SPATIO-TEMPORAL ANALYSIS OF VOLATILE ORGANIC COMPOUNDS (VOCS) CONCENTRATIONS AT ROAD JUNCTIONS IN ILORIN METROPOLIS, NIGERIA

BY

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ABSTRACT

Volatile Organic Compounds (VOCs) impacts negatively on human health and the environment globally. Information on transport induced VOCs emission from urban roads is scanty. This study therefore determined the ambient concentration of VOCs and examined its spatial and temporal variations along urban roads in Ilorin, Nigeria. Multi-stage sampling techniques were used to select sites for emission measurement. Multi-rae plus was used to determine the concentration of VOCs at 0, 250 and 500 meters from selected road junctions in the morning (0730 – 0930 Nigerian Local Standard Time, LST), afternoon (1130 – 1400 LST) and evening (1430 – 1800 LST) of each day of the week of survey at the seven selected road junctions. A total of 441 air samples were taken and analysed in situ. Measured real time concentrations of VOCs were analyzed using descriptive statistics and Analysis of Variance. The result showed that the overall concentration of VOCs emissions averaged 1.600 ±1.600 ppm. Mean concentrations of VOCs varied as 1.494 ±1.714 ppm, 1.101 ±1.101 ppm and 1.005 ±1.417 ppm, at 0, 250 and 500 meters, respectively from the road junctions. The mean concentration of Volatile Organic Compound in the morning (0.957 ± 0.899ppm), afternoon (0.670 ±0.762ppm) and evening (1.973 ±2.251ppm) thus reveal 'peaks' and 'off-peaks' of traffic. The highest concentration (1.588ppm) was recorded at the Post office junction. Significant spatial variations existed in the mean concentration of VOCs across the various junctions F (6.434) $p<0.05$). The study associated variations in VOCs emission to traffic flow in the study area, and concluded that VOCs emission can be reduced if traffic flows are controlled.

Keywords: Emissions, Off peak, Peaks of traffic, Spatial variations, Peaks of traffic, Off peak, Spatial variations,

INTRODUCTION

Air pollution is a known problem in urban areas globally. Transportation has made a significant contribution to the level of air pollution in urban areas of developing countries. The contribution of automobiles is reported in the range of 40-80% of the total air pollution (Goyal et al., 2006). Volatile organic compound (VOC) is one of the gases emitted by automobiles. Volatile organic compound (VOCs) is an important precursor of ozone formation and secondary organic aerosols (SOA). High level of ozone in urban areas worldwide has long been a major air quality issue (Kun et al., 2020).

Anthropogenic sources of VOCs include road transport emissions, solvent use (paints, adhesives, aerosols, metal cleaning and printing), production processes, extraction and combustion of fossil fuels. The top 5 VOCs emitted by vehicles are hexagonal, acetone, toluene, P-xylenes and isu-pentane. The emission factor of gasoline vehicles was 84.2% lower than that of diesel vehicles. Volatile organic compounds are emitted both from the tailpipe and through fuel evaporation. About 2.7 grams of VOCs are emitted from the tail pipe if the engine is warm and evaporative emission (during travel and while cooling down) results in 2.8 grams of VOCs. Starting the car cold generates another 2.5 grams of VOCs. As a vehicular pollutant, it can cause fatal blood diseases (Ogunsanya, 2002).

Human exposure to certain levels of VOCs can cause an increase in cancer risk, DNA breakdown in bone marrow cells, respiratory diseases and reduction of reproductive processes in plants. Additionally, water and soil qualities can be disturbed by the presence of VOCs in the environment. Some VOCs such as benzene known to be carcinogenic are associated with Leukaemia. Also, short-time exposure to Ethylbenzenis known to be responsible for eye and throat irritation, dizziness, cancer and liver problems in man and animal (US. Department of Health and Human Services, 2006; US. Department of Health and Human Services, 2010).

Traffic emissions from automobile transport modes in urban areas are crucial factors in the deterioration of urban air quality and have become highly dangerous to man and the environment (TERRI, 2001). Over 600 million people globally are exposed to hazardous level of traffic generated pollutants (Cacciola et al., 2002). Traffic emission remains very high and accounts for a large proportion of air pollution in most urban areas today (Giorgio et al., 2008). In many developing countries, traffic accounts for 80-90% pollution at micro level such as city centres and congested streets (Odhiambo et al., 2010).

In Nigeria and other developing countries, urbanization is on the increase. The increasing rate of urbanization has been linked to the increased volume of vehicles and traffic flows in many regions (Okelola & Okhimamhe, 2013). This has considerably increased vehicular emissions to have been implicated over 60% of air pollution cases in many urban areas (Bhandarkar, 2013). Increasing motorization and accompanying increase in vehicular emissions in urban areas have been impacting negatively on human health and the global environment (Salvatore & Daniela, 2002; Okelola & Okhimamhe, 2013). Emission from vehicles especially automobiles has been responsible for about two third of air pollution in urban areas (Bhandarkar, (2013).

Existing studies on transport emissions conducted in the Federal Capital Territory, Abuja and Kaduna reported greater concentrations of carbon dioxide at major road junctions than the surrounding areas (Ndoke et al., 2006). Similar studies were conducted in Minna, Niger State (Okelola & Okhimamhe, 2013). Utang and Peterside (2011) also investigated the concentration of selected vehicle induced gases around traffic corridors in Port Harcourt, Rivers State. A similar study conducted in Abeokuta observed that dangerous vehicular emissions increase with traffic flow and vehicle types (Oguntoke & Yussuff, 2008). Also, carbon-monoxide emission concentrations were observed to be related to traffic flows and reduced with increasing distance from selected road junctions with higher level of traffic congestion in Ilorin (Aboyeji et al., 2018). In view of the variations in the levels of urbanization of various urban areas across the country, increasing level poverty, the continuous patronage of fairly used vehicles, increase in vehicular emission and its negative implications on human health and the environment makes it imperative to investigate transport induced gases.

Although, Aboyeji et al. (2018) investigated the concentrations of road transport induced carbon monoxide emission in Ilorin, information on the concentrations of volatile organic compounds and its distribution with traffic flow in the study area is scanty; this is considered necessary due to the unique attributes of various gases hence, this study. Therefore, the objectives of this study determined; the ambient concentration of VOCs emission at designated distances from selected road junctions and; the concentrations of VOCs emission at the 'peak' and 'off-peak' of traffic periods over selected road junctions in Ilorin, Nigeria.

THE STUDY AREA

The study area is Ilorin metropolis which is located between Latitudes 8º 3' - 10º 18" N and, Longitudes 4º 15' - 4º 51' E, in the North Central part of Nigeria by geo-political division. The metropolis is the capital of Kwara State in the North-Central geopolitical zone of Nigeria. It comprises Ilorin East, Ilorin West and Ilorin South local government area is the largest town in the middle belt of Nigeria. Ilorin has an area of 765 km^2 with an estimated population of about 1576902. Ilorin is 293 km from Lagos the commercial Capital of Nigeria and 500 kilometers from Abuja the Federal capital territory of Nigeria (Figure 1).

Ilorin falls within the savannah vegetation. It experiences both the wet and dry seasons annually. The rainy season usually starts in March and lasts until mid-November. While the dry season usually starts from mid-November-early March. The dry season is naturally very hot, except during the harmattan period, when it is cold and dry. Harmattan sets in by late November and ends by early January.

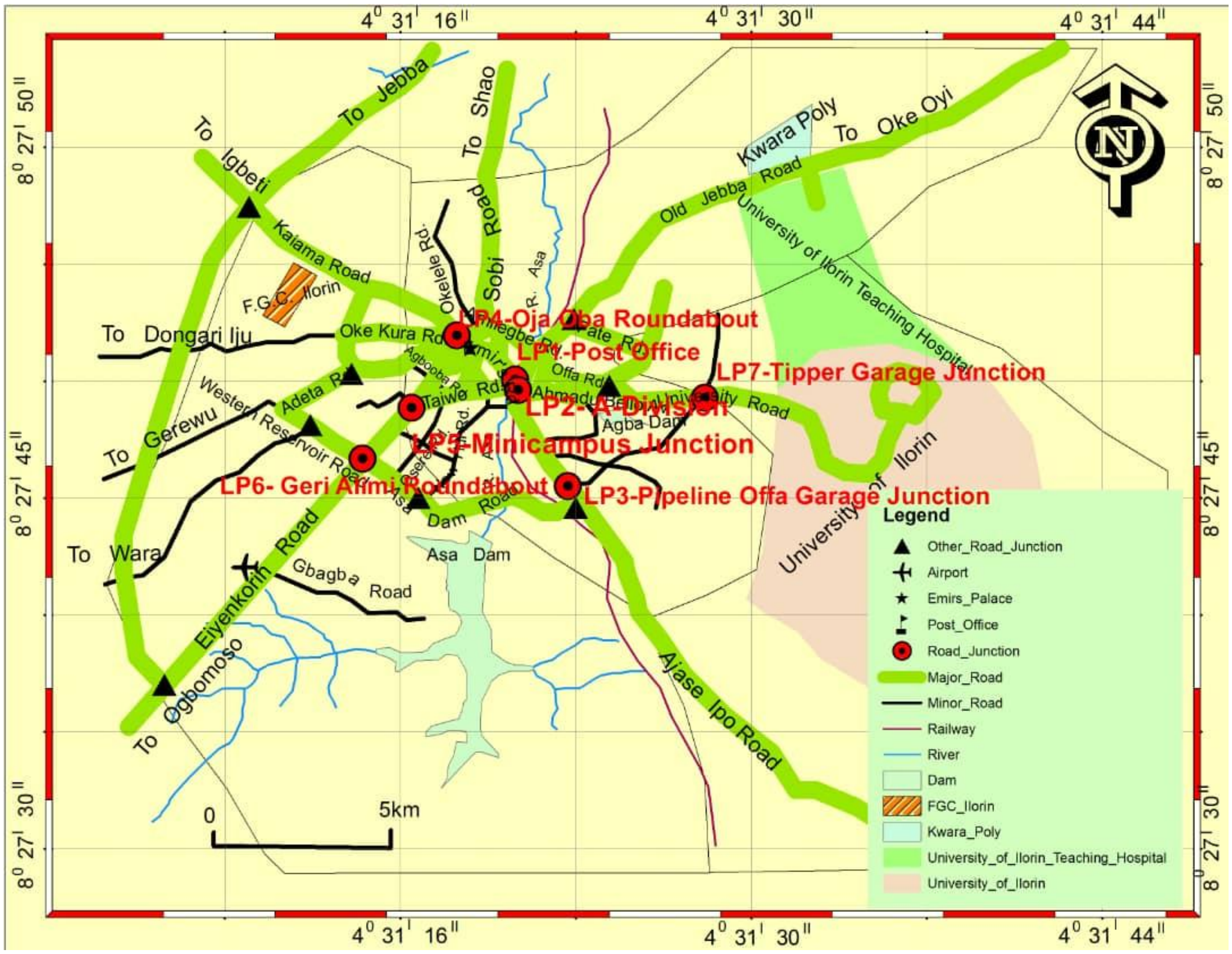

Figure 1: The Study Area showing various road junctions

MATERIALS AND METHODS

The Data used for this study was collected using Multi-Rae plus Emission analyzers as road transport emissions inventory. The device is an in-situ gas monitor with the capability for instantaneous direct read out display through which real time ambient concentrations of Volatile Organic Compounds (VOCs) gas are continuously monitored in parts per million (ppm). VOCs emissions were measured with Multi-rae gas analyzers at 7.30 am-9.30 am, 11.30 am-2.00 pm and 2.30 pm-6.00 pm (designated as the morning peak, off peak and evening peak periods of traffic in the area, respectively) at each of the selected distances (0 meter (center of road junction), 250 meter and 500 meter's distance along selected road junctions) in the week of survey (Monday, 24th October to Sunday, 30th October, 2022). The concentrations of VOCs emission were determined at (0 meter (center of road junction), 250 meter and 500 meter's distance along selected road junctions. Multi-stage sampling procedure was used to select sites for emission measurement. The selected sites were road junctions in Ilorin with higher level of exposure to road transport emissions. The selected sites were road junctions in Ilorin high traffic and greater tendency to experience traffic congestion and higher traffic emission (Aderamo & Atomode, 2012).

In the first place, two by two kilometres grid line was overlaid on the road network map of Ilorin on a scale of 1:100,000 to form cells. This produced 42 cells. Out of these, only 14 grid cells contained road junctions and were purposively selected because, junctions formed the focus of the study (Figure 2). Out of these, seven junctions were purposefully selected for emission measurements. A total of 441 samples were taken. Concentration of (VOCs) was determined at designated time and locations. Data were analysed using descriptive statistics such as Mean, Standard deviation, Tables and column charts as well as Isoline or line chart were used for presentation of results. It is important to note that the preference of isoline to choropleth or any other colour techniques presumed as best for showing spatial and temporal variations in the concentration of pollutants including VOCs in this study is because, the journal is usually printed in black and white; which makes differentiations difficult.

RESULTS AND DISCUSSION

Spatial variation in Volatile Organic Compound (VOCs) emission

The Mean concentration of VOCs levels across the seven junctions is shown in Table 1 revealed that the highest measured concentration was found at LP1 (Post Office junction) (1.588±1.45 ppm), followed by the value obtained at LP2 (A-Division roundabout) (1.0541 ±1.95 ppm). The lowest concentration was 0.931 ±1.07 ppm recorded at LP4 (Oja Oba roundabout). The Lp1 (Post office junction) is a major hub for inter-city and intra-city vehicular traffic and as such, has higher propensity for high concentration of VOC. The situation in LP2 (A-Division was also similar in terms of traffic volumes, hence the high level of concentration. The lowest mean concentration of VOC was measured at LP4 (Oja Oba roundabout); this must have been largely influenced by the flow of traffic at the time of carrying out this survey. It may also have occurred as a result of comparatively lower number of heavy-duty vehicles largely using diesel engine. Vehicles using diesels are known to have higher emission factor than gasoline vehicles (Kun et al., 2020). This must have been impacting negatively on human health in the urban environment.

The analysis of variance (ANOVA) (Table 2) shows significant spatial variation in the mean concentration of VOC emission across the sampled junctions ($F(6,434) = 4.40$, $p<0.05$).

Table 1: Volatile Organic Compound (VOCs) Emission by junction

	Location name	No	Min.	Max.	Total	Mean	SD
1	Post office	63	0	6.1	97.9	1.588	1.45
2	A. division	63	0	11.3	97.1	1.541	1.95
3	Pipe line/Offa garage	63	0	4.4	58.7	0.931	1.07
4	Oja oba	63	0	4.1	47.6	0.755	.843
5	Garin Alimi	63	0	10.4	67.3	1.085	1.66
6	Mini Campus	63	0	11.7	90.2	1.436	2.37
7	Tipper garage	63	0	10.2	67	1.063	1.86

Table 2: ANOVA - Showing concentration of VOCs emission at various junctions

Source	SS	Df	MS	F	P value
Between groups	39.3637188	6	6.5606198	2.33	0.0315
Within groups	1220.65619	434	2.81257187		
Total	1260.01991	440	2.86368161		

Figure 2 is the isoline showing the mean concentration of VOCs at the seven sampled junctions in the study area. The higher mean concentration of VOCs was found at LP1 (1.588 ±1.45ppm), followed by (1.541 ±1.95ppm) at LP 2. These are depicted with relatively higher clustered isolines.

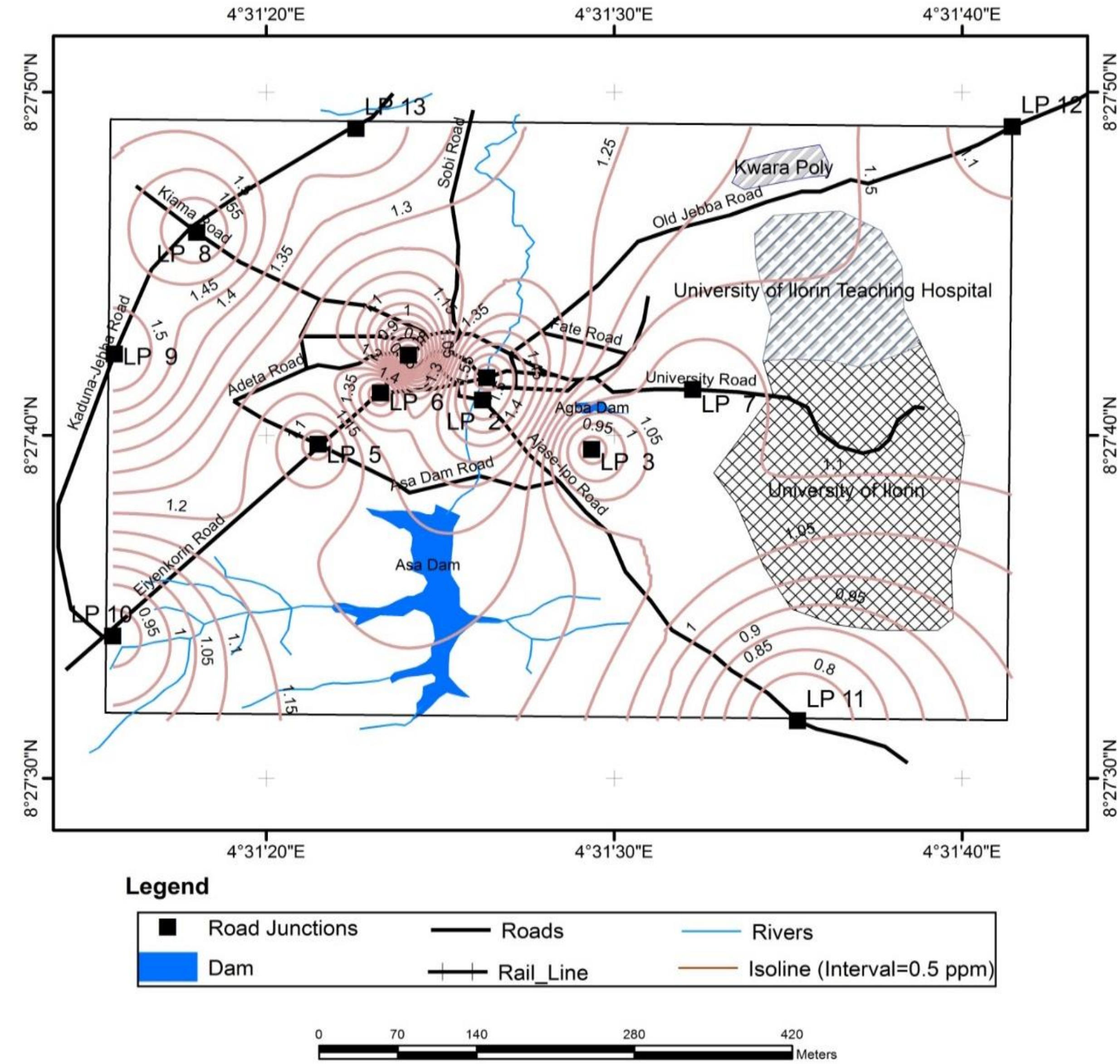

Figure 2: Isoline showing Spatial concentration of mean VOC emission in Ilorin

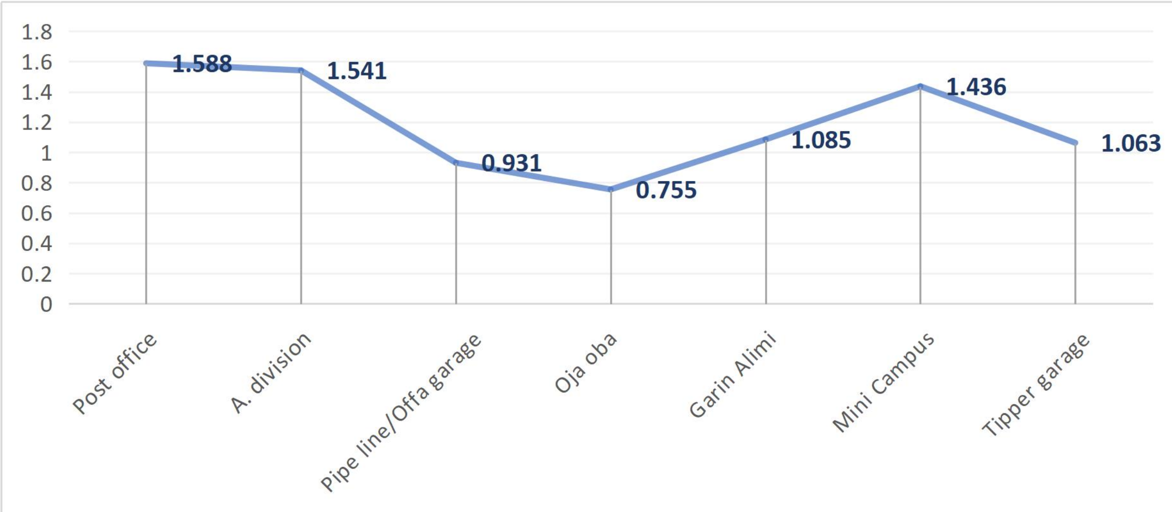

Figure 2: Spatial variation in Volatile Organic Compounds (VOCs) emission

Volatile Organic Compound (VOCs) concentration at selected distances

The mean concentration of VOCs emission at selected distances from the sampled junctions is shown in Table 3. The highest concentration of VOCs emission at selected distances was recorded at LP2 (A-Division roundabout 2.114 ± 2.49 ppm, 1.480 ±1.99 ppm and 1.028 ± .998 ppm at 0, meter, 250 meter and 500 meter, respectively. This was followed by 2.109 ± 1.63 ppm, 1.419 ± 1.35 ppm and 1.238 ±1.25 ppm at 0, 250 and 500 metres, respectively recorded at LP1 (Post Office junction). The lowest concentration values of 0.847 ± .792 ppm, 0.714 ±1.01 ppm and 0.704 ±1.01 ppm at 0, 250 and 500 meters, respectively were recorded at LP4 (Oja Oba round about). Obviously, the mean concentration at each of the selected junction decreases with increasing distance from the centre of each junction (0 meter) across the sampled location (Figure 3). Relatively higher emission values were recorded at centre of each junction 0 metre than were recorded at 250 meter and 500 metres. This follows the tenets of distance decay that states: the farther away a location is from the center, the less is the effects of the phenomenon on them (in this case mean concentration of VOCs emission). The high concentration of VOCs can be attributed to the high volume of traffic and human activities at each junction in Ilorin and elsewhere in Nigeria are noted for (Aderamo & Atomode, 2012). Similarly, several studies in Nigeria have shown that positive correlation exists between congestion and emission (Utangs & Peterside 2011; Ndoke et al., 2006; Aboyeji et al., 2018).

Further analysis using analysis of variance (ANOVA) shows that mean VOCs emission varies from one distance to the other at each of the seven junctions. The results (Table 3) show that no significant variations were revealed in the mean concentration of VOCs at selected distances from each of the sampled junctions.

Table 3: Volatile Organic Compounds concentrations at various distances

	0 metre					250 metre					500 metre					ANOVA	
Loc. Code	No	Min	Max	Mean	SD	No	Min	Max	Mean	SD	No	Min	Max	Mean	SD	F	P
LP 1	21	0	6.1	2.109	1.63	21	0	5.2	1.419	1.35	21	0	4.3	1.238	1.25	2.19	0.1212
LP 2	21	0	11.3	2.114	2.49	21	0	9.1	1.480	1.99	21	0	3.2	1.028	.998	1.67	0.1960
LP 3	21	0	4.2	1.095	1.15	21	0	4.4	0.880	1.10	21	0	3	0.819	.994	0.37	0.6898
LP 4	21	0	2.5	0.847	.792	21	0	1.8	0.714	1.01	21	0	4.1	0.704	1.01	0.18	0.8330
LP 5	21	0	4.4	1.138	1.27	21	0	4	0.866	1.11	21	0	10.4	1.252	2.36	0.29	0.7476
LP 6	21	0	9.4	1.642	2.59	21	0	6.3	1.180	1.61	21	0	11.7	1.485	2.83	0.20	0.8195
LP 7	21	0	10.2	1.514	2.08	21	0	9.5	1.166	2.08	21	0	1.4	0.509	.481	1.60	0.2113

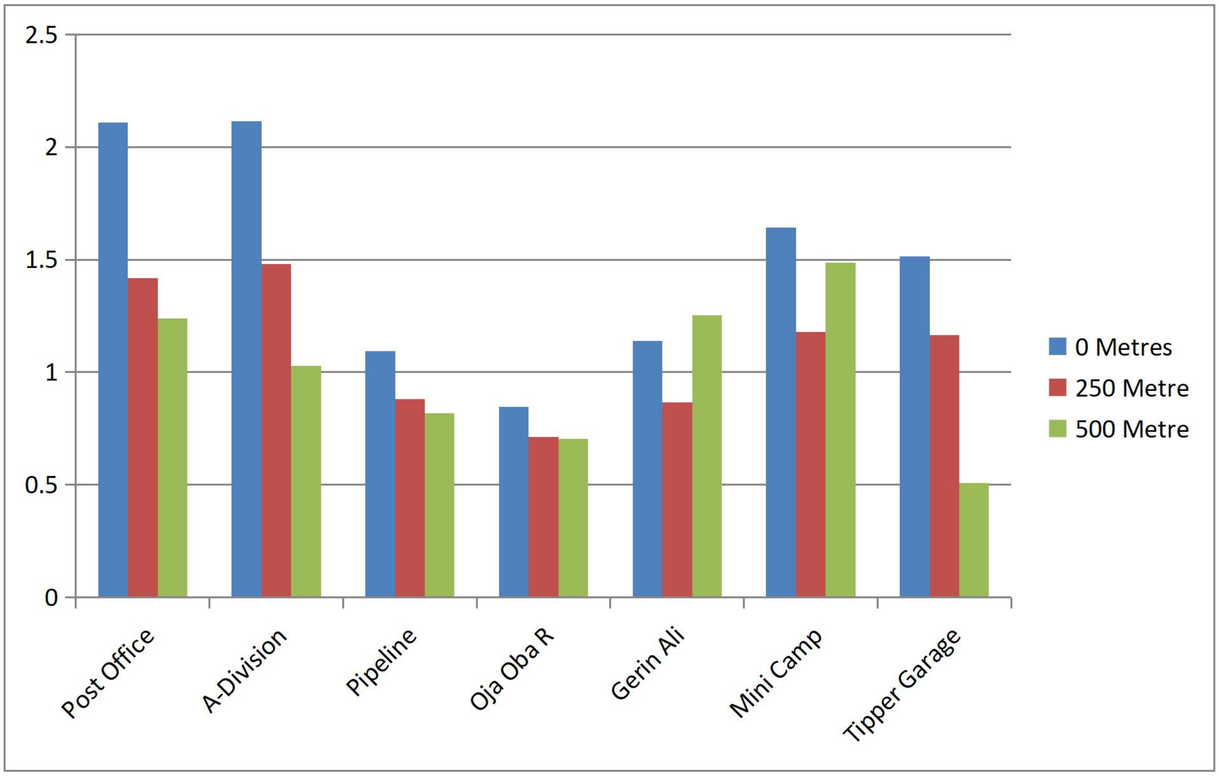

Figure 3: Mean concentration of VOCs based on distances from the seven junctions

Daytime Temporal Variation in Volatile Organic Compounds (VOCs)

The highest mean concentration of VOCs emission at various peaks (morning, afternoon and evening) were found at LP1 (Post office junction) with concentration values of 1.690 ± 1.21 ppm, 1.042 ± 1.023 ppm and 2.033 ±1.86 ppm in the morning, afternoon and evening, respectively (Table 4). This was followed by1.485 ± 1.27 ppm, 0.914 ±1.06 ppm and 2.223 ± 2.85 ppm in the morning, afternoon and evening, respectively as the values obtained at LP2 (A-Division roundabout). The lowest mean concentrations (0.547 ± .596 ppm,.452 ± .626 ppm and 2.257 ± 2.37 ppm in the morning, afternoon and evening, respectively) were recorded at LP5 (Garin Alimi roundabout). It is also worthy of note that, the highest mean concentration in the morning peak was 1.690 ± 1.21 ppm, measured at LP1 (Post office junction). This may not be unconnected with the importance of Post office as the major hub and the central business district which connects major commercial, financial and academic activities in the metropolis. The highest in the afternoon was 1.042± 1.023 ppm also measured at LP1 (Post office junction) and the highest mean concentration of in the evening peak was 2.257 ± 2.37 ppm; observed at LP5

(Garin Alimi roundabout). Obviously, the concentration of (VOCs) emission was generally higher in the morning and evening peaks than it was in the afternoon peak (see Figure 4).

Generally, relatively higher emission values were recorded in both the morning and evening peaks, while the afternoon peak's value was comparatively lower. This may be attributed to the relatively higher vehicular movement associated with both the 'morning rush' and the 'evening rush' hours of the day. Similar patterns of temporal variation of vehicular emission were recorded in Port Harcourt (Utang & Petersides, 2011). This work also observed that emission are peak and off-peaks dependents; with higher emissions in the morning and evening peak hours and lower emission in the afternoon peaks.

Similarly, Aboyeji (2018) observed the same pattern in his research of the ambient concentration of Carbon monoxide in Ilorin. The relatively lower VOCs concentration generally experienced in the afternoon may be attributed to low volume of vehicular movement associated with off peak periods in all the sampled junctions. This finding is in consistence with Restrepo (2021) who confirmed higher concentration of NO_2 at high traffic zones in New York City. The traffic dependence of vehicular emission was clearly shown with significant reduction of No_2 during lock down in New York City due to little or no traffic. In a related development, a study conducted in London, Milan and Paris showed a reduction of NO_2 concentration during lockdown in 2020 compared to the same period for the year 2017-2019 (Collivignarelli et al., 2021). Thus, high level of emission from vehicles is associated with levels of traffic emission and vice versa.

The analysis of variance (ANOVA) on the variation between VOCs emission at various time across the sampled junctions shows that, significant variation existed in the mean concentration of VOCs at LP3, LP5, LP6 and LP7; with LP6 (Mini campus junction) having the most important significant level of $P<0.0002$ at various peaks (Table 5), whereas, no significant variations were recorded in the mean concentration of VOCs emission at LP2, LP4 and LP6 at the various peaks.

Table 5: Volatile Organic Compounds concentration at various time

	Morning					Afternoon					Evening					AVOVA	
Loc. Code	**No**	**Min**	**Max**	**Mean**	**SD**	**No**	**Min**	**Max**	**Mean**	**SD**	**No**	**Min**	**Max**	**Mean**	**SD**	**F**	**P**
LP 1	21	0	4.7	1.690	1.21	21	0	4.3	1.042	1.023	21	0	6.1	2.033	1.86	2.65	0.0787
LP 2	21	0	4.2	1.485	1.27	21	0	4.5	0.914	1.06	21	0	11.3	2.223	2.85	2.49	0.0915
LP 3	21	0	4.2	0.690	1.00	21	0	2.8	0.7	0.888	21	0	4.4	1.404	1.200	3.27	0.0449
LP 4	21	0	2.1	0.680	.683	21	0	1.8	0.623	0.737	21	0	4.1	.961	1.06	0.97	0.3868
LP 5	21	0	2.2	0.547	.596	21	0	2.2	0.452	0.626	21	0	10.4	2.257	2.37	10.19	0.0002
LP 6	21	0	1.3	0.690	.384	21	0	1.9	0.519	0.596	21	0	11.7	3.1	3.55	9.98	0.0002
LP 7	21	0	5.3	0.914	1.15	21	0	1.2	0.442	0.405	21	0	10.2	1.833	2.87	3.22	0.0469

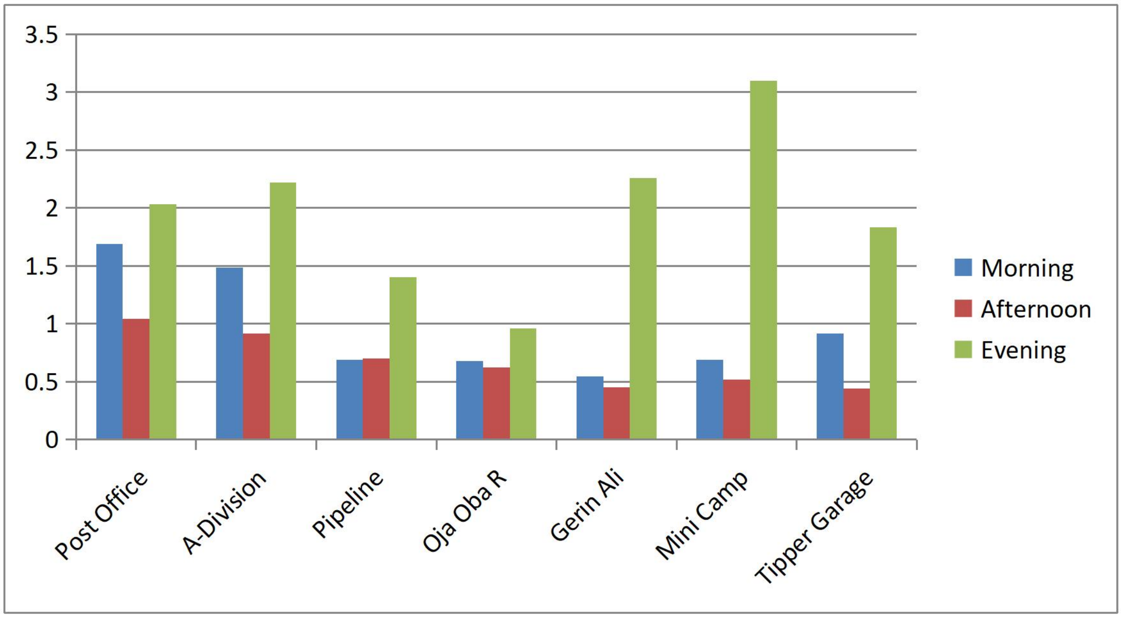

Figure 4: Mean concentration of VOCs based on different peaks

Concentrations of Volatile Organic Compounds concentration in Different days

The highest mean concentration of VOCs across the junctions was 4.333±3.4ppm recorded on a Tuesday at LP2 (A-Division roundabout). This was closely followed by 3.333± 4.54 ppm concentration level recorded at LP6 (Mini-Campus junction on the same day (Figure 5). Comparing the mean of VOCs per day, it was noticed that Tuesday had the highest mean total concentration of 2.688±2.685 ppm (Table 6b). This was followed by Friday with a mean total concentration value of 1.239±1.088ppm (Table 6 a & b). The day with the lowest mean total concentration was Sunday with a value of 0.676±0.752ppm (Table 6 a & b). This might not be unconnected with the relatively low traffic movement characteristics of the day (Sunday). Earlier, Kara et al. (2005), also observed 4% and 3% in the concentrations of $PM_{2.5}$ and NO_2 emissions, respectively in weekend than week days in Beijing, China (Hua et al., 2020).

Table 6a: Volatile Organic Compound Concentration on Daily Basis

	Monday					Tuesday					Wednesday					Thursday					Friday					Saturday					Sunday				
Loc. code	**No**	**Min**	**Max**	**Mean**	**SD**	**No**	**Min**	**Max**	**Mean**	**SD**	**No**	**Min**	**Max**	**Mean**	**SD**	**No**	**Min**	**Max**	**Mean**	**SD**	**No**	**Min**	**Max**	**Mean**	**SD**	**No**	**Min**	**Max**	**Mean**	**SD**	**No**	**Min**	**Max**	**Mean**	**SD**
LP 1	9	.9	4.2	1.455	1.04	9	1.2	6.1	2.8	1.82	9	0	4.3	1.344	1.33	9	1	4.7	2.122	1.22	9	.2	2.6	1.322	.783	9	0	4.5	1.566	.781	9	0	1.4	0.544	.610
LP 2	9	0	3.1	0.766	1.21	9	.9	11.3	4.333	3.54	9	0	4.2	1.511	1.18	9	0	2.3	1.055	.860	9	.2	2.6	1.211	.783	9	0	3.2	1.6	.963	9	0	1.3	0.311	.498
LP 3	9	0	4.4	1.344	1.71	9	.2	4.2	1.611	1.15	9	0	1.7	0.911	.493	9	0	.2	0.044	.088	9	0	1.9	1.011	.714	9	0	2.8	1.133	1.716	9	0	1.5	0.466	.634
LP 4	9	0	.4	0.133	.141	9	0	2.1	1.211	.596	9	0	1.8	0.9	.777	9	0	4.1	0.677	1.39	9	0	2	1.233	.728	9	0	.5	0.122	.156	9	0	2.5	1.011	.740
LP 5	9	0	.7	0.3	.254	9	0	10.4	2.188	3.12	9	0	2.2	0.988	.656	9	0	4.4	0.955	1.47	9	0	4.4	1.411	1.66	9	0	1.9	0.344	.650	9	0	4.3	1.411	1.65
LP 6	9	.1	1.4	0.633	.504	9	0	11.7	3.366	4.54	9	0	1.4	0.622	.569	9	0	7.6	2.055	2.60	9	0	8.2	2.155	2.59	9	0	1.9	0.744	.705	9	0	1.5	0.477	.519
LP 7	9	0	1.6	0.733	.585	9	.2	10.2	3.311	4.03	9	0	1.2	0.566	.466	9	0	4.1	1.211	1.56	9	0	.9	0.333	.364	9	0	1.4	0.744	.397	9	0	1.4	0.544	.610

Table 6b: Volatile Organic Compound Concentration on Each Day of the Week

	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday	
Locations	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Post Office	1.455	1.04	2.8	1.82	1.344	1.33	2.122	1.22	1.322	.783	1.566	.781	0.511	.610
A-Division	0.766	1.21	4.333	3.54	1.511	1.18	1.055	.860	1.211	.783	1.6	.963	0.311	.498
Pipeline	1.344	1.71	1.611	1.15	0.911	.493	0.044	.088	1.011	.714	1.133	1.716	0.466	.634
Oja Oba	0.133	.141	1.211	.596	0.9	.777	0.677	1.39	1.233	.728	0.122	.156	1.011	.740
Gerin Alimi	0.3	.254	2.188	3.12	0.988	.656	0.955	1.47	1.411	1.66	0.344	.650	1.411	1.65
Mini Campus	0.633	.504	3.366	4.54	0.622	.569	2.055	2.60	2.155	2.59	0.744	.705	0.477	.519
Tipper Garage	0.733	.585	3.311	4.03	0.566	.466	1.211	1.56	0.333	.364	0.744	.397	0.544	.610
Total	0.766	0.778	2.688	2.685	0.977	0.782	1.160	1.313	1.239	1.088	0.893	0.766	0.676	0.752

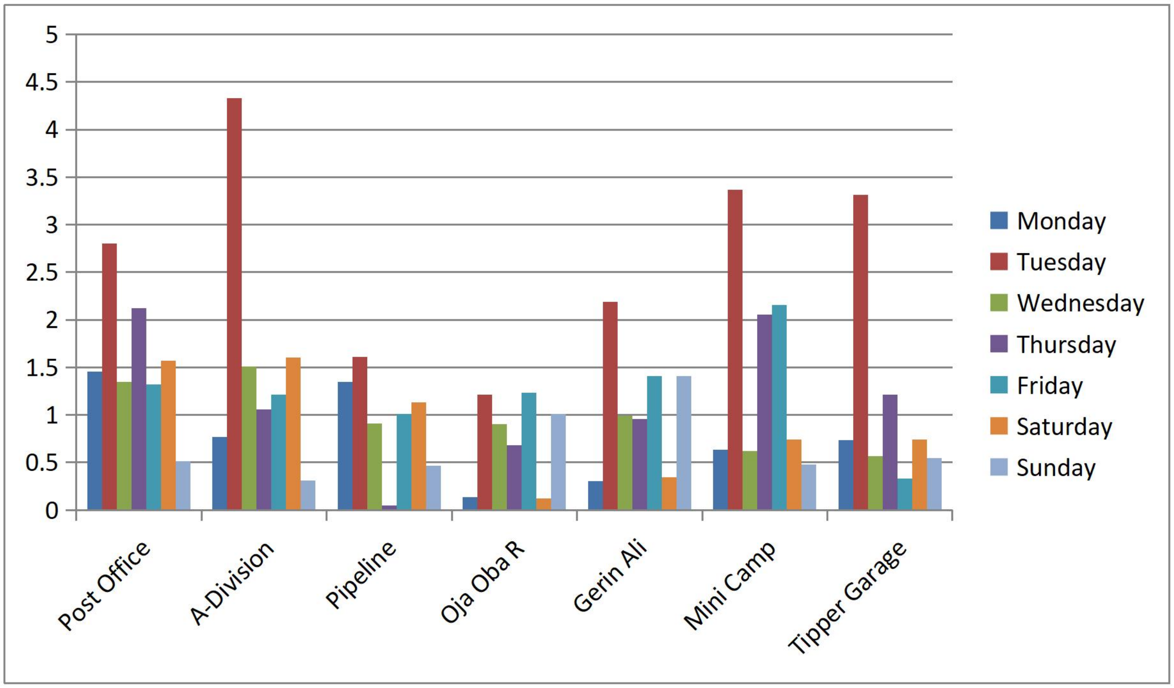

Figure 5: Mean concentration of VOCs on daily basis

CONCLUSION

The study examined the spatial and temporal patterns of Volatile Organic Compounds concentrations at selected distances from selected road junctions at various peaks of traffic of the day and on each day of the week of survey. This study has observed that various degrees of variations were revealed in the concentration of Volatile organic compounds at studied junctions and distances and at various times/peaks of the day and on each day of the week of survey. Relatively higher concentrations of Volatile organic compounds emission were observed at the center of road junctions than some distances away from the center of road junctions.

Mean concentrations of VOCs varied as 1.494 ±1.715ppm, 1.226 ±1.464 ppm and 0.932 ±1.418ppm, at 0m, 250m and 500m away from the road junctions. The mean concentration of Volatile Organic Compound in the morning (0.909 ±0.899), afternoon (0.670 ±0.762ppm) and evening (1.973 ±2.251ppm) thus reveal 'peaks' and 'off peaks' of traffic. The study also observed a direct association between volatile organic compounds emission and traffic flow in the study area, and concluded that the concentrations of volatile organic compounds emission are influenced by traffic flow, vehicle types, age of vehicles and fuel types, among others. The study equally noted that the average mean concentration of VOCs recorded across the seven junctions was 1.333 ±1.600 ppm; which is already higher than the threshold limit values of 0.5ppm (Okelola & Okhimame, 2013) in most of the location.

In view of the increasing poverty and the continuous patronage of fairly used vehicles as a strategy for meeting increasing mobility challenges of urban residents, the associated increase in emission of volatile organic compounds and other vehicle induced gasses constitute monumental threat to human health and the urban environment. The study therefore recommends the formulation and enforcement of policies by relevant stakeholders on acceptable traffic emission standards, improvement in fuel efficiency, provision of public transit, provision of adequate space on urban roads, dualization of more urban roads and construction of more overhead bridges in urban areas, especially at highest traffic congestion areas and general improvement in road transport planning. These will help to create an enabling environment for the provision of basic access to adequate, safe, resilient and emission friendly traffic flow as spelt out in vision 2030 Sustainable Development Goals.

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