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Real-Time Quantitative Assessment of Transport Induced Greenhouse Gases Emissions in Lagos, Nigeria.

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Abstract: Over the years, scientists have established that when fossil fuels are burned, the resultant effect is the pollution of the ambient air. Pollutants such as carbon monoxide (CO), methane (CH_4), oxides of nitrogen (NO_X), oxides of sulfur (SO_X), volatile organic hydrocarbons, particulate matter, atmospheric greenhouse gases (GHGs) such as carbon dioxide (CO_2) and methane (CH_4) are released into the atmosphere. Delineating transport emissions to traffic periods is a crucial step towards emission reduction policies. However, only a few published quantitative observations of the magnitude of such impact exits and none appear to have indicated the varying contributions of the different traffic periods or bring to limelight the concentrations of transport induced GHGs. This study deployed a quantitative technique to determine the emission profile of transport nodes in Ikeja, Lagos through the use of AEROQUAL 500s to sample CO, CO_2, CH_4 and N_2O at the three selected locations. Each gas was determined three times at 20 minute intervals for 1hour during each of the peak periods. CO, CO_2 and CH_4 concentrations were highest during the AM peak and PM peak periods and lower during the inter-peak period, while NOx concentration were relatively stable throughout the time periods. The study also revealed that the concentrations of CO, CO_2 and CH_4 in all the locations did not comply with both local and international standards. However, the concentration of NO_X complied with both standards. The study concludes that in order to achieve less emission from the transport sector, traffic regulations during the AM Peak and PM Peak periods should be better enforced by the State's Ministries of Transport and Environment

1. Introduction

When fossil fuels are burned, the resultant effect is the pollution of the ambient air with pollutants such as carbon monoxide (CO), methane (CH_4), oxides of nitrogen (NO_X), oxides of sulfur (SO_X), volatile organic hydrocarbons, particulate matter and atmospheric greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4). Since around 1750, human activities especially transportation have increased the concentration of CO_2 and other greenhouse gases in the atmosphere by many tens of percent over the last two centuries. Different studies on the impacts of urban road transportation on ambient air quality carried out by scholars have suggested that most pollutant gases in the atmosphere are traffic-related because of the combustion of petroleum-based products such as gasoline and diesel in internal combustion engines. Delineating transport emissions to traffic periods is a crucial step towards emission reduction policies. However, none appears to have indicated the varying contributions of the different traffic periods or bring to limelight the concentrations of transport induced GHGs. With the growth in the use of fossil fuels especially by the transport sector, a number of these pollutants are now present in the atmosphere at concentrations that can affect the environment and society as a whole. Monitoring the concentrations of these pollutants therefore has become an essential step in maintaining a set standard. **Table (1)** shows the ambient air quality standards in Nigeria.

Table (1): Nigerian Ambient Air Quality Standards

Pollutant	Average time	Standard limit
Particulate matter	1-hour average	250µg/m^3
Non-methane hydrocarbon	3-hour average	160µg/m^3
CO	8-hour average	10ppm-20ppm (Nigerian NAAQs) 9ppm (US NAAQs)
	1-hour average	10-35ppm (NESREA)
Nitrogen oxides (Nitrogen dioxide)	1-hour average	0.04ppm-0.06ppm (NESREA)
CO_2	1-hour average	20,000ppm (WHO) 150-250ppm (NESREA)
CH_4	1-hour average	160µg/m^3 (WHO) (0.16ppm)

Sources: (Ezeonyejiaku et al., (2022); Adeyanju and Manohar, (2017); Olajire et al., (2011); Soneye (2012) & Ndoke and Jimoh, 2017)

According to the (Environmental Protection Agency, (EPA), 2020), monitoring is referred to as the collection and use of measurement data to assess performance against a set standard or benchmark with respect to specific requirements. According to (Ibe *et al.,* 2017), atmospheric air quality is dependent not only on the quantity of pollutant in the atmosphere, but also on the prevalent air/weather conditions as this will affect the ability of the atmosphere to concentrate, disperse, or chemically destroy the pollutants emitted. Some of the prevailing conditions that can interfere include temperature, relative humidity, wind speed and direction, and chemical makeup. Most air quality assessment and monitoring are done in view of prevailing atmospheric conditions such as temperature, relative humidity, wind speed and direction (Ibe *et al.,* 2017).

Transportation plays a key role in urban emissions, especially that of greenhouse gases (GHGs), and with the current rate of fast urbanization and motorization in many cities, transport (especially road transport) is a growing and a major source of air pollutants. In a study, (Hena, 2017) reported the results of the investigation of vehicular emissions in selected areas in Calabar South of Nigeria. Each of the five monitored air pollutants was found to be present at an unacceptable level when compared with the Air Quality Index (AQI) level. The study pointed out that air pollution in the Calabar city as a result of transportation is very noteworthy and likely leading to health consequences. Furthermore, it also reported another study from the North West of Nigeria -Kano, and the results showed the concentrations of NO_2, CO, H_2S, and SO_2, were beyond the AQI threshold stipulated by United States Environmental Protection Agency (USEPA) with just minor exceptions, at some sampling locations and during the dry season. The study implied that emissions from road transportation within the city of Kano are not within safe limits. Hence, the transport induced air pollution in Kano metropolis is significant with potentially hazardous health consequences. From their study, on the impact of traffic emissions on air quality in Minna North Central Nigeria, (Ndoke and Jimoh, 2017) concluded that the CO concentration (15ppm) was a little lower than the Federal Environmental Protection Agency (FEPA) and could be solely attributed to vehicular emissions. They further pointed out that the CO_2 concentration of 5,000ppm (which is about 12 times the global background concentration) in Minna was still lower than the 20,000ppm limit for congested areas stipulated by the World Health

Organization (WHO). A study on the impact of urban road transportation on ambient air was reported by (Olajire *et al.,* 2011) on three cities in southwest Nigeria these are Lagos, Ibadan and Ado-ekiti. Not surprisingly, Lagos was found to have the highest levels of air pollution with concentrations of CO (233ppm) and SO_2 (2.9ppm) at Idumota in Lagos Island. At Iyana-Ipaja, the concentration of NO_2 was 1.5ppm. These results were seen to be higher than the FEPA limits of CO: 10ppm, SO_2: 0.01ppm, NO_2: 0.04-0.06ppm; clearly indicating the growing risk of traffic-related pollution problem in Lagos and the need for serious emissions control measures as Lagos continues to emerge as a mega city. In a study by (Osuntogun and Koku, 2007) on the impacts of road transportation on the ambient air and the health of residents of sixteen heavily trafficked locations in Lagos, Ibadan and Ado-ekiti; CO, SO_2, NO_2 and suspended particles were measured and results obtained indicated that the highest level of CO and SO_2 were seen at Idumota Lagos; (Soneye, 2012) investigated the concentrations of gases generated by petroleum products tank-farms along the popular Apapa-Oshodi Expressway Lagos, Nigeria. It assessed the levels of NO_2, CO and SO_2 around six bus stops through direct field measurements. The results showed that there were no traces of NO_2 at the selected bus stops throughout the study period. The absence of traces of NO_2 may be attributed to instrument detection limit, although this was not acknowledged by the author. SO_2 value of 0.4 ppm was recorded at some locations, which was above the regulatory limit, while some other locations recorded exactly the regulatory limit. CO was seen to be 3.2 ppm for the entire period and bus stops on the average which was below the regulatory limit.

On the other hand, (Nkwocha *et al.,* 2017) assessed air pollution levels from vehicular emission during the rainy season period. They selected three locations in the Port-Harcourt city noted for high traffic congestion. Air sampling was carried out for both peak and off-peak periods. NO_x, SO_x, CO and unburnt hydrocarbons (C_xH_y), as well as some climatic elements like temperature and relative humidity, were recorded. Results obtained indicated that SO_x was generally not detected; one of the locations experienced higher concentrations of NO_x and CO at evening peak periods. Also, high concentrations of NO_x, CO, and C_xH_y were prominent at evening peak periods. According to them, the NO_x concentrations were above the limit of 0.04 - 0.06 ppm, for all the locations and periods monitored excluding the last location during peak periods. The level of CO was within the local standard (10-20 ppm) for the off-peak period, but exceeded at peak periods in some locations.

In a study by (Utang and Peterside, 2011), estimation of emissions from vehicles during traffic peak periods within some parts of the Port Harcourt city in Nigeria was carried out. Air quality parameters: CO, NO_X, SO_X, and C_xH_y were measured and the results were seen to be above local standards but within international standards at all locations.

A 2018 study by (Obanya *et al.,* 2018) assessed air pollutants around residential areas and transport sector locations in Lagos, Nigeria. The results showed that the air quality, especially the PM concentrations around these locations, were poor because the measured value was above the accepted threshold set by the USEPA and Nigerian Federal Ministry of Environment (FMEnv). In another study, (Uhuegbu, 2013) measured CO in some selected areas in Lagos State. The results indicated that CO concentrations ranged between 45 to 835 ppm. The different values were dependent on the time of the day and also on the number and age of vehicles using the road at a particular time. He concluded that the major source of carbon monoxide emission observed in the studied area was from automobiles mainly heavy duty trucks with a minimum of 120 ppm to a maximum of 855 ppm.

Internationally, a study by (Kasim *et al.,* 2018) that measured air quality in Ethiopia based on the land uses showed that ambient air quality for SO_2 was very poor, NO_2 ranged from moderate to very poor, whereas CO rated moderate. It also observed that the average value of CO_2 across the various land uses was about 442.4 ppm, which was higher than the country's limit of 400 ppm. The authors concluded that the observed outcomes will have adverse effects on both human health and the environment. In Malaysia, according to a study by (Bin-Yahya, 2014), the average concentration of CO, SO_2 and CH_4 observed in the study areas were within the 9 ppm benchmark set by the country's regulatory body even though there were few days with unexplained hikes. This made the authors conclude that there is still need to look into emissions since the consequences of these gases to the human health is high based on a related health report by country's Ministry of Health. A study by (Yasmeen, *et al.,* 2019) indicated that emissions from intensive poultry facilities in Lahore, Pakistan are major public and environmental health concern. This was concluded when results from monitoring showed that NO_2, H_2S, CO_2 and CH_4 were on the increase especially with the increasing ages of birds meant for consumption. It was opined that ambient air quality in the poultry vicinities were not solely attributable to transport emissions rather emissions from poultry activities.

According to (Sandow, 2016), ambient air pollution due to vehicular traffic in Accra, Ghana with the exception of NO_2, had their mean concentrations to be higher than the acceptable reference values set by the WHO in its air quality guidelines. It was concluded that this could negatively impact human health. Another study by (Kiurski *et al.,* 2019) examined the state of air quality on the children's playgrounds of Novi Sad, Serbia, with special emphasis on the air quality indicators (CO_2, $PM_{2.5/10}$ and VOCs). Results concluded that the concentrations of air pollutants were within acceptable limits, but forecasted that a trend of increasing air pollutants can be expected in the future due to the migration in the urban environment.

In another study, (Jida *et al.,* 2021) compared the results of PM 10 and PM 2.5 emission levels Addis Ababa, Ethiopia with cities in other developing countries like Kenya, Ghana, Uganda, India, Congo, Brazil, Pakistin, Egypt and Algeria and concluded that in these developing countries, those in Africa, air quality has been severely affected by pollution from vehicles due to old vehicular age, long distances travelled and of course fuel quality. According to them, the PM concentration found in the majority of the sampled locations in these cities in addition to that of Addis Ababa all exceeded Air quality index and WHO 24-hr standard limit value. In France, (Mihaita *et al.,* 2019) deployed real-life mobile sensing to detect emission hotspots for NO_2 under the influence of severe traffic congestion. Results showed that majority of the tubes registered good NO_2 concentrations with the exception of one tube with higher NO_2 concentrations attributable to being positioned close to a narrow and highly circulated road. The NO_2 concentrations according to this study were also seen to vary according to the days of the week with Friday (a public holiday) recording the least value. In Egypt, (Mostafa *et al.,* 2018) studied the level of environmental pollution in Greater Cairo and found out that the emission patterns of some pollutants (NO_2, CO, O_3, and PM) were considerably higher than the national standards especially in some industrial areas while that of SO_2 never exceeded the standards. They recommended that better actions need to be taken in order to lower the levels of air pollution and enhance the quality of life in the area.

Most previous studies monitoring ambient air quality or estimating air pollution due to road transportation in Nigeria have succeeded in doing so for most gases such as CO, PM10, NO_X, and SO_X, other than the major GHGs such as CO_2 and CH_4. Most attempts have also been made to estimate these emissions based on peak and off-peak periods without much reference to inter-peak periods. This study in its novelty makes a difference to other dimensions of research in the use of AEROQUAL 500s (Aeroqual, 2019) portable air monitoring equipment for the real-time quantitative analysis of CO_2 and CH_4 for three time periods (AM peak, inter-peak and PM peak periods). It also delineates transport emissions to traffic periods as a crucial step towards emission reduction policies. Ikeja Local Government Area of Lagos State houses the seat of power in addition to being the commercial/administrative nerve center of the state which attracts vehicular traffic. All these factors contributed to the basis for undertaking this study aimed at determining the transport induced emissions profile for some selected areas in Ikeja, Lagos.

2. Methodology

A survey research design method was employed in this study. Real time quantitative data were collected from primary sources through the use of AEROQUAL 500s portable air monitoring equipment. Concentrations of emissions were measured at three locations within the Ikeja Local Government Area (LGA) of Lagos State as seen in **Figure (1)**.

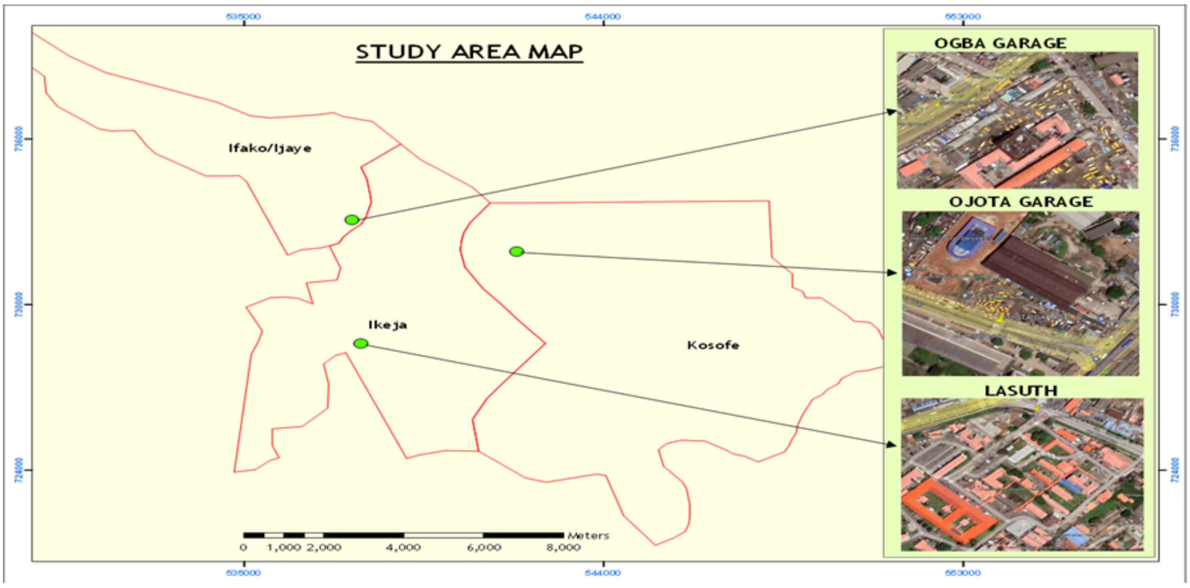

Figure (1): Map of the study area

2.1 Data Collection Method

The data collection was carried out in three working days within 2 weeks; a day each for Ikeja Under-bridge, Ogba garage and Ojota garage. Three days monitoring was considered adequate for this study because the days represented the typical busy days of the week. This is important as it will capture the emission trend of a typical day. The gases and other parameters were determined *in situ* using two (2) sets of Aeroqual Series 500 portable quality monitor as seen in **Figure (2)**. **Table (2)** shows the functionality of the instrument. For measurement, the devices were placed at the height of 1.5 meter above the ground level and almost 2 feet away from the service lane. Each gas was determined three times at a 20 minute interval for 1 hour during each of the peak periods at these three locations: Ikeja Under-bridge, Ogba garage and Ojota garage. This was done in accordance with the methods of (Utang and Peterside, 2011) and (Nkwocha *et al.,* 2017). Measurements of temperature and relative humidity were averaged as the corresponding exposure levels in each location during the am peak, inter-peak and pm peak periods. A 40-minute exposure time was observed during each of the periods. Within this time belt, the reading was taken three (3) times and averaged to get a figure for the time interval (Olajire *et al.,* 2011) and (Soneye, 2012).

• AM PEAK (8:00-10:00am): CO and CO_2 readings were taken simultaneously with separate instrument at 8:00am, 8:20am and 8:40am while CH_4 and NO_X readings were taken simultaneously at 9:00am, 9:20am and 9:40am.

• INTER PEAK (1-3pm): CO and CO_2 readings were taken simultaneously with separate instrument at 1:00pm, 1:20pm and 1:40pm while CH_4 and NO_X readings were taken simultaneously at 2:00pm, 2:20pm and 2:40pm.

• PM Peak (5-7pm): CO and CO_2 readings were taken simultaneously with separate instrument at 5:00pm, 5:20pm and 5:40pm while CH_4 and NO_X readings were taken simultaneously at 6:00pm, 6:20pm and 6:40pm.

In view of the prevailing air and weather conditions, the air quality assessment was done by measuring the pollutant gases along with temperature and relative humidity (Ibe *et al.,* 2017). The air quality data measured were analyzed with reference to the specific threshold limits as prescribed by the Nigerian and US NAAQS.

2.2 Instruments and Data Analysis

Figure (2): AEROQUAL 500 Series portable gas analyzer. Source: (Aeroqual, 2019).

Table (2): Instrument functionality information

Gas	Sensor Head Technology	Sensor Range (ppm)	Minimum Detection Limit (ppm)	Accuracy of Calibration Resolution (ppm)	Resolution (ppm)	Response time (seconds)	Operational Range	
							Temp	RH
Methane (CH_4)	GSS	0-10000	1	<±20 ppm +15%	1	30	0 to 40°C	10 to 90%
Carbon dioxide (CO_2)	NDIR	0-2000	10	<±10 ppm + 5%	1	120	0 to 40°C	0 to 95%
Carbon monoxide (CO)	GSS	0-1000	1	<±2ppm + 15%	1	30	0 to 40°C	0 to 90%
Nitrogen dioxide (NO_2)	GSE	0-1	0.005	<±0.02 ppm 0-0.2 ppm <±10% 0.2-1 ppm	0.001	30	0 to 40°C	15 to 90%

Source: (Aeroqual, 2019)

Uncertainty

Just as seen in every measurement, there is a doubt involved which must be known in order to decide if the measurement is good enough to be used. The components of the uncertainty analysis performed in this study include the repeated measurements taken to find out how much the concentration of gases differ between repetitions within the study area. The formulas below were used in estimating the standard deviation and uncertainty.

$$\sigma = \sqrt{\frac{\sum (xi - \mu)^2}{N}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{Equation 1}$$

Where:
σ = standard deviation
N = population size (9)
x^i = each value from the population
μ: population mean

$$U = \frac{\sigma}{\sqrt{N}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{Equation 2}$$

Where:
U = uncertainty
σ = standard deviation
N = population size (9)

3. Results and Discussion

The respective results are presented in tables and figures below. The quantitative data obtained are also presented in graphical illustrations to show the behavior of the gases at different times of the day.

Table (3): Air quality monitoring results, for Ojota motor garage Lagos

TIME 1	CO (ppm)	CO_2 (PPM)	TEMP (^{0}C)	RH (%)	TIME 2	CH_4 (ppm)	NO_x (ppm)	TEMP (^{0}C)	RH (%)
				AM PEAK					
8:00	65	807	26	98	**9:00**	19	0.016	27	90
8:20	74	826	26	98	**9:20**	31	0.016	28	90
8:40	65	868	26	95	**9:40**	19	0.016	29	89
Mean	68	833.7	26	97		23	0.016	28	89.7
				INTER PEAK					
1:00	53	775	29	79	**2:00**	1	0.017	31	74
1:20	60	785	30	78	**2:20**	2	0.017	31	73
1:40	55	746	30	78	**2:40**	1	0.017	30	73
Mean	56	768.7	29.7	78.33		1.33	0.017	30.7	73.3
				PM PEAK					
5:00	69	875	29	80	**6:00**	1	0.016	29	79
5:20	86	800	29	81	**6:20**	2	0.016	30	79
5:40	63	785	28	79	**6:40**	1	0.016	28	82
Mean	72.7	820	28.7	80		1.33	0.016	29	80

From **Table (3)**, it could be seen that CO concentration at Ojota motor garage was high at an hourly averages of 72.7ppm during the pm peak and 68ppm during the am peak period and lowest during the inter-peak period (56ppm). The same trend was seen in CO_2 concentration with the hourly average of 833.7ppm and 820ppm during the am peak and the pm peak, respectively and lowest during the inter-peak period (768.7ppm). These values can be attributed to high vehicular traffic during these periods as earlier reported (Ibe *et al.,* 2017) and this may be especially true during the am peak. Therefore this result shows that CO_2 emissions are higher during the am peak this may be attributed to higher vehicular movement at that time relative to the pm peak. This is apparently the spill-over of the 'morning rush hour' wish usually begin by 6 am, when most Lagos roads are busy with usually higher private and public vehicular movements and several commuters. The absence of adequate layby, relatively small size of bus garage and several commuters crossing the road slow vehicle at this vicinity, are critical factor that could increase the vehicular emissions from the several public buses that are often delayed on the road side awaiting other buses to move out of the garage, before creating space for other buses to move in. Result from Table 3 shows that CH_4 exhibits the highest concentration at the am period relative to off peak and pm periods. This is likely not unconnected to the high methane emissions concentration from Olusosun dumpsite (Ahove *et al.,* 2020), which was enhanced by the wind direction, which is the largest dumpsite in Africa about 1km away from this motor park, being the study location. In addition to this, the relative humidity was also highest at this period of time which may be attributed to the morning dew as well as low temperature associated with rain forest region. NO_x concentrations on the other hand were relatively stable (0.016 ppm-0.017ppm) throughout the three time periods without exceeding the (0.04-0.06ppm) threshold prescribed by NAAQs. From **Table (4)**, it could be seen that CO concentration at LASUTH Ikeja were highest with hourly averages of 68ppm and 64ppm during the a.m. peak and the inter-peak, respectively, and lowest during the p.m. peak period (37ppm). The same trend is seen in CO_2 concentration with the hourly average of 834ppm and 765ppm during the a.m. peak and the inter-peak, respectively and lowest during the p.m. peak period (736ppm). These values can be attributed to high level of activities during these working and visiting hours with the Lagos State University Teaching Hospital (Okafor, 2021).

Table (4): Air quality monitoring results for LASUTH Ikeja Lagos

TIME 1	CO (PPM)	CO_2 (ppm)	TEMP (^{0}C)	RH (%)	TIME 2	CH_4 (ppm)	NO_x (ppm)	TEMP (^{0}C)	RH (%)
				AM PEAK					
8:00	65	807	26	98	**9:00**	6	0.016	26	94
8:20	74	826	26	98	**9:20**	11	0.016	27	91
8:40	65	868	26	95	**9:40**	3	0.016	27	90
Mean	68	833.7	26	97		6.7	0.016	26.7	91.7
				INTER PEAK					
1:00	63	738	30	79	2:00	0	0.016	31	74
1:20	65	775	31	77	2:20	0	0.016	31	74
1:40	65	782	31	76	2:40	0	0.016	30	74
Mean	64.3	765	30.7	77.3		0	0.016	30.7	74
				PM PEAK					
5:00	24	728	30	73	6:00	0	0.016	28	86
5:20	46	758	29	83	6:20	0	0.016	28	88
5:40	42	721	28	85	6:40	0	0.016	27	89
Mean	37.3	735.7	29	80.3		0	0.016	27.7	87.7

It is also seen from the results that the CH_4 levels were usually higher during the a.m. peak period and undetected throughout the inter-peak and p.m. peak periods in line with the works of (Olajire *et al.,* 2011). This is likely not unconnected to the presence of the stench from nearby gutters in addition to the relatively high relative humidity which was highest at that time period while the temperature was lowest. NO_x concentrations on the other hand were relatively stable (0.016 ppm) throughout the three time periods without exceeding the threshold prescribed by NAAQs. **Tables (3), (4)** and **(5)** show the air quality monitoring results in the three divisions in Ikeja L.G.A of Lagos. From **Table (5)**, it could be seen that CO concentrations at Ogba motor garage were highest with hourly averages of 85.7ppm and 90ppm during the a.m. peak and the inter-peak respectively and lowest during the p.m. peak period (58ppm).

Table (5): Air quality monitoring results for Ogba motor garage Lagos

TIME 1	CO (PPM)	CO_2 (ppm)	TEMP (^0C)	RH (%)	TIME 2	CH_4 (ppm)	NO_x (ppm)	TEMP (^0C)	RH (%)
					AM PEAK				
8:00	76	1032	26	92	**9:00**	1	0.016	27	89
8:20	97	1034	26	93	**9:20**	1	0.016	27	88
8:40	84	951	27	90	**9:40**	1	0.016	28	86
Mean	85.7	1005.7	26.3	91.7		1	0.016	27.3	87.7
					INTER PEAK				
1:00	95	814	31	73	**2:00**	1	0.017	30	76
1:20	80	956	31	72	**2:20**	0	0.017	31	73
1:40	95	819	31	71	**2:40**	1	0.017	31	76
Mean	90	863	31	72		0.7	0.017	30.7	75
					PM PEAK				
5:00	67	954	29	78	**6:00**	0	0.016	30	76
5:20	52	973	29	79	**6:20**	1	0.016	30	77
5:40	56	841	28	81	**6:40**	1	0.016	29	76
Mean	58.3	922.7	28.7	79.3		0.7	0.016	29.7	76.3

CO_2 concentrations however had the highest hourly average of 1005.7ppm during the a.m. peak and then had a lower hourly average value of 863ppm and 922.7ppm during the inter-peak and p.m. peak, respectively; these values when compared to about 250 ppm for clean air is considered very high. These values can be attributed to high vehicular traffic during these periods as already pointed out by (Olajire *et al.,* 2011; Okafor, 2021). CH_4 and NO_x concentrations on the other hand were relatively stable (0-1ppm; 0.016-0.017ppm, respectively) throughout the three time periods without exceeding the threshold prescribed by NAAQS. From **Table (6),** concentrations in the study area can also be said to have a particular trend of being highest during the AM and PM peak periods and a bit lower during the inter-peak period. The trend in this study area is an indication that high mean concentration estimates are associated with traffic. The high standard deviation seen in the concentrations of CO and CO_2 implies that they are more spread out from the mean when compared with the concentrations of NO_X and CH_4. This finding is o not surprising due to the fact that a large numbers of banks and high net-worth commercial centers are within the highly accessible and connected locations in the study area such as: Allen Avenue, Obafemi Awolowo Way, Aromire Avenue, Oba Akran Avenue, Adeniyi Jones etc. This trend of the emission profile and the comparison of the different sampling points in the study area are demonstrated by the figures below. The error bars seen in **Figures (3), (4), (5) & (6)** represents how the real values (standards; CO-50ppm, CO_2-250ppm, CH_4- 0.16ppm & NO_X- 0.06ppm) deviates from the measured values in the study area. From **Figures (3), (4), (5), (6), (7) & (8),** the concentrations measurements were seen to increase with an increasing temperature and a decreasing relative humidity at different times of the day, but significantly correct at the AM and PM periods but partially correct for the inter peak, at all the three locations sampled. The inter peak apparently had less vehicular movement and thus less emissions is expected. On a general note however, this outcome can be attributed to the greenhouse effect phenomenon of the trapping/absorption of heat/sunlight by the pollutant gases being measured in line with the concept of global warming which is causing climate change (Ahove *et al.,* 2020). This experience may be described as the local communities' contribution to the global climate change experience. Thus to act locally is to contribute globally to the greenhouse gases emissions. Normally this heat/sunlight would have escaped into the space if the pollutants did not trap it to cause more heat. A warming earth is already a challenging global issue and the outcome of this study contributes to the fact that transport emissions make it even worse. Reducing transport emissions through varying traffic flow strategies for the three traffic periods will be a sustainable practice.

Table (6): AIR QUALITY MONITORING RESULTS FOR IKEJA L.G.A

PERIOD	LOCATIONS (Within Ikeja LGA)	CO	CO_2	Temp	RH	CH_4	NO_x	Temp	RH	LAT	LONG
AM Peak (8:00-10:00am)	Ikeja Under-bridge (LASUTH)	65	807	26	98	6	0.016	26	94	N6⁰35'31.02889"	E3⁰20'34.97953"
		74	826	26	98	11	0.016	27	91		
		65	868	26	95	3	0.016	27	90		
	Ogba garage	76	1032	26	92	1	0.016	27	89	N6⁰37'56.79624"	E3⁰20'27.86964"
		97	1034	26	93	1	0.016	27	88		
		84	951	27	90	1	0.016	28	86		
	Ojota garage	58	817	26	91	19	0.016	27	90	N6⁰35'19.45356"	E3⁰22'42.0654"
		58	802	26	91	31	0.016	28	90		
		53	790	27	90	9	0.016	29	89		
	Mean	70	880.7	26.2	93.1	9.1	0.016	27.3	89.6		
	SD	14.2	98.9	0.4	3.2	10.2	0	0.9	2.2		
	Uncertainty	±4.7	±32.9	±0.1	±1.1	±3.4	0	±0.3	±0.7		
Inter peak (1-3pm)	Ikeja Under-bridge (LASUTH)	63	738	30	79	0	0.016	31	74	N6⁰35'31.02889"	E3⁰20'34.97953"
		65	775	31	77	0	0.016	31	74		
		65	782	31	76	0	0.016	30	74		
	Ogba garage	95	814	31	73	1	0.017	30	76	N6⁰37'56.79624"	E3⁰20'27.86964"
		80	956	31	72	0	0.017	31	73		
		95	819	31	71	1	0.017	31	76		
	Ojota garage	53	775	29	79	1	0.017	31	74	N6⁰35'19.45356"	E3⁰22'42.0654"
		60	785	30	78	2	0.017	31	73		
		55	746	30	78	1	0.017	30	73		
	Mean	70.1	798.9	30.4	75.9	0.7	0.017	30.7	74.1		
	SD	16.1	64.7	0.7	3.1	0.7	0.0005	0.5	1.2		
	Uncertainty	±5.4	±21.6	±0.2	±1	±0.2	0	±0.2	±0.4		
PM Peak (5-7pm)	Ikeja Under-bridge (LASUTH)	24	728	30	73	0	0.016	28	86	N6⁰35'31.02889"	E3⁰20'34.97953"
		46	758	29	83	0	0.016	28	88		
		42	721	28	85	0	0.016	27	89		
	Ogba garage	67	954	29	78	0	0.016	30	76	N6⁰37'56.79624"	E3⁰20'27.86964"
		52	973	29	79	1	0.016	30	77		
		56	841	28	81	1	0.016	29	76		
	Ojota garage	69	875	29	80	1	0.016	29	79	N6⁰35'19.45356"	E3⁰22'42.0654"
		86	800	29	81	2	0.016	30	79		
		63	785	28	79	1	0.016	28	82		
	Mean	51.0	745.7	25.9	72	0.6	0.014	25.9	73.2		
	SD	17.9	92.4	0.7	3.4	0.7	0	1.1	5.1		
	Uncertainty	±5.9	±30.8	±0.2	±1.1	±0.2	0	±0.4	±1.7		

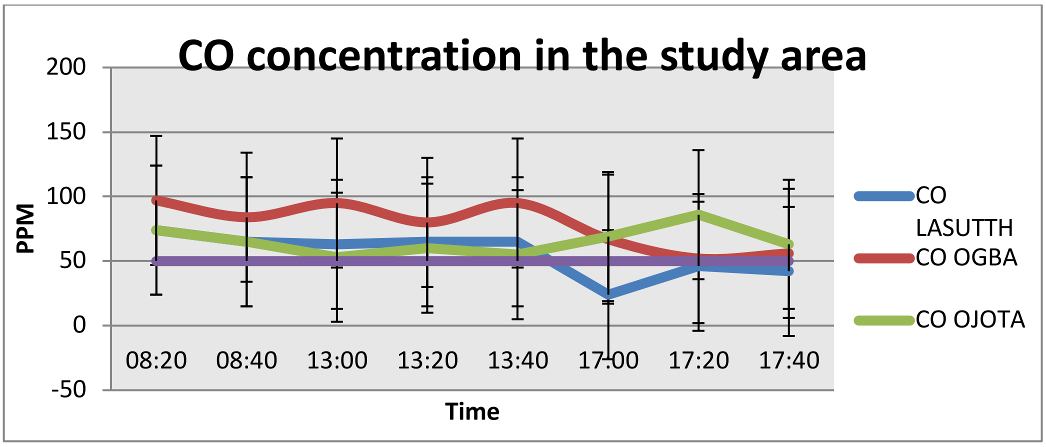

Figure (3): Time histories for the concentration of CO in the Study Area.

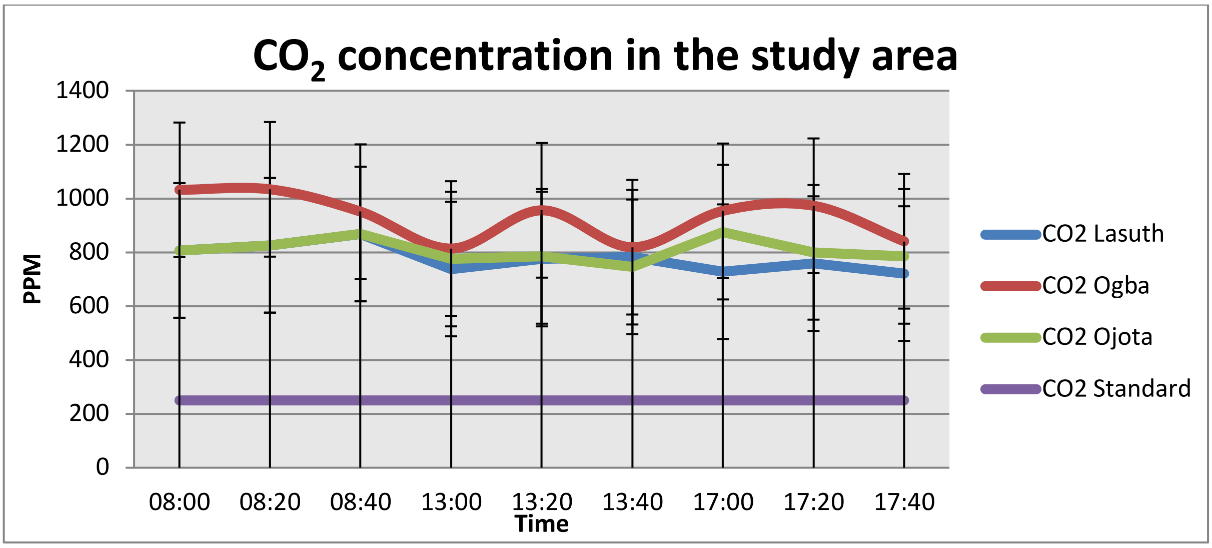

Figure (4): Time histories for the concentration of CO_2 in the Study Area.

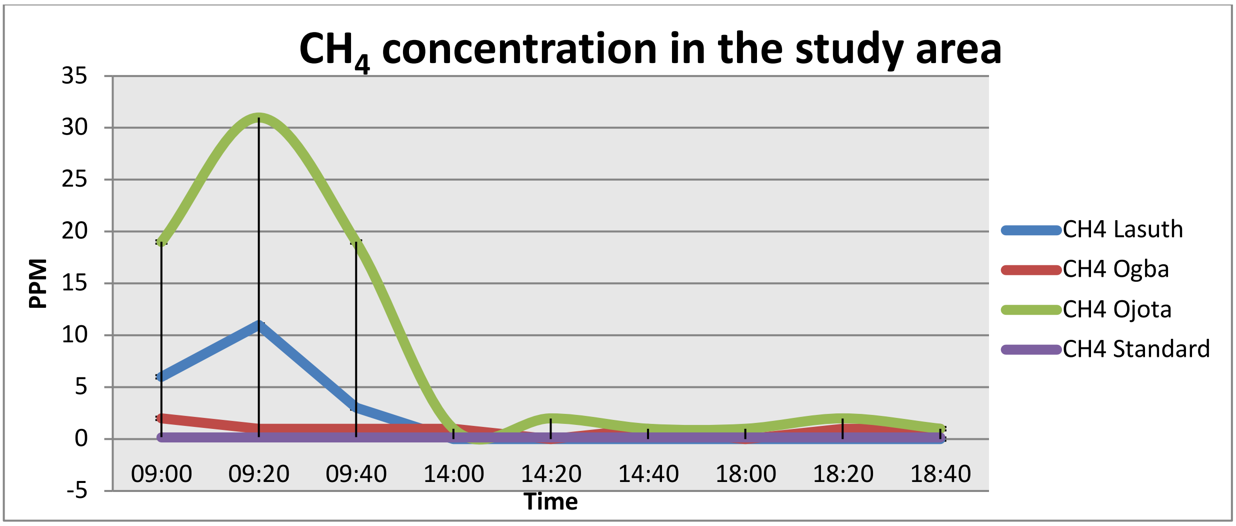

Figure (5): Time histories for the concentration of CH_4 in the Study Area.

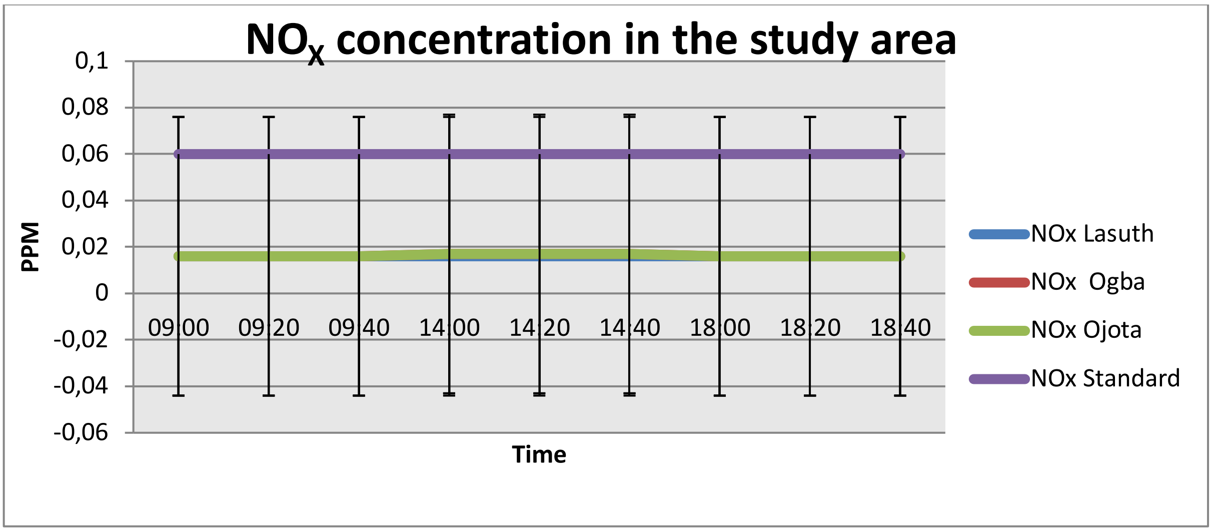

Figure (6): Time histories for the concentration of NO_x in the Study Area.

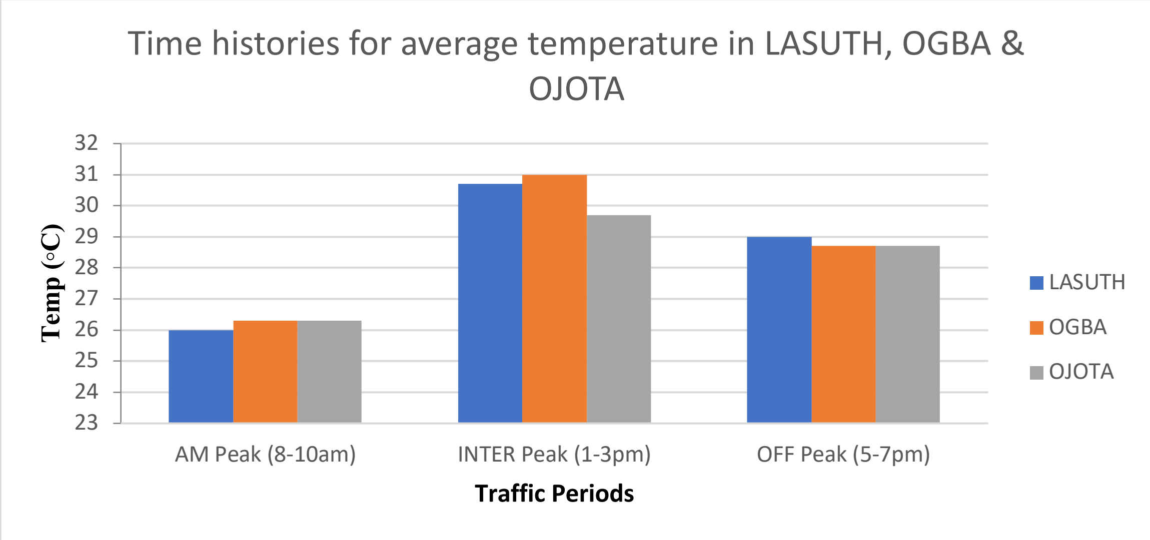

Figure (7): Time histories for average temperature in the study area.

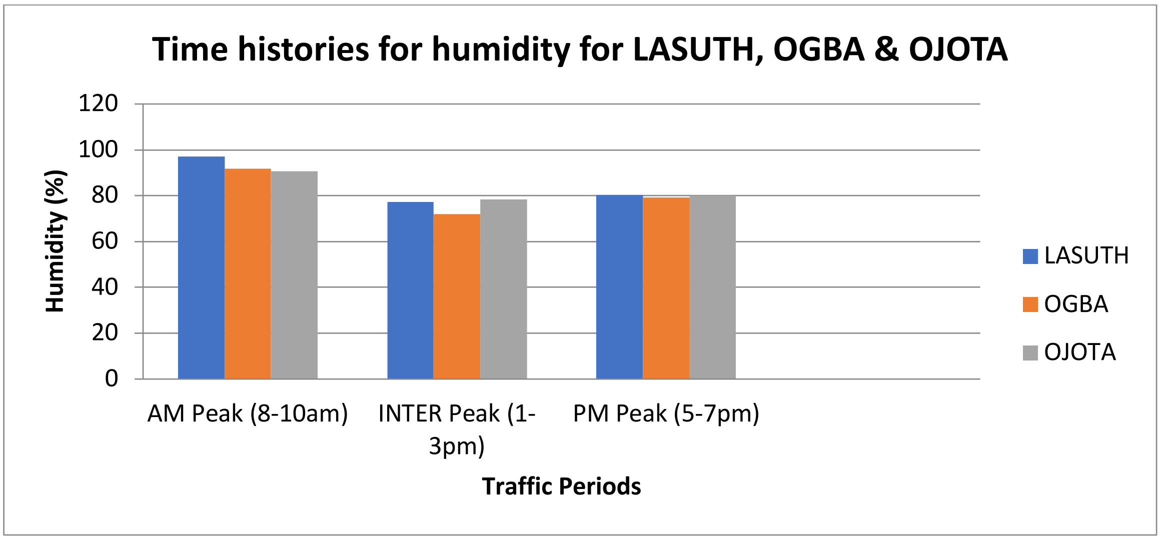

Figure (8): Time histories for relative humidity in the study area.

Concentrations of CO for Ogba were seen in **Figure (3)** to be higher than that of Lasuth and Ojota during the AM peak and Inter peak periods but lower during the PM peak period. A higher CO found at Ogba may not be linked to higher vehicular movement but due to a pocket of heavy duty vehicular movement. A reverse was witnessed in the case of Ojota which recorded a lower concentration of CO during the AM and Inter peak periods but higher concentration during the PM peak period. Lasuth on the other hand maintained an almost same concentration of CO at all time periods with a drop at the beginning of the PM peak period. What is interesting about the result obtained from the CO measurements in the three locations is that the CO results obtained were apparently due to heavy duty vehicular movement. The result pattern obtained from the CO is different from the pattern obtained from CO_2, where outcomes are higher consistently during the AM and PM peaks and lower during the inter peak. CO obtained at Ogba is consistently higher than the required standard from the AM till about 5pm. At Ojota, CO was high during the AM period very possibly due to the influence of heavy duty vehicle dumping solid waste at the dumpsite not far from the research location, but it dropped at the interpeak but spike at about 5 pm. Lasuth was slightly higher than Ojota and follows the same parttern as Ojota.

On a general note, all the locations exhibited higher CO_2 emissions at all time of the data collection than the required standard shown in **Figure (4).** Evidently all the study locations had significant GHGs emissions which are traceable to vehicular emissions. These results can be attributed to high vehicular traffic during these periods as buttressed by previous studies (Olajire *et al.,* 2011) and (Okafor, 2021). The concentrations of CO_2 for Ogba were found to be the highest at all time periods when compared with that of Ojota and Lasuth exhibiting the least emissions. These result calls for improved traffic flow in these locations to ameliorate vehicular idling. Methane emissions at Ojota was reported to be exceptionally high, this obviously is due to the emissions from the unusually large dumpsite at about 1 km from the study location, whose methane emissions spreads to the adjoining communities as reported in a previous study (Ahove *et al.,* 2020) and this is evidently reported to also emanate from the stench from the surrounding gutters at the dumpsite (Olajire *et al.,* 2011). Other locations had methane emissions lower or within standard, and this indicates that the dumpsite influenced the methane emissions reported for Ojota.

Conclusion

Increasing greenhouse gas emission has become a worldwide concern as it is considered a major driver of global warming and climate change. This study showed that CO, CO_2 and CH_4 concentrations were highest during the AM peak and PM peak periods and lower during the inter-peak period, while NOx concentration were relatively stable throughout the time periods. This also revealed that the concentrations of CO, CO_2 and CH_4 in all the locations did not comply with both local and international standards. However, the concentration of NO_X complied with both local and international standards. When compared with previous estimates as found in the literature reviewed, CO_2 and CO concentrations from this study appear to be the highest values ever measured in Lagos and this mainly stems from the locations sampled which are vehicular as well as commuters hotspots of Lagos, being the largest economy of west Africa and the commercial nerve center of Nigeria. Previous research studies, as gleaned from literature, involved study locations with busy roads and moving traffic, however in this study, locations sampled were not just busy road but had intersections that had loading points (garages) near them. Also, the garages were very small to accommodate the volume of buses available to pick passengers, hence buses experienced gridlock before getting into the garage and also cause traffic for other private vehicles.

There is a need for effective air pollution monitoring and control programs for mobile emission sources. In addition, improved road network and traffic control have the potential to ease congestion and associated air pollution problems. The construction of modern roundabouts and overhead bridges could also be a useful approach; such structures would be expected to improve the flow of traffic and consequently cut down vehicular emissions/fuel consumption by reducing the idle time of vehicles at various intersections. Standard garages should be built in these locations for public commercial buses to accommodate these buses and commuters, this will go a long way to free our roads and eliminate significantly traffic gridlock. These are golden keys to reducing GHGs emissions in these study locations. This would lead to a cleaner environment. There should also be an immediate enforcement of existing laws banning the use of old and obsolete vehicles and carrying out road worthiness test for commercial vehicles.

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