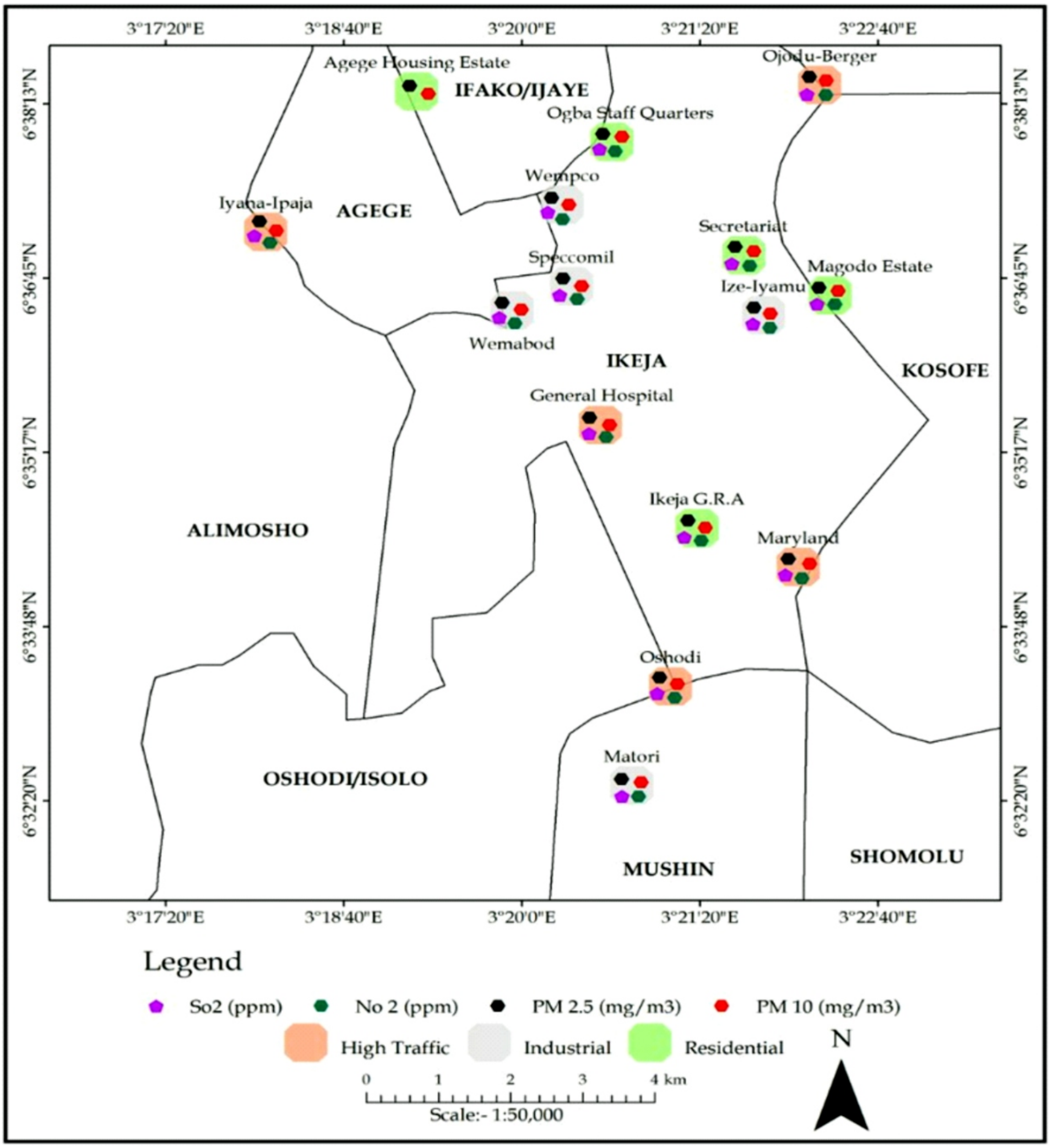

Figure 3: Spatial pattern of Hotspot areas of pollutants
Source: Authors Fieldwork, 2016

Conclusion

Spatial variation in the distribution of Criteria pollutants in Lagos was established. From the findings, it was evident that $PM_{2.5}$, $PM_{10,}$ SO_2 and NO_2 in sample areas clearly exceeded the regulatory limit set by WHO especially in the high traffic zones. Furthermore, CO and O_3 are well below the statutory standards. Areas such as Ojodu-berger, Oshodi, Ojota, Ikeja and Iyana-ipaja were classified as high risk areas. Also, the toxicity potential values for $PM_{2.5}$, $PM_{10,}$ SO_2 and NO_2 in the area of study are greater than unity while the values for CO and O_3 are lesser than unity. However, toxicity potential values greater than unity indicates that such concentration has a tendency of causing harm to people and hence should be avoided. This was because most of the criteria pollutants exceeded the recommended WHO value.

Recommendations and Policy Measures

There is need for better air quality in the state in order to reduce the health effect of air pollutants. These could be achieved, if only the Government could implement the following recommendations that was made based on the findings of this study. Government should create Lagos State air quality health index (AQHI) and report on cumulative health impacts associated with criteria pollutants to be monitored at suitable locations within the state. Enforcement agencies such as Lagos State Traffic Management Agency (LASTMA) and LAMATA should ensure the compliance of Industrial and vehicular emission standard and provision of database for determining air quality in major metropolitan area of the state. There are needs to encourage mass transportations throughout the state, cleaner modes of transportation and more sustainable energy generation in the state. Also, tree planting and greening of the environment should be sustained and improved upon throughout the state for aesthetics and carbon sequestration purposes.

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