ISSN 1118-2083

ENVIRONMENTAL ISSUES

Volume 8, No. 1, 2018

Published by:
Department of Geography
and Environmental Management
Faculty of Social Sciences
University of Ilorin,
Ilorin, Nigeria

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1. Format of manuscript:

Manuscript should be typed doubled-spaced on one side of A4 paper with generous margins at least 2.5cm. it should not exceed 15 pages, including tables and illustration. 12 point font size and Time New Roman style should be used.

- The title page, abstract, and references should be typed on separate sheets. The title page should include the title of the paper, the full names(s) of the author(s), postal address, telephone and fax numbers, Email address and the institutional affiliation.
- The paper proper should start on page 2 with Title, Abstract, Introduction, etc.
- The Abstracts should contain objective, materials and methods, major findings, conclusion and keywords.
- The paper should contain abstract, introduction, methodology, results, discussion, conclusion, recommendations (if necessary)

2. Tables, Illustrations and Plates

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3. References

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Geographical Analysis of Criteria Pollutants in Selected Areas of Lagos: Lessons for Human Health

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Abstract: Atmospheric air plays a significant role in all lives on earth as it acts as a gaseous blanket protecting the earth from dangerous cosmic radiation from outer space. This study examines the spatial pattern of criteria pollutants and its implications for human health in selected areas of Lagos state, Nigeria. The study area was divided into three (3) namely; high traffic, industrial and residential areas. The data for the study includes three years (2010-2012) data of criteria pollutants such as particulate matter (PM2.5, PM10), ground-level ozone, carbon monoxide, Sulphur dioxides, nitrogen dioxides and coordinates of the sample area which were collected from Lagos State Ministry for Environment and direct field measurement of coordinates with handheld GPS. The study reveals that the highest concentrations of pollutants were recorded in High traffic areas followed by Industrial areas and Residential areas respectively. Criteria Pollutants such as SO2, CO, PM2.5 and PM10 are highly concentrated in the High traffic and Industrial areas. Data were analyzed using descriptive and GIS procedure. It was therefore recommended that the government should adopt or create air quality health index (AQHI) and report on cumulative health impacts associated with criteria pollutants to be monitored at suitable locations within the state.

Keywords: Ambient air, criteria pollutant, air pollution, vehicular emissions

Introduction

Air is a combination of gaseous elements that have a remarkable uniformity in terms of their contribution to the totality of life. Air quality is a measure of the degrees of ambient atmospheric pollution, relative to the potential to inflict harm on the environment (WHO, 2002). The constituent elements are primarily nitrogen (N_2) and oxygen (O_2), with a small amount of argon (Ar). Below 100km, the three main gaseous elements which account for about 99.9% of the total atmosphere are N_2, O_2 and Ar and they have concentration by volume of 78%, 21% and 0.93% respectively while the presence of trace amount of other gases account for 0.07% (Stanley, 1975; Dara, 2004). These remaining trace gases exist in small quantities and they are measured in terms of a mixing ratio. Thus, oxygen support life on earth, nitrogen serves as an essential macronutrient for plants; and carbon (iv) oxide is responsible for the photosynthetic activity of plants. Any major disturbances in the atmosphere resulting from anthropogenic activities may lead to disastrous consequences or may even endanger the survival of life on earth (Dara, 2004). The concentration of greenhouse gases in the atmosphere has increased tremendously over the past decades and some of these gases (Sulphur (iv) oxide, nitrogen (ii) oxide and carbon (iv) oxide emitted from thermal power stations, burning of fossil fuel, moving vehicles, etc.) are responsible for acid rain, global warming, malfunctioning of human and animal haemoglobin. Other causes of air pollution arising from human activities include inappropriate solid waste disposal, gas flaring and oil exploration. Air pollution can also arise from natural causes such as volcanic eruption, whirlwind, earthquake, a decay of vegetation, pollen dispersal, as well as ignition by lightning (Stanley, 1975; Ifabiyi and Ojoye, 2013). The World Bank (1978) reported that the presence of one or more contaminants such as dust, fumes, gas, mist, odour, smoke or vapour in outdoor atmosphere makes it polluted and in turn becomes potentially injurious to human, plant or animal life, or property

which unreasonably interferes with the comfortable enjoyment of life and property.

The United State Environmental Protection Agency (2012) identifies six criteria pollutant namely particulate matter, ground-level ozone, carbon monoxide, Sulphur oxides, nitrogen oxides and lead exposure as toxic and injurious because they are capable of causing various human health problems. The natural environment in which we live in is increasingly threatened by human activity and has potentially led to deterioration and damage to both public health and the environment itself. (Theophanides, 2002). Human health is threatened with diseases and early mortality and is even more prevalent in emerging economies facing rapid industrialization like Lagos state. Epidemiological studies of occupational diseases on the working population are showing ill effects of the environment on people working in a contaminated environment over a lifetime of employment (Macbeth, 1999; Samoli, et al, 2008).

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 a loss of life and destruction of properties in the state. The overall effects of air pollution on Lagos citizens and environment contribute to drag in the efforts for its most sustainable programs (Akinola et al. 2014). This study, therefore, seeks to examine the pattern of distribution of criteria pollutants over selected areas of Lagos state with a view to identifying the implications for human health.

Study Area

Lagos state is located between latitudes 6°.35N to 6.58°N and longitudes 3°.45'E to 3.75°E of the Greenwich meridian. The state has a tropical wet and dry climate but there is hardly a month without precipitation in all parts of the state. The wet season is of double maxima experienced from March to July and the other in late August to early September and a dry season from late September to early November. The maximum temperature ranges between 29°C - 34° C, the lowest being in the month of July and the highest in February and minimum temperature varies between 24°C - 28°C. The annual mean rainfall is between 1381.7mm and 2733.4mm in recent time from one location to another. 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 rainforest. The swamp forest is a combination of mangrove forest and coastal vegetation developed under the brackish conditions of the coastal areas, swamp freshwater lagoons and estuaries. Lying to the north of the swamp forest is the lowland (tropical) rainforest 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 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. The population of Lagos according to the Lagos State Government was 17.5 million, a number disputed by the Nigerian Government and judged unreliable by the National Population Commission of Nigeria. The latest reports estimate the population at 21

million, making Lagos the most populated city in Africa (Lagos State portal, 2017). 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. 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.

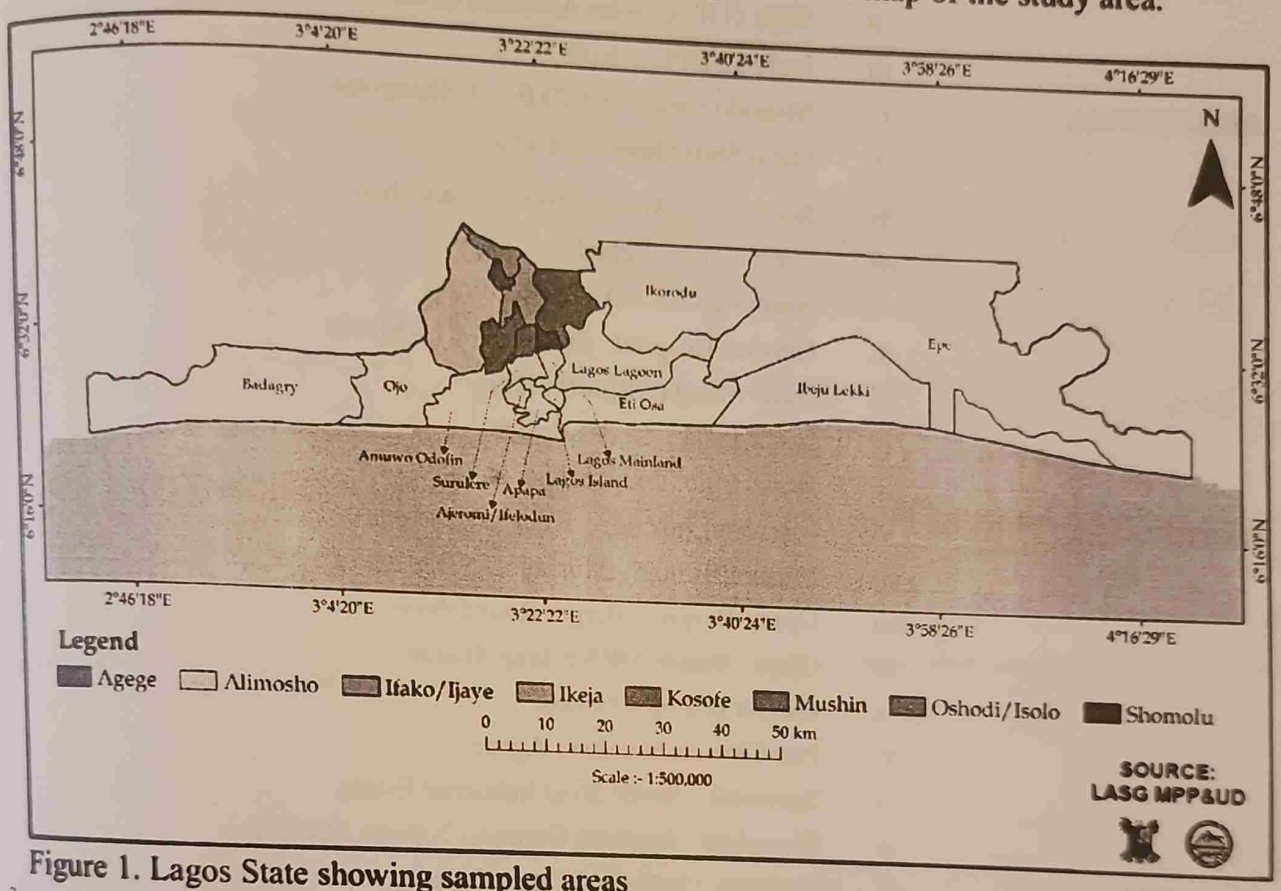


Figure 1. Lagos State showing sampled areas

Materials and Methods

The data required for this study were coordinates of the (21) sample sites and 3 years atmospheric (criteria) pollutants which include particulate matter (PM2.5 and PM10), ground-level ozone, nitrogen dioxide, Sulphur dioxide and carbon monoxide. The data on criteria pollutants were collected from Lagos State Ministry for Environment (MOE), Office of Environmental Services, on the other hand, direct measurement of coordinates of sample sites were taken from the field with the aid of the Global Positioning System handheld device (Garmin GPS 76S.). The study area was divided into three (3) namely; high traffic, industrial and residential areas. Areas considered as residential areas were a land use in which only residential housing predominates. In this light, State Government staff quarters and estates owned by private agencies were considered. The high traffic areas were the major road intersections where high volumes of traffic are experienced during the working hours of the day while regions with high concentration of industries were considered as industrial areas (See Table 1). The study employs the use of non-parametric statistics which include the use of tables and graphs and GIS procedure was employed to produce a map showing the sample sites distribution and spatial pattern of criteria pollutants (See figure 2 and 3).

Table 1: Sites Distribution in the Study Area.

LOCATION TYPE		Locations/Sites
RESIDENTIAL	i	Agege Housing Estate; Oko-oba
	ii	Ikeja G.R.A: Sobo Arobiodu street.
	iii	Isolo LSDPC : Isolo
	iv	Magodo Estate : CMD Road, Shangisha
	v	Ogba Staff Quarters; Ogba
	vi	Secretariat; Alausa : front of Skye bank
	vii	Unity Estate, Egbeda
HIGH TRAFFIC	i	Anthony-Oke : Anthony B/Stop
	ii	General Hospital: Frontage of LASUTH
	iii	Ikeja-Along (Airport) : Ikeja
	iv	Iyana-Ipaja : Under Bridge
	v	Iyana-Isolo: under bridge Isolo.
	vi	Maryland Junction, Ikeja
	vii	Mushin B/Stop : Mushin
	viii	Ojodu-Berger : Berger Roundabout
	ix	Ojota : Beside MRS Filling Station
	x	Oshodi B/Stop : Oshodi
	xi	Pen-Cinema Junction : Agege
INDUSTRIAL	i	Specomil : Inside Ikeja Industrial Estate
	ii	Wemabod : Adjacent Guinness Nigeria PLC office
	iii	Wempco : Industrial Estate Ogba
	iv	Ize-Iyamu

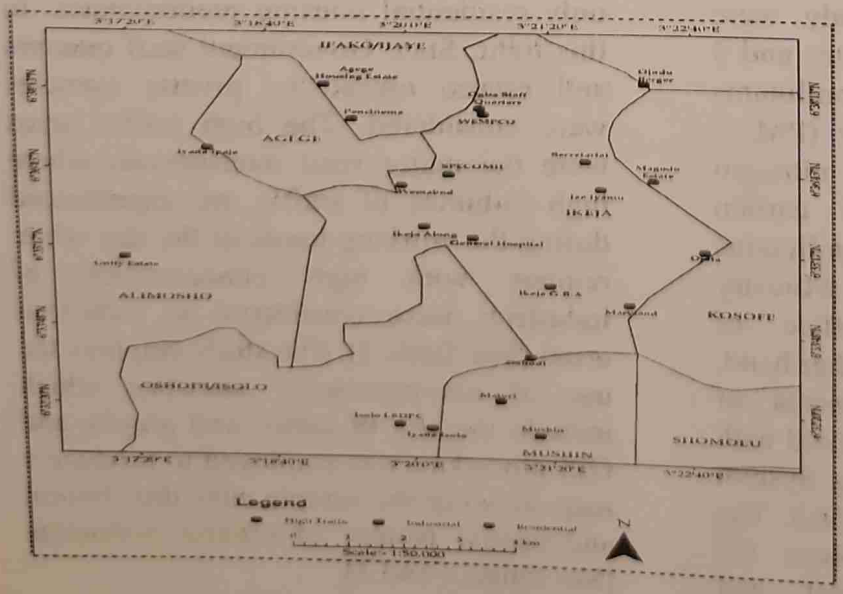


Fig. 2: Map Showing Sites Distribution in the Study Area

Results and Discussion

The results obtained in this study are presented below. The values presented in the tables below depict that the pattern of criteria pollutants vary from one part of the metropolis to the other.

Table 2: Level of criteria pollutants in the study area

	PM2.5 X10 (mg/m^3)	PM10 (mg/m^3)	CO $X10^{-1}$ (ppm)	NO_2 (ppm)	SO_2 (ppm)	O_3 (ppm)
Residential	0.165238	0.155238	0.085238	0.035714	0.049048	0.02523
High traffic	0.320667	0.250667	0.425	0.278	0.417333	0.026667
Industrial	0.25	0.211333	0.184667	0.065333	0.098	0.027333

Source: Author's Computation, 2013.

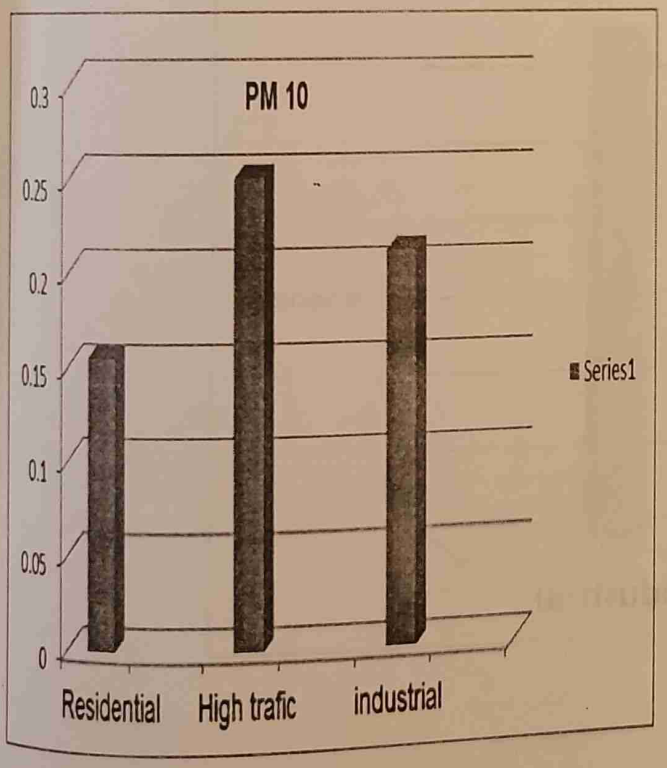


Figure 3: Level of $PM_{2.5}$

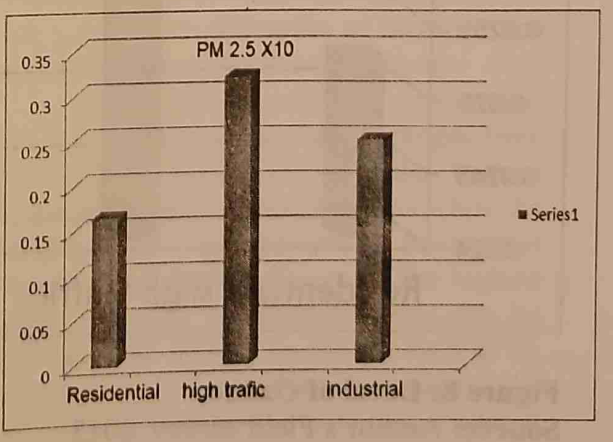


Figure 4: level of PM_{10}

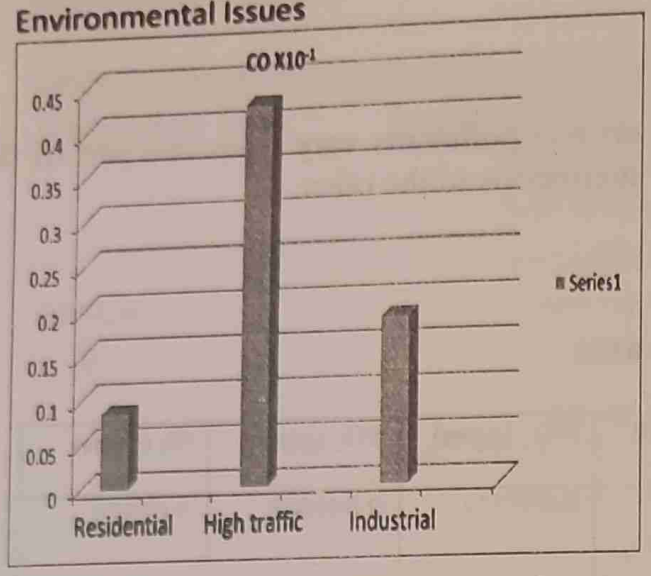


Figure 5: Level of carbon monoxide

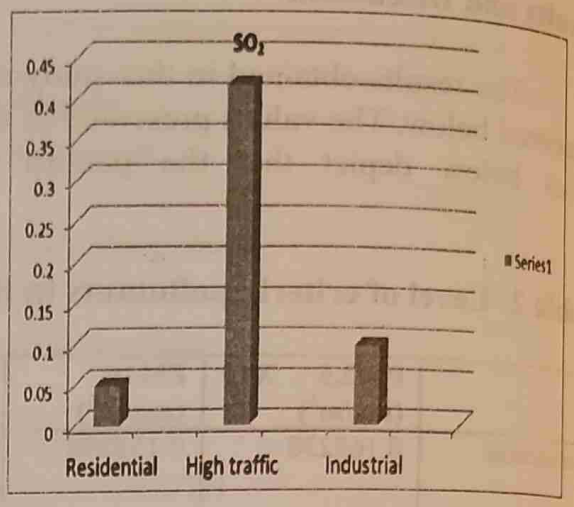


Figure 7: Level of Sulfur dioxides

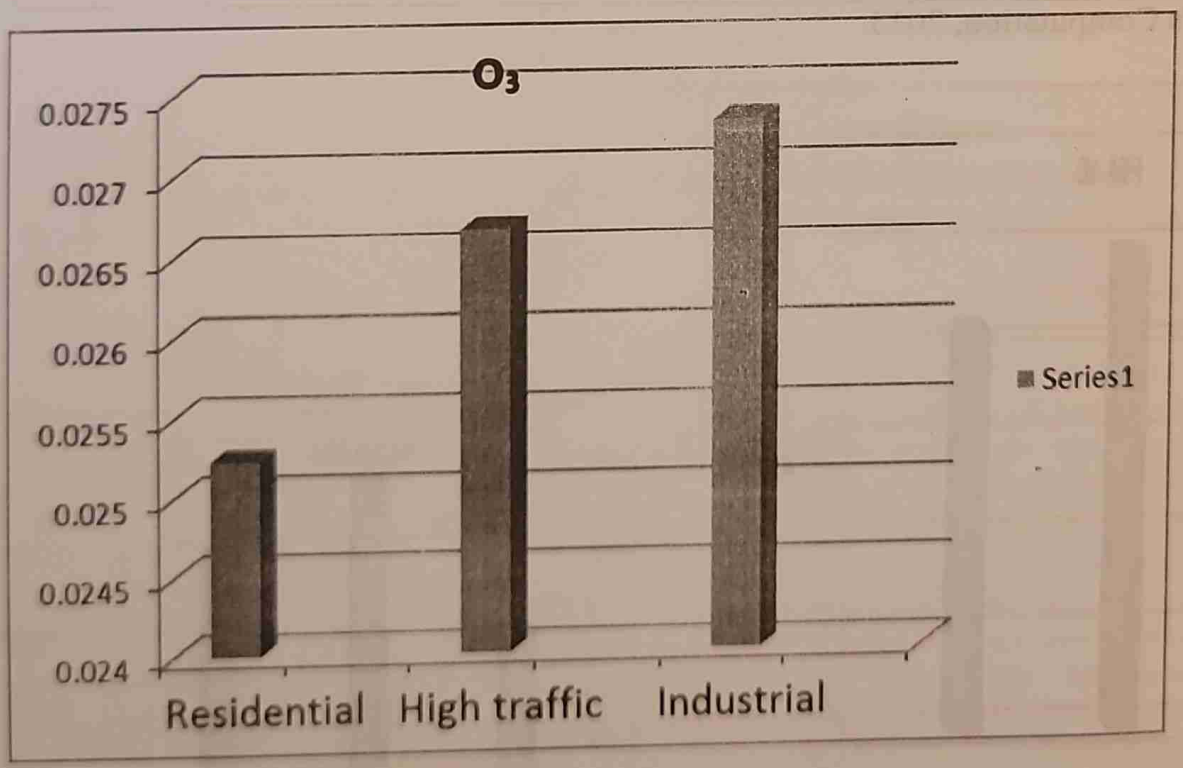


Figure 8: Level of Ozone
Source: Author's Field survey, 2013

According to Figure 3, the average value of PM2.5 for three years range from 0.165238 - 0.25 with the highest value recorded in the High Traffic area while the lowest value was at Residential Areas. The high traffic areas have the highest level of PM2.5 this is due to to the thick, black smoke emitted from the exhaust pipes of a vehicle, swirls of dust picked up by the wind, ash and soot coming out of the fire. The level of PM2.5 in the Industrial areas is higher than that of the Residential areas, this is because of the smokestacks of factories, power plants and that are peculiar to the industrial areas in the area of study. Wood or coals for cooking, renovations of buildings and roads, accumulation of clouds of dust in the yards are sources of PM2.5 in the study area.

The average value of PM10 for the period of study range from 0.155238 - 0.250667 with the highest value recorded at High traffic area while the lowest value recorded was at the Residential area as revealed in Figure 4. The PM10 particles are small enough to be inhaled and accumulate in the respiratory system. The PM2.5 discussed above has similar attributes in terms of sources and causes in the area of study with PM10 except for their respective sizes.

Figure 5 indicates that the average value of carbon monoxide (CO) for the period under study ranges from 0.085238 - 0.085238 with the highest value recorded at High traffic areas while the lowest value recorded was at Residential areas. The high traffic areas have the highest level of CO. This is because of the high vehicular emission during the day, relatively low wind speed and high traffic congestion. The CO recorded in industrial areas is also higher than that of the residential areas; this can be attributed to the nature of epileptic power supply of the State and the increasing use of big generator plants. However, the residential areas recorded the lowest level of CO; this is because most of the residents would have gone to work, and the use of generators, woods or coal for cooking and vehicular movement would have been reduced drastically as at the time of collecting samples.

Furthermore, Figure 6 shows that the average value of nitrogen dioxide (NO2) for the three years under review ranges from 0.035714 – 0.278 with the highest value recorded at high traffic areas while the lowest value recorded was at residential areas. NO2 is of major concern as a pollutant; it is emitted by fuel combustion and Nitric acid plants. This explains why the level was so high in the High traffic and Residential areas respectively.

So also the Figure 7 revealed that the average value of sulfur dioxide (SO2) for the period of study ranges from 0.098 – 0.049048 with the highest value recorded at high traffic areas while the lowest value recorded was at Residential areas. Coal and petroleum contain Sulfur compound and their combustions generate sulfur dioxide (SO2). The high level of SO2 in the High traffic areas can be attributed to vehicular emission while that of the industrial areas can be attributed to emissions of smokestacks of factories and power plants around the study area.

The average value of ozone (O_3) for the 3 years period of study ranges from 0.025238 – 0.027333 with the highest value recorded at Industrial areas while the lowest value recorded was at Residential areas as indicated in Figure 8. The highest value recorded in industrial areas can be attributed to various emissions such as an automobile, bus, construction equipment's, gas stations and print shops that clustered around the industrial areas. Figure 10 shows the level and spatial distribution of the criteria pollutants in the study area.

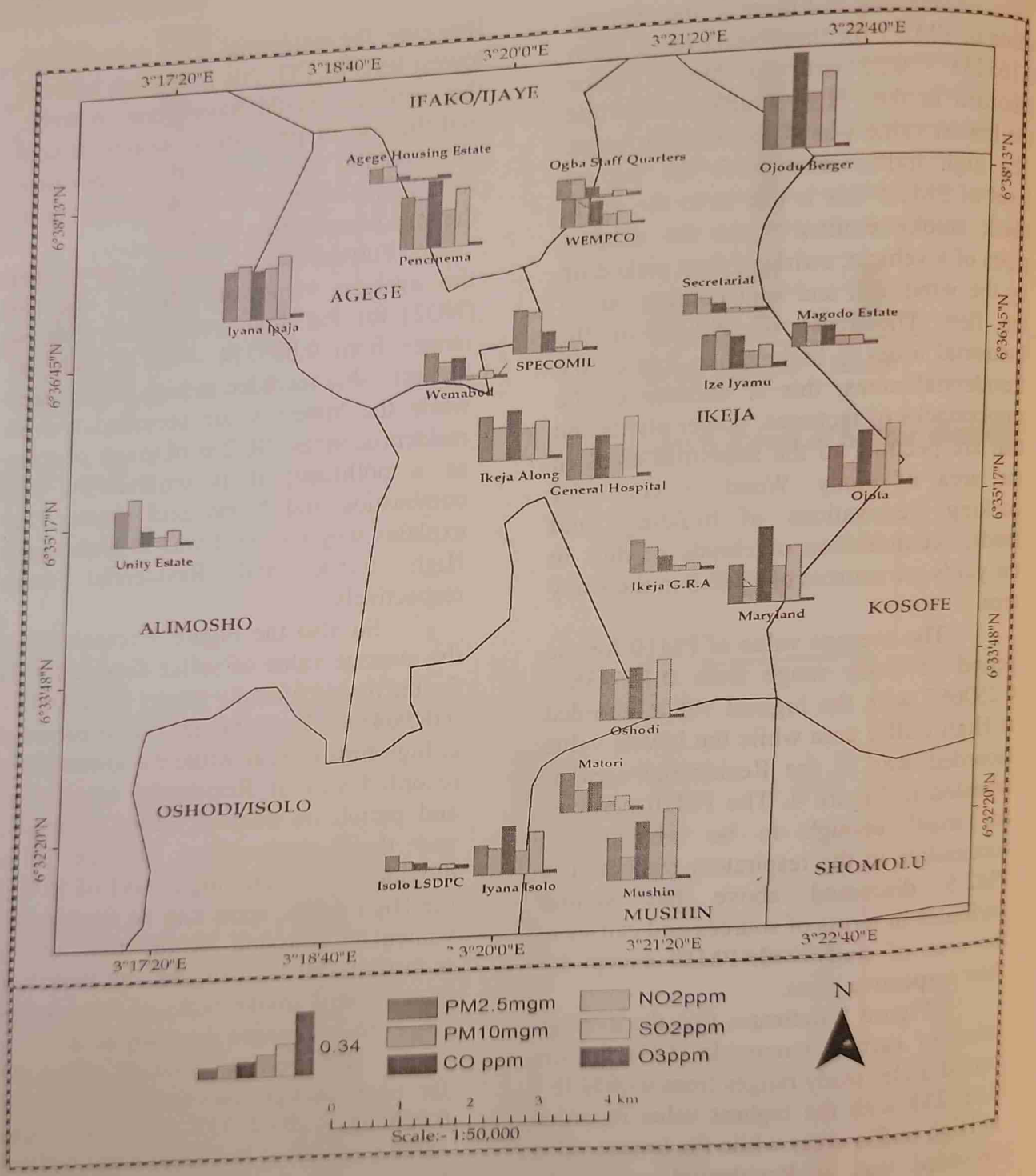


Figure 10. Spatial Spread of Pollutants in the Study Area
Source: Authors Computation, 2013

However, there is a significant level of O_3 in the High traffic areas; this was as a result of combustion from the exhaust pipe of vehicles and various construction projects going on in the study area. There is a significant variation in the distribution of criteria pollutant in the study area. Based on the classification, the highest concentration of pollutants was recorded in High traffic areas followed by Industrial areas and Residential areas respectively. Criteria Pollutants such as SO_2, CO and PM are highly concentrated in the High traffic and Industrial areas. Burnnet et al (1998) posited that 4.3% increase in NO_2 levels was responsible for all-cause mortality rate in 24 hours average on daily basis. Furthermore, Dennison et al (2002) summarize the health effects that are associated with exposure to Ozone as an increase in daily Mortality, Respiratory and Cardiovascular diseases such as High Blood Pressure, Cough, Phlegm and wheeze. He 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.

Conclusion

This study has investigated the pattern of criteria pollutants in parts of Lagos state. It is evident from the study that the highest concentrations of pollutants were recorded in the High traffic areas followed by Industrial areas and Residential areas respectively. Areas such as General Hospital, Iyana-Ipaja, Maryland, Oshodi, Ojodu Berger are high in criteria pollutants concentration. More so, this research work reveals that particulate matter PM10 and PM2.5 deviates above the WHO standard which is 20 and 10 µg/m3 (annual mean) in all the area under study.

There is a need for better air quality in the state in order to reduce the effects of air pollutants on health. The government should adopt or create air quality health index (AQHI) to allow appropriate monitoring of air quality, among other suggestions.

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