IMPACT OF VEHICULAR EMISSION ON AIR POLLUTION IN OJO LOCAL GOVERNMENT AREA OF LAGOS STATE, NIGERIA

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ABSTRACT: *This study was carried out to assess the impact of vehicular emission on air pollution at some locations in Ojo Local Government Area of Lagos State, Nigeria, with a view to determining the contribution of motor vehicle emissions to air pollution. The sites were: Iyana Iba Bus-stop, LASU Main Gate, Okokomaiko Bus stop, LASU Second Gate and LASU Main Campus. Some of the air pollutants measured include carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), hydrogen sulphide (H_2S) and suspended particulate matter (SPM). MSA 5x Multi Gas Detector was used to measure the concentration of air pollutants of CO and H_2S while Kanomax Single Gas Detector was used to measure NO_2 and SO_2 and TSI Aero Trak Handheld Particle Counter Model 9303 was used to determine SPM. Vehicular traffic was observed during the peak traffic periods; 8:00 a.m. – 10:00 a.m. and 4:00 p.m. – 6:00 p.m. each day for eight days. The number of traffic at each site per hour was counted using an electronic counting machine. The results indicated that the concentration of CO at Okokomaiko Bus-stop was the highest with an average of 54.88±7.94 ppm (n=8). At this site, the concentration fell between 41.00 and 65.00 ppm between the hours of 8:00 a.m. and 10:00 a.m. while the average concentration between 4:00 p.m. and 6:00 p.m. was 49.63±10.50. The reason for high concentration of CO at Okokomaiko was due to high vehicular traffic. CO concentration is influenced greatly by traffic flow, in which case the concentration for free - flowing traffic was less compared to an impeded flow due to traffic jam as experienced in most of the locations. The result of the study also showed that hydrogen sulphide profile within the metropolis and control stations was not detected within the equipment's detection limit. The assessment of the impact of vehicular emissions on the air quality at the study locations showed that traffic density can increase the concentration of air pollutants (NO_2 SO_2, CO and SPM) emanating from vehicular emissions because pollutants concentrations showed high correlation with traffic density except for H_2S. All the pollutants were either within or above the WHO standards for ambient air quality. The study also revealed that measured gaseous pollutants in the air directly or indirectly threaten the environment and life of inhabitants of the locations and that motor vehicles emission and other related activities carried out along these roads remain the main sources of these pollutants.*

KEYWORDS: vehicular emission, air pollution, concentration, traffic density

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INTRODUCTION

Man's technological advancement on earth has brought along a major consequence of pollution to the society. Pollution of all kinds is probably the biggest of environmental problems we are facing today. Air pollution has heightened over the years and now poses a big threat to our existence on earth. Pollution is undesirable change in the physical, chemical or biological characteristics of environment including air, water and solid which causes harmful effects to various form of life and property. According to World Health Organization (WHO) definition, Pollution is "the presence of material in air in such concentrations which are harmful to human and environment" (Ethopia Herald, 2017). Secondly, National Environment Research Institute (1976) also defines Pollution as "the undesirable products and energy produced as a result of actions of human beings, which have adverse effect on the environments.

Air pollution is defined as the contamination of air by discharge of harmful substances, which can cause health problems including burning eyes and nose, itchy irritated throat and breathing problems (USEPA, 1994). Air pollution can also be defined as the presence of harmful substances in the air, either particulates or microscopic biologic molecules that pose health hazards to living organisms, such as people, animals or plants (West, 2017). Air pollution comes in many forms and may include a number of different pollutants and toxins in various combinations. It is far more than a nuisance or inconvenience. According to the World Health Organization report, air pollution in 2014 caused the deaths of around 7 million people worldwide (West, 2017).

Basically, air pollution can result from both natural and man-made (anthropogenic) sources (Botkin and Keller, 2000): i. Natural Sources: These include volcanic eruption releasing poisonous gases, forest fire, natural organic and inorganic decays or vegetation decay, pollen scattering, deflation of sands and dust, sea salt particles being blown up from the surface of the sea by winds, extraterrestrial bodies, cosmic dust, and comets. ii. Man-made (anthropogenic) sources: The major anthropogenic sources include but not limited to substances emitted due to the burning of fossil fuels in engines, gas and particulate matter created in the production process (industrial and agricultural), suspended particulate matter and chemical substances created in the process of waste disposal and even war. Examples of air pollutants include sulphur dioxide (SO_2), Nitrogen Dioxide (NO_2) suspended particulate matter, Carbon Monoxide (CO), photochemical oxidants (OX), Non-Methane Hydrocarbon Species (NMHC) etc.

The nature of air pollution is dependent on the source profile of the city, the presence of sunlight to promote production of secondary pollutants, such as ozone, through photochemical reactions, the altitude, which affects combustion processes and global air circulation patterns. Clean air is the basis of a healthy life. Air pollution causes discomfort or harm to people and other living organisms. Therefore, air pollution must be controlled if air quality is going to be maintained. Poor or deteriorating air quality in many cities results from high levels of energy consumption by industry, transport and domestic use (UNEP/WHO, 1992).

.Indeed motor vehicle has been identified as one of the leading causes of air pollution in most urban cities of the world, though China, United States, Russia, Mexico, and Japan are the world leaders in air pollution emissions, but the two sources of air pollutants ubiquitous in most urban

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areas are transportation and fuel combustion by stationary sources, including industrial heating (WHO, 2000). However, motor vehicle emissions seem to be the dominant source of air pollutants especially in areas with high traffic densities and industrial activities (Seinfeld, 1989).

Health and Environment Research Institute, (2001), reported that some chemicals found in polluted air could cause cancer, birth defects brain and nerve damage, and long-term injury to the lungs and breathing passages in certain circumstances. The concentrations of such chemicals beyond a limit, and an exposure over a certain period are extremely dangerous and can cause severe injury or even death. In support of this, it was stated that transportation accounts for an important fraction of greenhouse gases (especially carbon monoxide) emission (Cline, 1991).

In developing countries like Nigeria, the rural-urban migration for economic and social opportunities over the years has contributed to the generation of air pollution challenges of most of the cities. Therefore, due to the economic growth of Nigeria, the increase in industrialization and commercial activities since petroleum was discovered, there has been an increase in the population of the country which has contributed largely to high vehicular pollution in the air which has not been managed appropriately, thereby causing devastating effects on both nature and living beings. This situation is therefore pathetic especially in developing countries where motorization growth has been largely unchecked by environmental regulation, thereby creating high levels of pollution (Han and Naeher, 2006).

In developing nations, it is envisaged that with rising income and the rapidly rising mobility that accompanies it, the increase in vehicular emissions will be greater than what occurs in the developed nations. Steady growth in vehicular populations has put environmental stress on urban centres in various forms particularly causing poor air quality. There is growing evidence that links vehicle pollutants to human ill health (Weyn et al., 1994). Motor vehicles are major emission sources for several air pollutants, including nitrogen oxides (NOx), carbon monoxide (CO), particulate matter (PM), and hydrocarbons (HC) (WHO, 2005).These pollutants have significant adverse effects on human beings and the environment. Vehicle emissions cause both short and long term problems associated with health effects. For example, HCs and NOx are the precursors of ozone gas, which has effects ranging from short term consequences such as chest pain, decreased lung function, and increased susceptibility to respiratory infection, to possible long-term consequences, such as premature lung aging and chronic respiratory illnesses (Weyn et al., 1994, Gibbs et al, 1995).

Policy makers all over the world have been partially successful in improving air quality. In the US, the ambient levels of most pollutants have been reduced steadily since the 1960s (Calvert *et al.*, 1993, Harrington *et al,* 1995, Small and Kazimi, 1995) reported that Europe has lagged behind the US in emission controls on motor vehicles. Africa is even worse off. In Nigeria, the government has banned the importation of vehicles over eight years old. Good as this policy may look like, what remains to be done is how to control emission from the existing old vehicles plying the streets and highways of Nigeria. Some of the policies are aimed at reducing overall vehicle use, so as to minimize congestion/or pollution. However, these policies really do little to reduce the twin effect of congestion and pollution (FEPA, 1991, EPA, 2001).

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According to Hall (1995) the problem of congestion is specific to location and time, whereas emissions are specific to vehicle characteristics and driving behaviour. The diesel or petrol-fired electricity generator is also a source of air pollution, and it is contributing to the choking air in cities like Abuja and Lagos, which are plagued by daily smog shrouding the skyline of the central city. As sub-Saharan African cities experience increased urbanization and motorization, air pollution, particularly from vehicles still using leaded gasoline, is worsening. By providing access to business and public facilities, urban transport plays a critical role in the development of urban areas and overall economic growth but it also generates a number of externalities in terms of accidents, noise, traffic congestion, and air pollution. The latter is becoming a major environmental and health concern in sub-Saharan Africa. High rate of urbanization (4–8% in a number of cities) expected to be sustained for the next decade, combined with low-income solutions to daily commuting, has resulted in the rapid increase in pollutants emitted by motorized vehicles.

This paper will, therefore, focus on the impact of vehicular emission on air pollution in Ojo Local Government area of Lagos State, Nigeria.

METHODOLOGY

Measurements of air pollution were conducted between February and March 2018 in order to collect background information for calculating the concentration of pollutants in the air from vehicular sources for the metropolis. Based on the knowledge of air quality within the metropolis from the preliminary screening study, the measurement sites and compounds to be studied were selected in order to cover different microenvironments (e.g. roadside, urban background, regional background) and emissions. The sites were visited twice a day for the eight (8) days sampling period between 7.00 and 11.00 hours to capture the impact of heavy traffic and business start-up at the time (designated as AM) and between 13.00 hour and 16.00 hour, when the vehicular movement is less on the highways and work is on-going at most offices and factories (designated as PM).

Description of Sampling Sites

Lagos is located in the south-western part of Nigeria on the narrow coastal flood plain of Bight of Benin. It lies approximately on longitude $2^0$42´E and 3^0 42´E respectively and between latitudes 6^0 22´N and 6^0 42´N. The metropolitan city is bounded in the North and East by Ogun State of Nigeria, in the West by the Republic of Benin, and in the South by the Atlantic Ocean. The land area of the city is 3,577 km^2 (Research Alliance to Combat HIV/AIDSREACH), 2013). Generally, the state has two climatic seasons: Dry (November-March) and Wet (April-October). The drainage system of the state is characterized by a maze of lagoons and waterways which constitute about 22% or 787 km^2 of the state total landmass, yet it has the highest population, which is over five per cent of the national estimate (Fasona et al., 2005).

The state has a population of 17 million out of a national estimate of 150 million. The UN estimates that at its present growth rate, Lagos state will be third largest mega city in the world by 2020 after Tokyo in Japan and Bombay in India. In the built-up areas of Metropolitan Lagos, the average density is over 20,000 persons per square km. The rate of population growth is about

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600,000 per annum with a population density of about 4,193 persons per sq. km. This is ten times faster than New York and Los Angeles with grave implication for urban sustainability (World Bank, 1996; Lagos State Government, 2011).

The choice of the five (5) monitoring stations was based on a number of factors including preliminary report on hot spots in the city, meteorological conditions, and accessibility to site for sample collection and prevailing activities (economic and construction) in the area.

Iyana Iba Bus-stop - An area with potential high traffic volume, with numerous point sources of vehicular emissions which make it an important contribution to this research. LASU Main Gate - An area with minimal traffic volume Okokomaiko Bus stop - the vehicular density at Okokomaiko with predominant traffic jam also makes it an important contribution to this study. LASU Second Gate - the sampling point would be used to represent transportation route where there is a relatively free flow of traffic compared to the sites at Iyana Iba. LASU Main Campus – Faculty of Science would be used as the control station

Figure 1: Map Showing Sampling Point in Yellow Tags

Table 1: Sampling Locations (Data Collection)

SITE	Coordinates, decimal	
	Northings (N)	Easting´s (E)
Botanical Garden, Faculty of Science, Lagos State University	06.46680	003.19975
Lagos State University Iba Gate	06.47404	003.20254
Lagos State University Main Gate	06.46078	003.20413
Iyana Iba Bus-stop Beside the armored vehicles	06.46287	003.20084
Okokomaiko Bus-stop Opposite the Police Station	06.47245	003.18747

Field Instruments

MSA 5x Multi Gas Detector: It was used to collect oxygen, carbon monoxide (CO), hydrocarbon (LEL) and hydrogen sulphide (H_2S). The unit of measurement for all the above gases except O_2 is parts per million of volume (ppm), O_2 was measured in % volume. Kanomax Single Gas

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Detector: This was used to detect Nitrogen dioxide (NO_2) and Sulphur dioxide (SO_2). Pre-calibrated digital readout noise meter: Noise levels at each point were measured with a pre-calibrated digital readout noise meter. A logger (Testo 450): This was used for measuring temperature, atmospheric pressure and relative humidity.
The TSI AeroTrak® Handheld Particle Counter Model 9303: This was used to determine the suspended particulate matter (SPM).

Method of Data Analysis

Traffic Count
The traffic density was determined by directly observing and counting the traffic during the usual peak traffic periods 8:00 a.m. - 10.00 a.m., and 4:00 p.m. – 6:00 p.m. each day for eight days. The number of traffic at each site per hour was counted using an electronic counting machine.

Statistical Analysis
The statistics for the data obtained during the period included mean, standard deviation, min and max values. Statistical analyses were carried out using Microsoft Excel 2007. In order to evaluate the ambient air quality, the mean results of each parameters ± standard deviation were compared to standards from the World Health Organization and National Ambient Air Quality Standards.

Table 2 Nigerian Ambient Air Quality Standard
Source: FEPA (Federal Environmental Protection agency), 1991

Pollutants	Time of Average	Limit
Particulates	Daily average of daily values 1 hour.	250 µg/m^3 *600 µg/m^3
Sulphur oxides (Sulphur dioxide)	Daily average of hourly values 1 hour	0.01 ppm (26 µg/m^3) 0.1 ppm (26 µg/m^3
Non-methane Hydrocarbon	Daily average of 3-hourly values	160 µg/m^3
Carbon monoxide	Daily average of hourly values 8-hourly average	10 ppm (11.4 µg/m^3) 20 ppm (22.8 µg/m^3)
Nitrogen oxides (Nitrogen dioxide)	Daily average of hourly values (range)	0.04 ppm-0.06 ppm (75.0 µg/m^3-113 µg/m^3)
Photochemical oxidant	Hourly values	0.06 ppm

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Table 3 Noise Exposure Limits for Nigeria

Duration Day, Hour	Permissible Exposure Limit dB (A)
8	90
6	92
4	95
3	97
8	90
6	92
4	95
3	97
2	100
1.5	102
1 0.5	105 110
0.25 or less	115

LOCATIONS	O_2%	NO_2 (ppm)	VOC (ppm)	CO (µg/m^3)	CO_2 (ppm)	SO_2 (µg/m^3)	SPM (µg/m^3)	HUM %	Temp 0^0C
NESREA LIMITS	NS	313 µg/m^3	-	30,000 µg/m^3	NS	425 µg/m^3	250 µg/m^3	NS	35 Max
NAAQS (FEPA 1991) Limits	NS	75 – 113 µg/m^3	-	11.4 – 113 µg/m^3	260-425	26 µg/m^3	250 µg/m^3	NS	35 Max

RESULTS AND DISCUSSION

The results of the monitoring carried out at different sampling stations within the metropolis were analysed and the statistics of the various parameters examined per sampling area is contained in Table 4 to 17

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Table 4: Traffic volume between the hours of 8am and 10am

Sampling Station	**Sampling Days**								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Botanical Garden, Faculty of Science, LASU	**Bike**	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
	Vehicles	14	8	11	13	15	13	13	14
	Articulated vehicles	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
LASU Iba Gate	**Bike**	11	14	15	15	18	13	15	20
	Vehicles	105	98	118	132	102	108	119	127
	Articulated vehicles	132	157	147	157	149	163	163	154
Iyana Iba Bus stop	**Bike**	31	33	32	38	28	35	33	27
	Vehicles	107	127	112	112	108	126	108	126
	Articulated vehicles	138	146	160	148	150	146	161	156
LASU Main Gate	**Bike**	35	26	34	32	28	31	25	27
	Vehicles	156	136	142	113	119	112	112	121
	Articulated vehicles	164	150	155	140	126	132	133	151

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Okokomaiko Bus stop	**Bike**	37	37	26	40	31	31	28	28
	Vehicles	142	137	149	142	110	128	130	136
	Articulated vehicles	159	139	139	145	148	152	148	157

Table 5: Traffic volume between the hours of 4pm and 6pm

Sampling Station	**Sampling Days**								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Botanical Garden, Faculty of Science, LASU	**Bike**	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
	Vehicles	9	10	10	8	13	11	7	10
	Articulated vehicles	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
LASU Iba Gate	**Bike**	28	18	27	23	25	18	27	23
	Vehicles	109	155	120	138	114	134	146	118
	Articulated vehicles	162	92	126	125	138	92	147	163
Iyana Iba Bus stop	**Bike**	24	22	27	24	28	19	19	27
	Vehicles	116	154	144	151	148	133	153	120
	Articulated vehicles	92	101	127	159	153	101	121	103

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LASU Main Gate	**Bike**	22	26	25	24	22	27	24	22
	Vehicles	143	119	151	119	133	118	123	155
	Articulated vehicles	117	164	138	133	153	128	117	94
Okokomaiko Bus stop	**Bike**	21	21	25	27	27	22	19	18
	Vehicles	124	134	132	115	136	138	120	138
	Articulated vehicles	120	137	101	94	123	147	158	152

Table 6: Ambient Air Monitoring between the hours of 8am and 10am

Sampling Station	**Sampling Days**								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Botanical Garden, Faculty of Science LASU	**NO_2**	0.01	0.04	0.04	0.02	0.00	0.06	0.03	0.00
	SO_2	0.03	0.08	0.09	0.04	0.01	0.13	0.06	0.01
	CO	5.00	3.00	2.00	5.00	5.00	3.00	4.00	3.00
	H_2S	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	SPM	53.82	35.30	36.89	35.60	36.47	42.05	39.28	50.00
	Temperature	31.2	31.6	31.5	31.3	31.6	31.6	31.0	31.1
	Humidity	75.1	74.9	76.3	76.9	75.3	76.0	75.4	76.4
LASU Iba Gate	**NO_2**	0.03	0.07	0.07	0.00	0.03	0.10	0.09	0.06
	SO_2	0.05	0.57	0.65	0.03	0.27	0.85	0.81	0.55
	CO	13.00	8.00	13.00	11.00	13.00	10.00	8.00	6.00
	H_2S	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	SPM	94.42	84.97	53.47	92.78	69.17	86.39	93.51	95.23
	Temperature	31.1	31.6	31.5	31.9	31.4	31.3	31.2	31.4
	Humidity	77.0	75.0	76.2	75.7	74.1	76.7	74.1	75.9
Iyana Iba Bus stop	**NO_2**	0.43	0.77	0.45	0.04	0.21	0.57	0.36	0.44
	SO_2	0.35	0.63	0.37	0.04	0.18	0.47	0.29	0.36

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	CO	31.00	47.00	48.00	30.00	33.00	52.00	54.00	40.00
	H_2S	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	SPM	115.75	85.87	119.97	77.35	92.97	94.66	108.15	86.89
	Temperature	31.2	31.5	31.1	32.0	31.4	31.9	31.7	31.9
	Humidity	76.9	75.5	75.5	74.1	74.0	76.3	75.9	75.2
LASU Main Gate	**NO_2**	0.66	0.55	0.85	0.66	1.20	1.05	1.30	0.02
	SO_2	0.79	0.66	1.00	0.79	1.43	1.24	1.54	0.02
	CO	34.00	25.00	29.00	32.00	24.00	29.00	29.00	33.00
	H_2S	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	SPM	87.65	92.97	116.62	110.84	114.72	85.65	74.82	96.58
	Temperature	31.3	31.1	31.0	32.0	31.9	31.1	31.5	31.1
	Humidity	76.8	75.9	75.6	74.6	76.1	76.3	77.0	75.1
Okokomaiko Bus stop	**NO_2**	0.99	1.25	0.02	0.49	0.05	1.02	1.46	0.62
	SO_2	0.91	1.17	0.02	0.46	0.05	0.95	1.36	0.58
	CO	41.00	63.00	65.00	55.00	47.00	58.00	53.00	57.00
	H_2S	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	SPM	136.78	68.92	81.43	136.21	97.07	102.40	155.78	131.23
	Temperature	31.8	31.1	31.7	31.2	31.3	31.1	31.7	31.2
	Humidity	74.6	75.0	74.4	76.1	76.9	76.9	75.5	75.8

Table 7: Ambient Air Monitoring between the hours of 4pm and 6pm

Sampling Station	**Sampling Days**								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Botanical Garden, Faculty of Science, LASU	**NO_2**	0.04	0.03	0.01	0.00	0.01	0.03	0.05	0.07
	SO_2	0.09	0.06	0.03	0.01	0.02	0.06	0.12	0.14
	CO	3.00	5.00	3.00	4.00	4.00	3.00	4.00	3.00
	H_2S	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

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	SPM	37.73	37.72	49.26	37.15	52.79	39.88	37.39	43.50
	Temperature	32.1	32.9	32.6	32.9	32.9	32.3	32.0	32.0
	Humidity	65.2	66.9	64.0	65.4	66.9	64.2	65.8	66.4
LASU Iba Gate	**NO_2**	0.49	0.14	0.38	0.47	0.05	0.08	0.03	0.03
	SO_2	0.86	0.25	0.67	0.81	0.44	0.72	0.24	0.23
	CO	15.00	13.00	15.00	10.00	9.00	10.00	8.00	11.00
	H_2S	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	SPM	89.29	46.96	59.04	69.65	80.92	46.80	54.44	88.61
	Temperature	32.6	32.3	32.6	32.4	32.6	32.6	32.2	32.1
	Humidity	66.4	66.2	66.9	66.6	64.1	64.7	64.0	64.2
Iyana Iba Bus stop	**NO_2**	0.75	0.05	0.68	0.41	0.35	0.71	0.61	0.65
	SO_2	0.62	0.04	0.56	0.34	0.28	0.58	0.50	0.53
	CO	28.00	36.00	27.00	49.00	41.00	26.00	40.00	34.00
	H_2S	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	SPM	66.36	84.78	82.20	68.46	102.52	72.32	65.91	98.98
	Temperature	32.9	32.2	33.0	32.6	32.4	32.3	32.2	32.1
	Humidity	64.1	65.5	64.4	65.9	66.0	65.4	65.0	64.6
LASU Main Gate	**NO_2**	0.37	0.35	0.98	1.31	0.68	1.17	0.13	0.70
	SO_2	0.44	0.42	1.17	1.55	0.81	1.38	0.16	0.82
	CO	28.00	26.00	27.00	23.00	26.00	31.00	32.00	24.00

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	H_2S	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	SPM	114.09	97.14	81.02	107.25	70.17	111.05	87.19	101.49
	Temperature	32.9	32.7	32.0	32.2	32.8	32.3	32.7	32.1
	Humidity	64.5	66.8	66.5	64.9	65.1	66.5	66.4	64.3
Okokomaiko Bus stop	**NO_2**	0.30	0.36	1.31	0.34	0.30	1.76	1.24	0.68
	SO_2	0.28	0.33	1.22	0.32	0.28	1.64	1.16	0.63
	CO	49.00	54.00	40.00	55.00	47.00	32.00	67.00	53.00
	H_2S	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	SPM	86.39	126.46	115.00	139.88	112.71	76.98	84.14	138.78
	Temperature	32.9	33.0	33.0	32.8	32.4	32.2	32.6	32.0
	Humidity	65.5	65.3	64.1	64.2	65.7	66.3	66.0	64.3

Table 8a: Comparison of mean for traffic volume between the hours of 8am and 10am for all sites (n=8)

Sampling Station	**Transport Type**	Min	Max	Average	Stdev
Botanical Garden, Faculty of Science, LASU	**Bike**	0.00	0.00	0.00	0.00
	Vehicles	8.00	15.00	12.63	2.20
	Articulated vehicles	0.00	0.00	0.00	0.00
LASU Iba Gate	**Bike**	11.00	20.00	15.13	2.80
	Vehicles	98.00	132.00	113.63	12.25

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	Articulated vehicles	132.00	163.00	152.75	10.18
Iyana Iba Bus stop	**Bike**	27.00	38.00	32.13	3.56
	Vehicles	107.00	127.00	115.75	8.96
	Articulated vehicles	138.00	161.00	150.63	7.87
LASU Main Gate	**Bike**	25.00	35.00	29.75	3.77
	Vehicles	112.00	156.00	126.38	16.43
	Articulated vehicles	126.00	164.00	143.88	13.15
Okokomaiko Bus stop	**Bike**	26.00	40.00	32.25	5.12
	Vehicles	110.00	149.00	134.25	11.91
	Articulated vehicles	139.00	159.00	148.38	7.44

Table 8b: Comparison of mean for **traffic volume between the hours of 8am and 10am for all sites (n=8)**

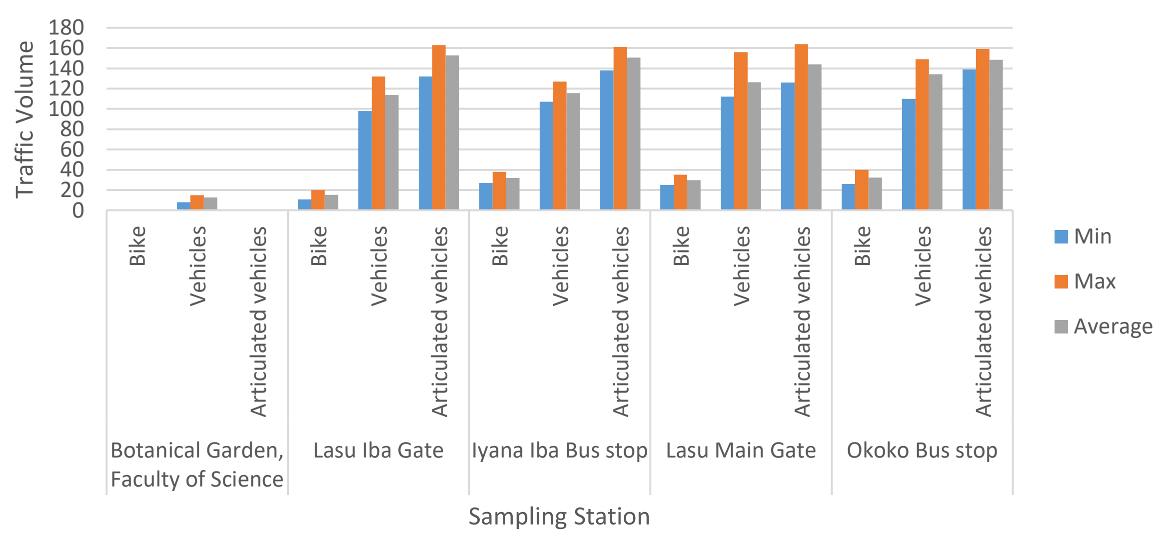

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Table 9a: Comparison of mean for **traffic volume between the hours of 4pm and 6pm for all sites (n=8)**

Sampling Station	**Transport Type**	Min	Max	Average	Stdev
Botanical Garden, Faculty of Science, LASU	**Bike**	0.00	0.00	0.00	0.00
	Vehicles	7.00	13.00	9.75	1.83
	Articulated vehicles	0.00	0.00	0.00	0.00
LASU Iba Gate	**Bike**	18.00	28.00	23.63	3.93
	Vehicles	109.00	155.00	129.25	16.46
	Articulated vehicles	92.00	163.00	130.63	27.75
Iyana Iba Bus stop	**Bike**	19.00	28.00	23.75	3.54
	Vehicles	116.00	154.00	139.88	15.08
	Articulated vehicles	92.00	159.00	119.63	25.22
LASU Main Gate	**Bike**	22.00	27.00	24.00	1.93
	Vehicles	118.00	155.00	132.63	15.23
	Articulated vehicles	94.00	164.00	130.50	22.02
Okokomaiko Bus stop	**Bike**	18.00	27.00	22.50	3.46
	Vehicles	115.00	138.00	129.63	8.81
	Articulated vehicles	94.00	158.00	129.00	23.56

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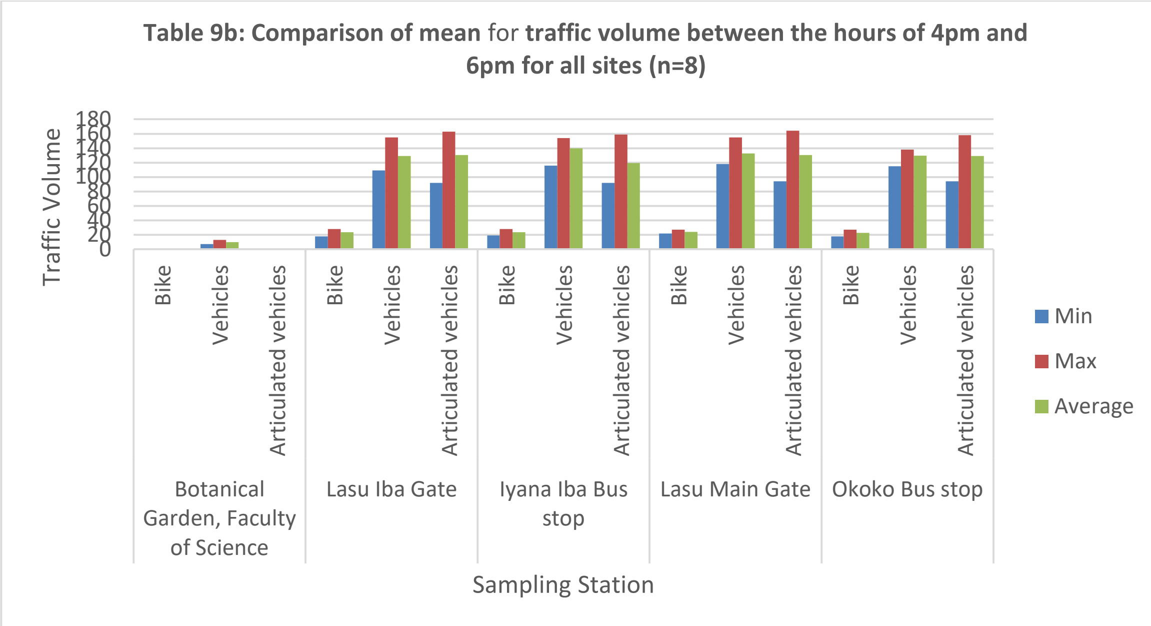

Table 10: Comparison of Mean for Ambient Air Monitoring by Sampling Stations Between the Hours of 8am And 10am

Sampling Station	Pollutants	Min	Max	Average	Stdev
Botanical Garden, Faculty of Science, LASU	**NO_2**	0.00	0.06	0.03	0.02
	SO_2	0.01	0.13	0.06	0.04
	CO	2.00	5.00	3.75	1.16
	H_2S	0.00	0.00	0.00	0.00
	SPM	35.30	53.82	41.18	7.05
	Temperature	31.00	31.60	31.36	0.24
	Humidity	74.90	76.90	75.79	0.71
LASU Iba Gate	**NO_2**	0.00	0.10	0.06	0.03
	SO_2	0.03	0.85	0.47	0.32
	CO	6.00	13.00	10.25	2.71
	H_2S	0.00	0.00	0.00	0.00
	SPM	53.47	95.23	83.74	14.93
	Temperature	31.10	31.90	31.43	0.25
	Humidity	74.10	77.00	75.59	1.10
Iyana Iba Bus stop	**NO_2**	0.04	0.77	0.41	0.22
	SO_2	0.04	0.63	0.34	0.18
	CO	30.00	54.00	41.88	9.67

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	H_2S	0.00	0.00	0.00	0.00
	SPM	77.35	119.97	97.70	15.28
	Temperature	31.10	32.00	31.59	0.34
	Humidity	74.00	76.90	75.43	1.00
LASU Main Gate	**NO_2**	0.02	1.30	0.79	0.41
	SO_2	0.02	1.54	0.93	0.49
	CO	24.00	34.00	29.38	3.58
	H_2S	0.00	0.00	0.00	0.00
	SPM	74.82	116.62	97.48	15.18
	Temperature	31.00	32.00	31.38	0.39
	Humidity	74.60	77.00	75.93	0.81
Okokomaiko Bus stop	**NO_2**	0.02	1.46	0.74	0.53
	SO_2	0.02	1.36	0.69	0.50
	CO	41.00	65.00	54.88	7.94
	H_2S	0.00	0.00	0.00	0.00
	SPM	68.92	155.78	113.73	30.63
	Temperature	31.10	31.80	31.39	0.29
	Humidity	74.40	76.90	75.65	0.96

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Table 11: Comparison of Mean for Ambient Air Monitoring by Sampling Stations Between the Hours of 4pm and 6pm

Sampling Station	Pollutants	Min	Max	Average	Stdev
Botanical Garden, Faculty of Science, LASU	**NO_2**	0.00	0.07	0.03	0.02
	SO_2	0.01	0.14	0.07	0.05
	CO	3.00	5.00	3.63	0.74
	H_2S	0.00	0.00	0.00	0.00
	SPM	37.15	52.79	41.93	6.06
	Temperature	32.00	32.90	32.46	0.41
	Humidity	64.00	66.90	65.60	1.12
LASU Iba Gate	**NO_2**	0.03	0.49	0.21	0.20
	SO_2	0.23	0.86	0.53	0.27
	CO	8.00	15.00	11.38	2.67
	H_2S	0.00	0.00	0.00	0.00
	SPM	46.80	89.29	66.96	17.71
	Temperature	32.10	32.60	32.43	0.21
	Humidity	64.00	66.90	65.39	1.25
Iyana Iba Bus stop	**NO_2**	0.05	0.75	0.53	0.24
	SO_2	0.04	0.62	0.43	0.20
	CO	26.00	49.00	35.13	8.04
	H_2S	0.00	0.00	0.00	0.00
	SPM	65.91	102.52	80.19	14.50
	Temperature	32.10	33.00	32.46	0.34
	Humidity	64.10	66.00	65.11	0.70
LASU Main Gate	**NO_2**	0.13	1.31	0.71	0.42
	SO_2	0.16	1.55	0.84	0.49
	CO	23.00	32.00	27.13	3.14
	H_2S	0.00	0.00	0.00	0.00
	SPM	70.17	114.09	96.18	15.50
	Temperature	32.00	32.90	32.46	0.35
	Humidity	64.30	66.80	65.63	1.02
Okokomaiko Bus stop	**NO_2**	0.30	1.76	0.79	0.57
	SO_2	0.28	1.64	0.73	0.53
	CO	32.00	67.00	49.63	10.50
	H_2S	0.00	0.00	0.00	0.00
	SPM	76.98	139.88	110.04	24.90
	Temperature	32.00	33.00	32.61	0.38
	Humidity	64.10	66.30	65.18	0.86

Table 12: Comparison of Mean for Ambient Air Monitoring of Pollutants between the Hours of 8am to 10am

Pollutants	**Sampling Station**	Min	Max	Average	Stdev
NO_2	**Botanical Garden, LASU**	0.00	0.06	0.03	0.02
	LASU Iba Gate	0.00	0.10	0.06	0.03
	IyanaIba Bus stop	0.04	0.77	0.41	0.22
	LASU Main Gate	0.02	1.30	0.79	0.41
	Okokomaiko Bus stop	0.02	1.46	0.74	0.53
SO_2	**Botanical Garden, LASU**	0.01	0.13	0.06	0.04
	LASU Iba Gate	0.03	0.85	0.47	0.32
	IyanaIba Bus stop	0.04	0.63	0.34	0.18
	LASU Main Gate	0.02	1.54	0.93	0.49
	Okokomaiko Bus stop	0.02	1.36	0.69	0.50
CO	**Botanical Garden, LASU**	2.00	5.00	3.75	1.16
	LASU Iba Gate	6.00	13.00	10.25	2.71
	IyanaIba Bus stop	30.00	54.00	41.88	9.67
	LASU Main Gate	24.00	34.00	29.38	3.58
	Okokomaiko Bus stop	41.00	65.00	54.88	7.94
H_2S	**Botanical Garden, LASU**	0.00	0.00	0.00	0.00
	LASU Iba Gate	0.00	0.00	0.00	0.00
	IyanaIba Bus stop	0.00	0.00	0.00	0.00
	LASU Main Gate	0.00	0.00	0.00	0.00
	Okokomaiko Bus stop	0.00	0.00	0.00	0.00
SPM	**Botanical Garden, LASU**	35.30	53.82	41.18	7.05
	LASU Iba Gate	53.47	95.23	83.74	14.93
	Iyana Iba Bus stop	77.35	119.97	97.70	15.28
	LASU Main Gate	74.82	116.62	97.48	15.18
	Okokomaiko Bus stop	68.92	155.78	113.73	30.63

Table 13: Comparison of Mean for Ambient Air Monitoring of Pollutants Between the Hours of 4pm to 6pm

Pollutants	**Sampling Station**	Min	Max	Average	Stdev
NO_2	**Botanical Garden, LASU**	0.00	0.07	0.03	0.02
	LASU Iba Gate	0.03	0.49	0.21	0.20
	Iyana Iba Bus stop	0.05	0.75	0.53	0.24
	LASU Main Gate	0.13	1.31	0.71	0.42
	Okokomaiko Bus stop	0.30	1.76	0.79	0.57
SO_2	**Botanical Garden, LASU**	0.01	0.14	0.07	0.05
	LASU Iba Gate	0.23	0.86	0.53	0.27
	Iyana Iba Bus stop	0.04	0.62	0.43	0.20
	LASU Main Gate	0.16	1.55	0.84	0.49
	Okokomaiko Bus stop	0.28	1.64	0.73	0.53
CO	**Botanical Garden, LASU**	3.00	5.00	3.63	0.74
	LASU Iba Gate	8.00	15.00	11.38	2.67
	Iyana Iba Bus stop	26.00	49.00	35.13	8.04
	LASU Main Gate	23.00	32.00	27.13	3.14
	Okokomaiko Bus stop	32.00	67.00	49.63	10.50
H_2S	**Botanical Garden, LASU**	0.00	0.00	0.00	0.00

	LASU Iba Gate	0.00	0.00	0.00	0.00
	IyanaIba Bus stop	0.00	0.00	0.00	0.00
	LASU Main Gate	0.00	0.00	0.00	0.00
	Okokomaiko Bus stop	0.00	0.00	0.00	0.00
SPM	**Botanical Garden, LASU**	37.15	52.79	41.93	6.06
	LASU Iba Gate	46.80	89.29	66.96	17.71
	IyanaIba Bus stop	65.91	102.52	80.19	14.50
	LASU Main Gate	70.17	114.09	96.18	15.50
	Okoko Bus stop	76.98	139.88	110.04	24.90

Table 14: Variation of CO across the sampling sites

Pollutants	**Sampling Station**	**8am-10am**				**4pm-6pm**			
		Min	**Max**	**Average**	**Stdev**	**Min**	**Max**	**Average**	**Stdev**
CO	**Botanical Garden, LASU**	2.00	5.00	3.75	1.16	3.00	5.00	3.63	0.74
	LASU Iba Gate	6.00	13.00	10.25	2.71	8.00	15.00	11.38	2.67
	IyanaIba Bus stop	30.00	54.00	41.88	9.67	26.00	49.00	35.13	8.04
	LASU Main Gate	24.00	34.00	29.38	3.58	23.00	32.00	27.13	3.14
	Okokomaiko Bus stop	41.00	65.00	54.88	7.94	32.00	67.00	49.63	10.50

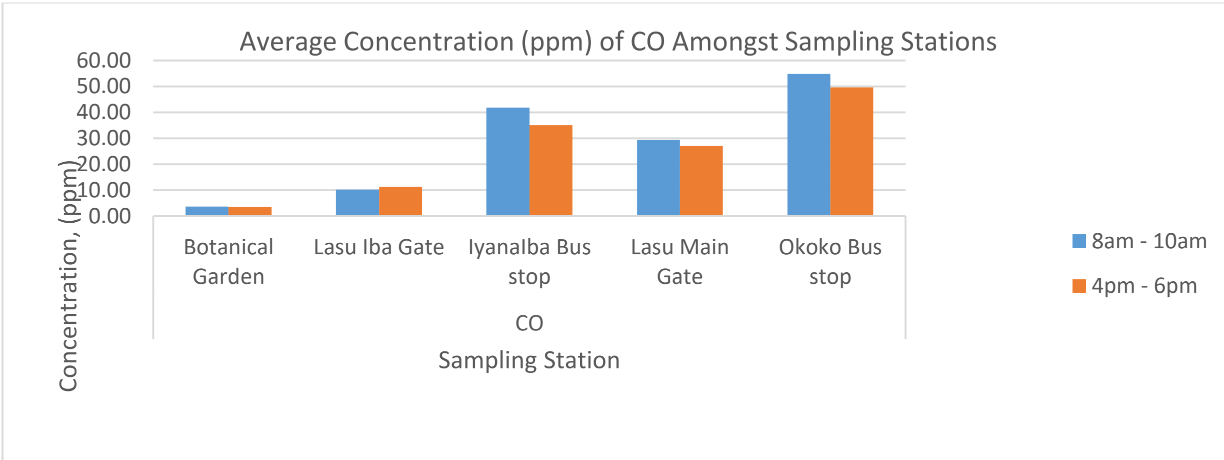


Table 15: Variation of NO_2 across the sampling sites

Pollutants	Sampling Station	8am-10am				4pm-6pm			
		Min	Max	Average	Stdev	Min	Max	Average	Stdev
NO_2	Botanical Garden, LASU	0.00	0.06	0.03	0.02	0.00	0.07	0.03	0.02
	LASU Iba Gate	0.00	0.10	0.06	0.03	0.03	0.49	0.21	0.20
	IyanaIba Bus stop	0.04	0.77	0.41	0.22	0.05	0.75	0.53	0.24
	LASU Main Gate	0.02	1.30	0.79	0.41	0.13	1.31	0.71	0.42
	Okokomaiko Bus stop	0.02	1.46	0.74	0.53	0.30	1.76	0.79	0.57

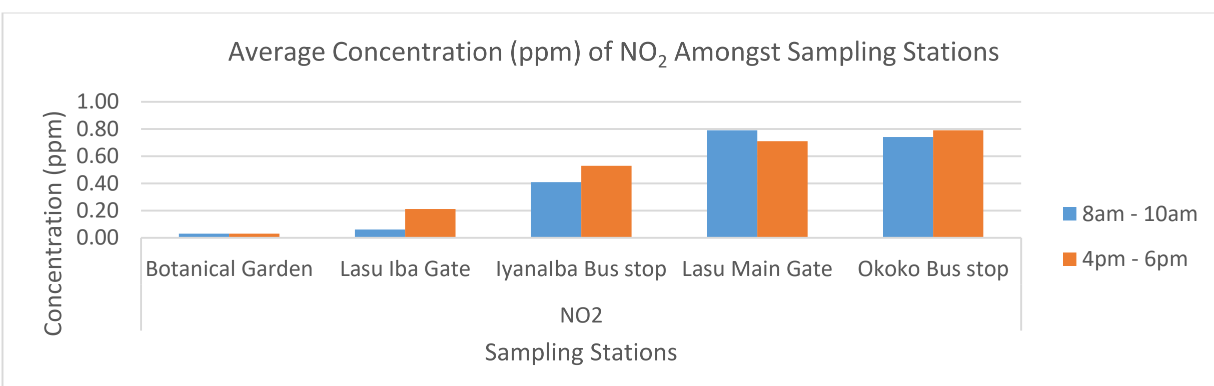


Table 16: Variation of SO_2 across the sampling sites

Pollutants	Sampling Station	8am-10am				4pm-6pm			
		Min	Max	Average	Stdev	Min	Max	Average	Stdev
SO_2	Botanical Garden, LASU	0.01	0.13	0.06	0.04	0.01	0.14	0.07	0.05
	LASU Iba Gate	0.03	0.85	0.47	0.32	0.23	0.86	0.53	0.27
	IyanaIba Bus stop	0.04	0.63	0.34	0.18	0.04	0.62	0.43	0.20
	LASU Main Gate	0.02	1.54	0.93	0.49	0.16	1.55	0.84	0.49
	Okokomaiko Bus stop	0.02	1.36	0.69	0.50	0.28	1.64	0.73	0.53

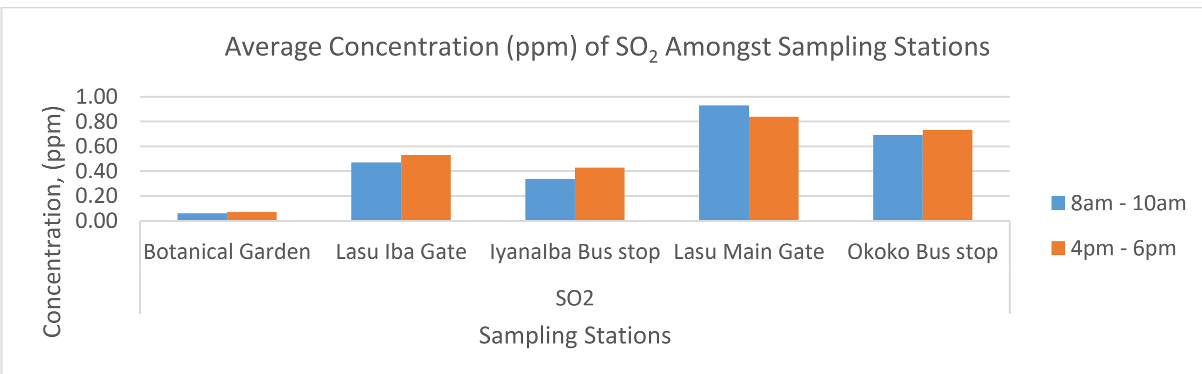
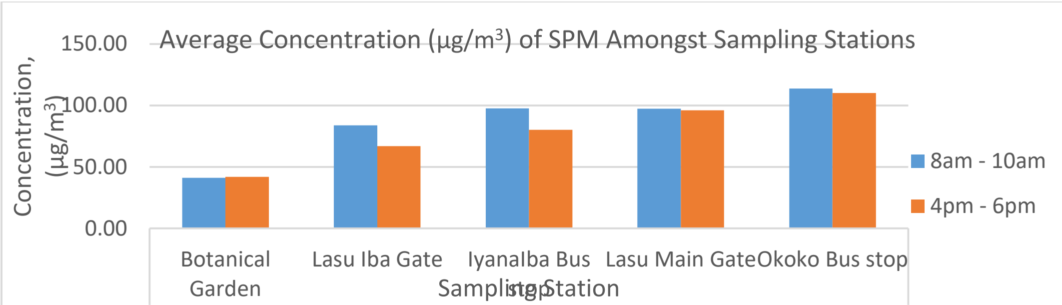


Table 17: Variation of SPM across the sampling sites

Pollutants	Sampling Station	8am-10am				4pm-6pm			
		Min	Max	Average	Stdev	Min	Max	Average	Stdev
SPM	Botanical Garden, LASU	35.30	53.82	41.18	7.05	37.15	52.79	41.93	6.06
	LASU Iba Gate	53.47	95.23	83.74	14.93	46.80	89.29	66.96	17.71
	IyanaIba Bus stop	77.35	119.97	97.70	15.28	65.91	102.52	80.19	14.50
	LASU Main Gate	74.82	116.62	97.48	15.18	70.17	114.09	96.18	15.50
	Okokomaiko Bus stop	68.92	155.78	113.73	30.63	76.98	139.88	110.04	24.90



DISCUSSION

Carbon Monoxide, CO

The results showed that the concentration of CO at Okokomaiko Bus-stop was the highest with an average of 54.88±7.94 ppm (n=8). At this site, the concentration fell between 41.00 and 65.00ppm between the hours of 8am and 10am while the average concentration between 4pm and 6pm was 49.63±10.50. CO is a colorless, odorless gas that can be harmful when inhaled in large amounts. CO is released when something is burned or is produced in the incomplete combustion of carbon-containing fuels, such as gasoline, natural gas, oil, coal, and wood. The greatest sources of CO to outdoor air are cars, trucks and other vehicles or machinery that burn fossil fuels. The reason for high concentration of CO at Okokomaiko Bus-stop is due to the high vehicular traffic

These concentrations at Iyana Iba Bus stop are also high and differ from the ambient standard of 10 ppm for CO. Around Iyana Iba bus stop area beside the mobile police armored tank by the kerbside, the average CO was 41.88±9.67 ppm during the AM monitoring and 35.13±8.04 ppm for the PM.

The mean concentration of carbon monoxide detected at LASU Iba gate ranged between 6 ppm and 13 ppm at the AM monitoring with at average concentration of 10.25±2.71 and an average concentration of 11.38±2.67 for the PM monitoring. Although the mean value of carbon monoxide for the LASU main gate and LASU Iba gate sampling stations were relatively lower than Iyana Iba and Okokomaiko areas of the metropolis, the result were however higher than the maximum standard of 10 ppm stipulated for ambient air. Carbon monoxide detected at the control site (Botanical garden, Faculty of Science) was less than 10ppm and this was expected since the little traffic influx was relatively low.

The emission of carbon monoxide from the preliminary assessment therefore followed the following trend and pattern.
Okokomaiko Bus stop>Iyana Iba Bus stop>LASU main gate>LASU Iba gate>Botanical garden Faculty of science. This was in agreement with the postulation by Baumbach et al (1995) that contribution of traffic to the metropolitan CO was the highest. The trend followed by the pattern is in line with the highest number of vehicles and articulated at Iyana Iba and Okokomaiko Bus stop followed by LASU Main gate to the control site where there was little vehicular movement nor power generator that could emit carbon monoxide into the atmosphere. It has also been demonstrated that there is a strong correlation between the roadside CO concentration and traffic volume on the road. This is in agreement with (Colucci and Begeman,1969). According to Colucci

and Begeman (1969), CO concentration is influenced greatly by traffic flow in which case the concentration for free-flowing traffic was less compared to an impeded flow due to traffic jam as experienced in most of the locations studied.

Hydrogen Sulphide, H_2S

Since the study was for ambient air quality purpose, H_2S gas was measured to determine if it could form part of the input into the monitoring framework. The result of the monitoring showed that hydrogen sulphide profile within the metropolis and control stations was not detected within the equipment's detection limit. Hydrogen Sulphide (H_2S) is a gas commonly found during the drilling and production of crude oil and natural gas, plus in wastewater treatment and utility facilities and sewers. The gas is produced as a result of the microbial breakdown of organic materials in the absence of oxygen. Colorless, flammable, poisonous and corrosive, H_2S gas is noticeable by its rotten egg smell. And there was no such smell in all the locations studied.

Nitrogen Dioxide

Nitrogen oxides, measured as nitrogen dioxide, is an important pollution index in air quality management. Many studies have been conducted on the ambient concentration of this gas in megacities of the world. The results of monitoring scenarios showed that the concentration varies from one part of the sampling station to the other. During the monitoring the mean nitrogen dioxide at all the sites was between <0.01 and 1.76 ppm. The control site had the least concentration values and at times below the detection limit of the equipment. LASU Iba gate had the lowest mean concentration of 0.06±0.03 ppm during the AM monitoring and 0.21±0.20 ppm followed by Iyana Iba and Lasu main gate sites with 0.41±0.22 ppm and 0.79±0.41 ppm for the AM monitoring respectively and 0.53±0.24 ppm and 0.71±0.42 ppm for the PM sampling.

The WHO ambient air quality standard guideline for one hour average time is 0.106 ppm. When compared with the result obtained, only LASU Iba gate and the control site had values that compare favourably with the standard. All other sites exceeded the limit. Hence, the need for its comprehensive monitoring as input into air quality model for the city. Although, there were times when the gas was not detected at all below the detection limit of the equipment, very high concentrations were detected at most of the site up to level of 1.76 ppm especially at Okokomaiko. NO_2 emission contributes negatively to acid rain and global warming due to its reactivity with hydrocarbon to form the ground level O_3

Sulphur dioxide, SO_2

Sulphur dioxide has been implicated in the formation of acid rain and exacerbation of respiratory illness from short-term exposure (WHO, 2011). Results of assessment of the quality of air within the sampling stations with respect to sulphur dioxide showed that the mean concentration for hourly average measurement at all the monitoring sites was between 0.06±0.04 ppm and 0.93±0.49 ppm for the AM monitoring and 0.07±0.05 ppm and 0.84±0.49 ppm for the PM monitoring. When compared with international standards, the mean sulphur dioxide at the control site was the only result that was lower than the USAAQ guidelines for the one-hour averaging time. At the other sites, the mean value was greater than 75 ppm by values ranging from 100 to over 500%.

Sulphur dioxide was detected at different concentrations within the sites at different times within the AM and PM monitoring period. However, the maximum value detected was 1.64 ppm at

Okokomaiko Bus stop. LASU Iba gate and control station had the lowest results while Iyana Iba and Lasu main gate followed suite. Maximum values of sulphur dioxide emission were detected at LASU main gate and Okokomaiko bus stop with average concentration of 0.93ppm and 0.69 ppm.

At LASU Iba gate, which is along a continuous traffic route, concentrations of SO_2 was lower than the none moving traffic at the LASU main gate, hence the wide range of the concentration.
According to WHO guidelines for ambient air quality the maximum tolerable annual sulphur dioxide on the atmosphere is 19.00 ppbv. America (US EPA) and Canada have more stringent guidelines with 3.00 and 2.00 ppbv annual guideline. From the results obtained at all the sites only Botanical garden and LASU Iba gate conformed to the standards. Other sites had results that exceeded the limit and is a cause for concern for air quality management in the metropolis. The non-flowing of traffic could be attributed to the increased concentration.

Suspended Particulate Matter, SPM
The mean suspended particulate matter at all the sampling locations except Botanical garden was very high. The mean SPM was as high as 139.88 μg/m^3 at Okokomaiko Bus stop. At LASU Iba Gate, the suspended particulate matter varied from 53.47 to 95.23 μg/m^{3}with a mean value of 83.74±14.93 μg/m^3 for the AM monitoring. This level is below the 250 μg/m^3 WHO standards for ambient air quality. Iyana Iba and Okokomaiko had concentration values of SPM ranging from 97.70±15.28 μg/m^3 and 113.00±30.63 μg/m^3 respectively for the AM monitoring and 80.19±14.50 μg/m^3 and 110.04±24.90 μg/m^3 for the PM monitoring. These values are relatively normal taking into consideration the flow and number of traffic. These results could also be attributed to the weather condition during the sampling period as humidity was in 70's. High SPM could also be attributed to unpaved roads or bad road conditions, high number of commercial Lorries that produce large quantities of soot and particulate among other sources.
The aerodynamic particulate matter was different from site to site and the results were in the following decreasing order of magnitude.
Okokomaiko>Iyana Iba>LASU main gate>>LASU Iba gate>Botanical garden, Faculty of Science

The limit set for SPM by the World Health Organization, EPA and NAAQ standards are 250 μg/m^3. When compared to the mean values obtained at all the sites within the metropolis, the SPM did not exceed the standard. The highest mean SPM result obtained at Okokomaiko was 139.88 μg/m^3.

CONCLUSION

Urban air pollution patterns may vary from one city to another depending on various factors, and pollutants need to be identified and quantified according to their potential sources. The assessment of the impact of vehicular emissions on the air quality of Ojo Local Government area Lagos showed that traffic density can increase the concentration of air pollutants (NO_2 SO_2, CO and SPM) emanating from vehicular emissions as pollutants concentrations showed high correlation with traffic density except for Hydrogen sulphide (H_2S) that was not detected. All the pollutants were either within or above the WHO standards for ambient air quality.

The overall situation regarding vehicular emissions in the study locations is poor with a potential human health effect. The results revealed that motor vehicle emissions in Ojo Local Government area, Lagos especially the urban core include pollutants like CO, NO_2, SPM and SO_2.

The levels of the CO measured at all the sampling points with exemption of the control station and LASU Iba gate were above the WHO standards for ambient air quality. The results of the sampling station at LASU Iba gate is lower than other sampling sites and could be attributed to the flowing traffic at LASU Iba gate and the static traffic at other sampling stations. Therefore, in this aspect air quality is poor and hazardous for health.
As for SO_2 measured, when compared with international standards, the mean sulphur dioxide at the control site was the only site with mean result that was lower than the WHO standards for the one-hour averaging time.

NO_2 compare favorably with the WHO standard for ambient air quality at the control station and LASU Iba gate while all other sites exceeded the safe limit of 75 – 113 $\mu g/m^3$. This implies that vehicular emissions within Ojo Local Government area, Lagos are not within the safe limits. Hence, the results revealed that transport-related pollution in studied locations is significant with potentially hazardous health consequences. The SPM did not exceed the WHO standards for ambient air quality for all the sites.

Finally, this study also revealed that gaseous pollutants in the air, such as CO, NO_2, SO_2 and SPM directly or indirectly threaten the environment and life of inhabitants of Ojo Local Government area, Lagos and that motor vehicles emission and other related activities carried out along these roads remain the main sources of these pollutants.

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