



GEO-SPATIAL INTERPRETATION OF VEHICULAR TRAFFIC RATE AND NOISE POLLUTION IN UYO, AKWA IBOM STATE.

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Abstract

Noise pollution constitutes serious threat to health and environment in urban region, especially in developing countries where it is generally unregulated. This study interprets noise pollution data obtained from vehicular traffic in Uyo, with the aim of examining the geospatial and temporal variation of vehicular traffic with noise levels in view of establishing the relationship between vehicular traffic velocity and noise level in Uyo. Quantitative data of noise pollution were collected from 16 sites known for high vehicular traffic; and from 2 sites along low traffic roads. Data were analyzed using ANOVA and multiple regression. Results show that noise level in 16 out of the 18 sites studied exceeded the acceptable limits for human well-being, and vehicular traffic significantly contributed to the total noise levels generated within Uyo metropolis. The noise levels were high (86-106dB) for sites with high traffic range volume; with the highest grand mean noise level (GMNL) of 83.98dB at Oron Road by Edet Akpan Avenue. This was interpreted to mean; traffic volume is directly proportional to the level of noise for any given road. The implication of this result is that, dense vehicular traffic spots pose higher noise threat, hence, should not be for occupancy. The study recommends restriction of vehicles based on their capacities to certain roads.

Keywords: Noise Pollution, Road Traffic, Geo-spatial, Temporal, Environment

1.0 Introduction

Environmental pollution from noise is one of the major hazards associated with vehicular movement. The impact of vehicular noise pollution is felt world over, with the developing nations being most affected (Kinder, 2015; Anderson and Glliver, 2016). Ironically, from ancient times transportation has been pertinent in the movement of man,

bulk cargo and related services from points of origin to points of destination with energy optimization as focus. This brings about evolution in the means transportation using new-fangled technology; hence, transportation sector becomes the hub of development. It aids accessibility of people and places, while enhancing social, economic and cultural interactions. Therefore,

transportation is considered a precondition for geospatial interaction at the national and international levels (Marathel, 2012; Bluhm *et al.*, 2004). Transportation has been the pivot for cross-cultural interaction and a driver of socio-economic and industrial activities (Rodrigue *et al.*, 2009). It has been discovered that urban productivity is a function of the efficiency of its transportation system in conveying production inputs between multiple origins and destinations by the various types of transport mode (Armah *et al.*, 2009; Odum and Aloba, 2014).

The road transportation involves vehicular motion, and it is the most common type of transportation used for inter and infra cities connectivity. Rodrigue *et al.* (2009) and Gan *et al.* (2012) asserted that vehicular transportation is extensively used and it contributes meaningfully to urban growth and development. This is also the case in Nigeria, where majority of the population relies heavily on vehicular transportation for distribution of goods and services.

However, vehicular transportation is not without social and environmental problems. For instance, it is an easy means for human trafficking in Nigeria. The present increase in greenhouse gases, which has not only birthed global warming but also climate change tends to be proportionate with the increasing vehicular traffic (Hansell *et al.*, 2016). Health problems associated with noise pollution include: hypertension, sleep disruption, low cognitive development in children, memory loss, psychiatric disorder, death and psyche related issues as well as social vices (WHO, 2011).

The chronic problems of air and water pollution from hydrocarbon and noise are associated with road transportation. In Akwa

Ibom State, the absence of railway has forced significant number of the dwellers to depend on road transportation as an affordable option. Therefore, the issue of noise pollution has drawn global attention, but has its origin at the local level.

In Nigeria, studies conducted on urban transportation with their attendant effects on health and environment have shown that, congestion and noise pollution are the most serious effects of vehicular transportation in cities (Akpan, 1998; Oni, 2004; Alam, 2006; Oyedepo and Saadu, 2009; Oyedepo & Saadu, 2010; Goswami, Nayak, Pradhan & Dey, 2011; Odum & Aloba, 2014; Kinder, 2015). At present, Nigeria is witnessing increase in the level of technology, industrialization, urbanization, communication and transportation systems, which has projected noise pollution to a disturbing level over the years. This needs to be studied and controlled to avoid associated effects. Unfortunately, noise pollution has not been sufficiently investigated in developing cities such as Uyo. Therefore, this study aimed at unraveling the geospatial variation of vehicular traffic with noise levels, and to establish the relationship between vehicular traffic velocity and noise level in Uyo. Previous studies have been limited to noise pollution and its effects on the environment (Ugwuanyi *et al.*, 2005; Thakur, 2006; Ogunleye and Ibitoye, 2008; Odum & Aloba, 2014; Esin and Afahakan, 2017). The present study will contribute significantly to noise control in developing cities for the safety of dwellers.

2.0 The Study Area

The study area lies between latitudes 4°59' and 5°04'N and longitudes 7°53' and 8°00'E. Uyo is on an average height of 60.96 meters (2090ft) above ocean level and situated at the focal point of the Akwa Ibom State. Uyo is bounded in the North by Ikono, Ibiono Ibom

and Itu; in the West, Uyo is bounded by Abak Local Government Area; in the East, it is bounded by Uruan Local Government Area; in the South, it is bounded by Etinan, Nsit Ibom and Ibesikpo Asutan Local Government Areas (Figure 1).

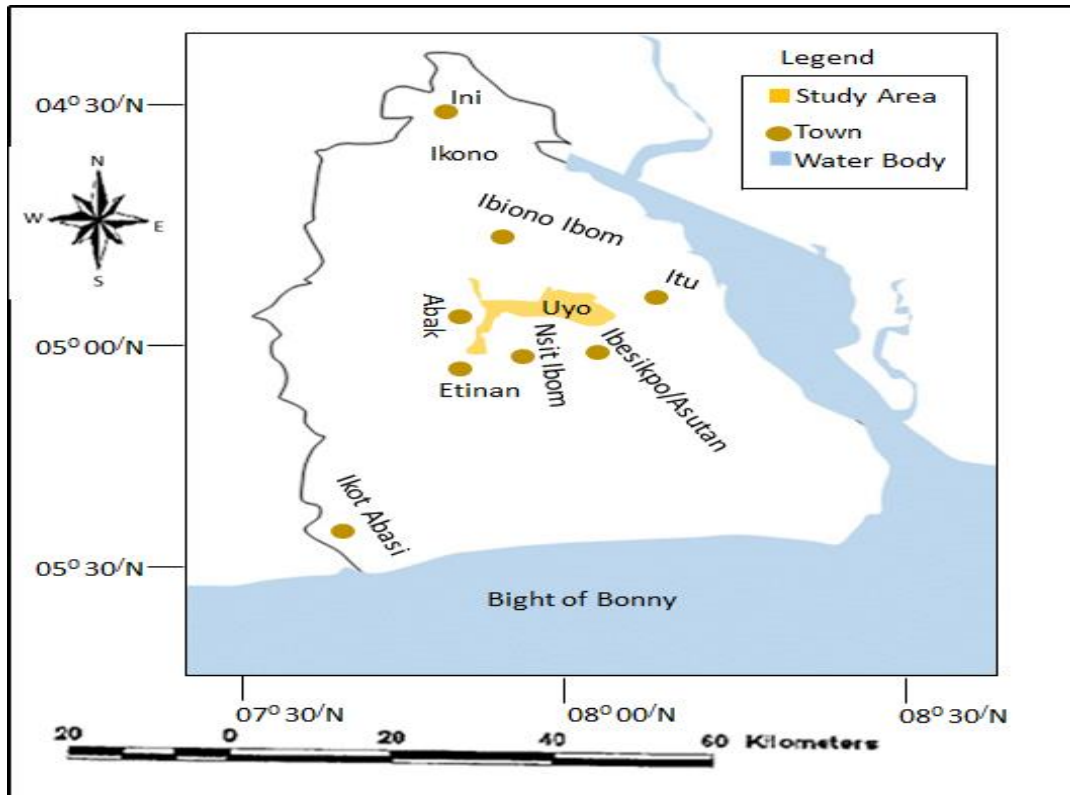


Figure 1: Map of Akwa Ibom State showing the Study Area

The land mass of Uyo is about 95 km² and it is located in the tropical rain backwoods Region, and has two unmistakable seasons; dry and wet seasons (Essien and Ekpo, 2012). The dry season is from November to March, while the stormy rainy season is between April and October. Within the rainy season, is a short drought notably in the month of August, known as August Break (Essien and Ekpo, 2012). Uyo is one of the fastest growing metropolises in the developing countries in terms of population and traffic rate because of its endowed blue economy.

With a population of 302,573 persons (National Population Commission, 2006), the study area is considered to have high population density, with increasing pressure on available transportation infrastructure. In addition, Uyo is becoming conjectured with vehicular traffic, which can automatically increase the level of noise with several implications on health and socio-economic status of the urban residents. Uyo has intensive network roads, they include; IBB Way, OBJ Way, Atiku Abubakar Avenue, Udo Udoma Avenue, Nsikak Eduok Avenue,

Edet Akpan Avenue and Goodluck Jonathan Boulevard. At present, Ring Road 3 is under construction.

3.0 Materials and Method

The materials used for data collection were; Sonometer (model Anologue cell 254K), which was used to measure noise intensity in decibels; observation forms were used in generating data on the traffic census; graphic designs for plotting; exercise book and pencils; camera. GPS was deployed to measuring heights and coordinates, and measuring tape for measuring distance from noise source as well as roads' dimensions. The functionality and reliability of all the instruments were tested before deploying them for field work. For instance, the sonometer was calibrated to avoid errors due to parallax in measurement of vehicular noise. Measurements were taken at traffic peak periods notably measured were 7–10am; 12–3pm and 4–7pm of Monday, Wednesday, Friday and Sunday.

Census on vehicular flow in the study area was conducted per sampled roads to determine the traffic levels, which was used to establish the peak periods of traffic along the roads. The specific areas identified for high traffic volume are the Plaza through Ikot Ekpene Road, Abak Road, Aka Road, Oron Road and Nwaniba Road. These were the areas for data collection for the study. There

are several roads linking the central business district (CBD) called Plaza. The vehicular traffic concentration (TC) was obtained by dividing the total vehicular flow (TFC) along each sample road by the area of the road (equation 1). The area of each road was estimated from the product of its length and width. A total of sixteen roads noted for heavy traffic, high population density and high residential/commercial activities in Uyo metropolis were selected intentionally. In addition, data were collected from two transportation roads noted for light traffic, low population density as well as low residential/commercial activities to serve as control roads for the study. In addition to the data obtained from two roads used as control, Table 1 was used to compare measured noise level with established threshold level.

$$TC = \frac{TFC}{RoadArea} \quad (1)$$

Data obtained were analyzed using descriptive and inferential statistical techniques were employed in the analysis of the data generated for the study. One-Way Analysis of Variance was used to establish geospatial and temporal variation in the rate of vehicular traffic along the sampled transportation roads as well as showing the geospatial and temporal difference in the level of noise generated from vehicular traffic along the sampled roads.

Table 1: Noise sensitivity classification (level of risk exposure)

dB	Sensitivity
55 – 60	Risk
60 – 65	Medium Risk
65 – 70	High Risk
70 – 75	Dangerous
75 – 80	Highly Dangerous
80 – 85	Extremely Dangerous

Source: USEPA (1974).

Also, Multiple Regression Analysis was employed to predict the degree of relationships between traffic flow rate, traffic concentration and noise levels in the study area. The regression model is given as shown below;

$$Nl = f(tfv, tc) \tag{2}$$

where f: a function to be specified

Nl = Noise levels (dependent variable)

Tfv = Traffic flow rate (Independent variable)

Tc = traffic concentration (independent variable)

In specific form, equation (1) can be written as;

$$Nl = \alpha_0 + \alpha_1 Tfv + \alpha_2 TC + \mu \tag{3}$$

where α_0 is a constant; α_1, α_2 are the regression coefficients; which determine the contributions of the independent variables (Tfv and Tc) and μ is residual or stochastic error term which reveals the strength of $\alpha_1 Tfv$ and $\alpha_2 Tc$. If μ is low then, the number of unexplained factors (not captured by the model) will be low and vice versa.

4.0 Results and discussion

Table 2 shows the temporal distribution of vehicular traffic along the sampled roads in the study area for the three peak periods of 7 – 10am (morning peak); 12 – 3pm (afternoon peak) and 4 – 7pm (evening peak). From the table, it is observed that the rate of vehicular traffic at every location is higher during the afternoon peak period than during the morning and evening peak periods for all weekday. This could be due to increased business activities within this period in the

metropolis. It was also revealed that the traffic rate along each road is lower on Sundays than any other day of the week except along Nwaniba road axis. The possible reason for this could be due to the fact that most worship centers in Uyo are located along the road. It is also shown on the table that traffic rates on Fridays are higher than those on the other days of the week. This could be attributed to the fact that special occasions like burial ceremonies, traditional marriages, etc, are usually scheduled for Fridays than the other days of the week.

Table 2: Temporal pattern of vehicular traffic flow rate along the sampled roads in Uyo Metropolis

S / N	Time	Morning Peak (7am – 10am)				Afternoon Peak (12 – 3pm)				Evening Peak (4 – 7pm)			
	Location	on	ed	ri	un	on	ed	Ri	un	on	ed	ri	un
	Abak Rd (by Plaza)	36	82	28	64	32	28	96	18	14	06	22	17
	Abak Rd (by IBB)	04	01	06	02	51	20	86	08	10	04	02	42
	Abak Rd (by Ekom- Imam Junction)	16	06	02	08	14	04	06	06	04	00	01	01
	Aka Rd (by Plaza)	98	88	31	19	42	31	40	29	91	94	96	45
	Aka Rd (by IBB)	02	09	16	12	51	17	96	39	94	06	21	53
	Oron Rd (by Plaza)	18	17	12	67	46	84	66	12	09	16	18	25
	Oron Rd (by Edet Akpan)	12	06	46	08	87	29	44	17	14	68	18	59
	Oron Rd (by Mbiabong Park)	71	68	82	06	01	12	61	04	51	00	61	09
	Oron Rd (by Udo- Udoma Ave.)	95	94	91	11	09	01	36	10	14	68	41	36
0	Oron Rd (by Gibbs Str.)	00	09	72	01	31	69	89	26	23	19	68	16
1	Nwaniba Rd (by Oron Rd)	71	23	02	71	14	04	89	52	91	09	96	97
2	Nwaniba Rd (by Water fountain)	18	20	14	18	21	02	86	35	16	00	16	99
3	Ikpa Rd (by Ikot Ekpene Rd)	06	81	19	18	71	07	23	46	11	01	44	07
4	Ikpa Rd (by Uniuoyomaingate)	90	06	12	2	08	04	16	76	06	13	91	62
5	Ikot Ekpene Rd (by Eka/Udi Str.)	81	96	90	03	45	01	81	03	09	26	41	23
6	Ikot Ekpene Rd (by Itam junction)	62	06	41	41	61	17	10	03	19	08	12	04
7	Barracks Rd (by Plaza)	13	40	29	23	47	10	84	14	98	10	10	16
8	Barracks Rd (by Uyo Village Rd)	82	36	86	96	06	96	11	08	09	21	24	89

Source: Author's fieldwork (2021)

Table 3 shows the geospatial variation in vehicular traffic rate along the sampled roads in Uyo Metropolis. The table indicates that the rate of vehicular traffic is higher along the

dual carriage roads such as Oron, Abak, Ikot Ekpene, Nwaniba and Aka than the minor arteries. This could be because these roads are the major hubs of commercial and

industrial activities in Uyo. It is also seen on the table that Oron Road and Edet Akpan Avenue (four lanes) have the highest rate of vehicular traffic. This could be attributable to the fact that these roads serve as the major link to the popular Ewet Housing Estate occupied predominantly by high income

earners with robust lifestyles, added to this is the fact that important and notable hotels are located within the estate with high patronage from influx of top government officials and politicians for both leisure and political conglomeration purposes.

Table 3: Geospatial variations of vehicular traffic rate along the sampled roads in Uyo Metropolis

S/N	Locations/Roads	Co-ordinate of sampling points		Traffic flow rate
		Latitude	Longitude	
1.	Abak Rd (by Plaza)	5.0533	7.9283	4943
2.	Abak Rd (by IBB)	5.1744	7.9916	7936
3.	Abak Rd (by Ekom-imam Junction)	5.0975	7.9358	8768
4.	Aka Rd (by Plaza)	5.0332	7.9279	4804
5.	Aka Rd (by IBB)	5.0136	7.9193	7416
6.	Oron Rd (by Plaza)	5.0542	8.1036	4890
7.	Oron Rd (by Edet Akpan Avenue)	5.0302	7.9336	10458
8.	Oron Rd (by Mbiabong Park)	6.0033	8.1058	8966
9.	Oron Rd (by Udo-Udoma Ave.)	5.2539	7.9422	5006
10.	Oron Rd (by Gibbs Str.)	5.0325	7.9350	6223
11.	Nwaniba Rd (by Oron Rd)	5.0083	7.9422	8219
12.	Nwaniba Rd (by Water fountain)	5.2022	7.9814	7145
13.	Ikpa Rd (by Ikot Ekpene Rd)	5.0955	8.0305	9134
14.	Ikpa Rd (by Uniuromaingate)	5.0777	8.0561	8276
15.	Ikot Ekpene Rd (by Eka/Udi Str.)	5.0350	7.9283	8099
16.	Ikot Ekpene Rd (by Itam Junction)	5.0257	8.1300	5284
17.	Barracks Rd (by Plaza)	5.0389	7.9353	4894
18.	Barracks Rd (by Uyo Village Rd)	5.0694	7.9083	2764

Source: Author’s field work (2021).

It is also evident from the table that traffic rate at Ikpa road axis (though not a dual carriage road is relatively high, but not as that of Edet Akpan avenue and Oron road. The observed relative high traffic along Ikpa road could be as a result of the sitting of two important higher institutions (University of Uyo and Uyo City Polytechnic) along this road. These tertiary institutions attract viable business centres and residential quarters together with influx of students to service the educational institutions. The table further reveals that the rate of vehicular traffic along Barracks Road axis is very low compared to other roads. This could be as a result of the

abolishment of tricycles from plying the road with attendant implication on commercial activities within the locality due to the location of the administration headquarters of Akwa Ibom State. The Table also shows that traffic rate around the entire plaza axis is quite low compared to that of Barracks Road. The observed low traffic rate in the plaza axis is due to the abolishment of tricycles from plying the plaza vicinity. Figure 2 is a surface contour map showing lines of equal vehicular traffic rate in Uyo. The map indicates traffic concentration at locations marked by the symmetrical ring.

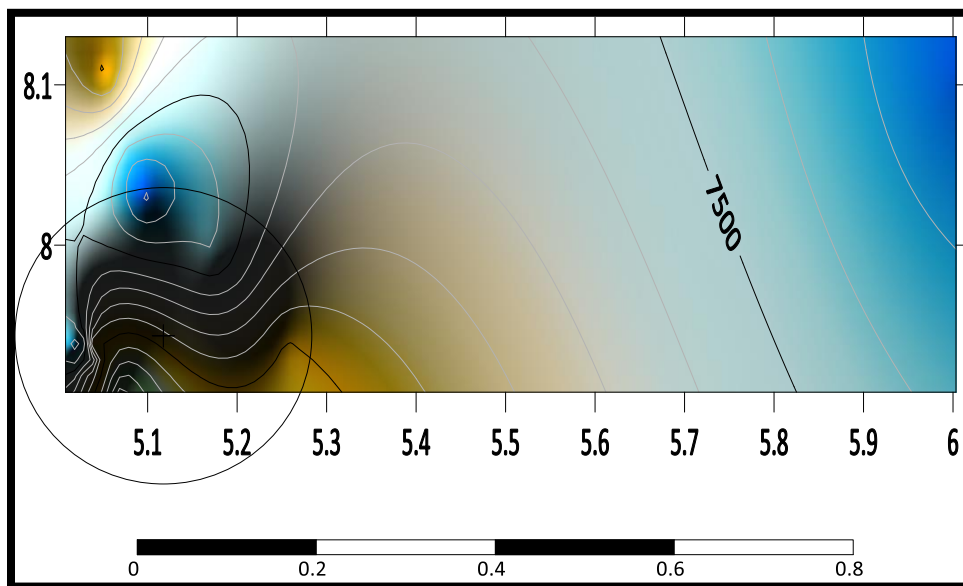


Figure 2: Contour map showing vehicular traffic concentration in Uyo

Result presented in Table 4 is the geospatial and temporal variations in the noise levels from vehicular traffic in Uyo metropolis. This result indicates that the noise ambient noise level for the residential areas exceed 55 decibels, while that of the industrial and commercial areas surpasses 70 decibels threshold level (WHO, 2016). From the

Table 4, it is evident that for all the weeks used for the study, day noise level was higher for both industrial and commercial areas. It further adduced a reduction in noise levels on Sunday evenings for all locations.

Table 4: Geospatial and Temporal Variations in Noise Levels from Vehicular Traffic in Uyo Metropolis

/N	Locations/Roads	Morning Peak (7 – 10am) dB				Afternoon Peak (12 – 3pm) Db				Evening Peak (4 – 7pm) dB			
		ON	ED	RI	UN	ON	ED	RI	UN	ON	ED	RI	UN
.	Abak Rd (by Plaza)	0.0	5.5	2.5	8.3	9.2	6.5	8.4	4.2	7.2	8.9	3.4	0.6
.	Abak Rd (by IBB)	2.2	9.7	3.7	1.4	4.6	3.5	5.2	3.0	2.8	1.6	3.0	6.0
.	Abak Rd (by Ekom-Imam Junc)	5.5	1.5	4.6	8.6	3.3	1.6	6.4	0.1	2.6	0.0	2.0	5.0
.	Aka Rd (by Plaza)	8.7	6.7	0.0	3.5	2.1	4.2	9.0	5.3	1.2	4.3	5.3	0.5
.	Aka Rd (by IBB)	2.0	2.3	0.1	0.0	4.5	3.6	5.1	5.4	1.3	9.2	2.4	5.8
.	Oron Rd (by Plaza)	9.5	3.2	9.7	7.6	0.2	6.5	1.6	7.0	7.1	7.6	5.2	1.7
.	Oron Rd (by Edet Akpan)	5.6	4.7	6.8	4.8	7.2	5.3	6.9	4.4	5.0	4.7	6.1	6.2
.	Oron Rd (by Mbiabong Park)	4.6	1.0	6.2	9.2	2.0	1.5	6.2	2.2	2.7	0.0	4.3	7.1
.	Oron Rd (by Udo-Udoma Ave.)	5.2	3.2	7.5	9.2	0.3	9.3	2.0	4.0	6.5	9.6	5.4	3.1
0.	Oron Rd (by Gibbs Str.)	3.1	2.0	8.1	0.1	9.1	9.4	1.1	2.4	6.4	3.2	7.5	4.2
1.	Nwaniba Rd (by Oron Rd)	2.4	1.3	5.1	5.3	3.5	2.5	4.5	6.8	4.2	0.3	7.3	9.0
2.	Nwaniba Rd (by Water fountain)	1.6	0.1	9.6	1.1	5.6	4.3	6.7	4.5	0.2	7.6	1.1	3.2
3.	Ikpa Rd (by Ikot Ekpene Rd)	4.6	3.1	6.8	2.0	7.3	5.7	6.1	3.4	4.5	2.5	5.6	5.0
4.	Ikpa Rd (by Uniyomain gate)	3.2	2.3	5.1	0.3	4.6	1.6	6.4	4.2	1.3	2.1	4.1	2.1

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5.	Ikot Ekpene Rd (by Eka/Udi Str.)	3.5	1.4	1.8	8.4	2.6	9.1	2.2	2.0	2.6	3.1	3.7	4.6
6.	Ikot Ekpene Rd (by Itam junction)	6.4	2.1	3.6	7.3	3.5	3.7	4.1	3.0	3.6	1.2	2.0	8.4
7.	Barracks Rd (by Plaza)	5.6	2.6	9.4	0.2	6.4	5.5	0.1	9.2	8.4	7.2	4.6	5.2
8.	Barracks Rd (by Uyo Village Rd)	0.4	0.1	5.4	0.0	5.6	1.6	6.7	2.8	3.6	4.1	4.1	9.4

Source: Author's fieldwork (2021)

The above Table shows that on the average, the noise levels on Fridays and Mondays are higher than that of Wednesdays and Sundays for all the sampled transport roads. The noise levels on Fridays are slightly higher than that of Mondays, implying that more travelling and commuting take place within and out of Uyo metropolis on Fridays. The noise levels on Wednesdays are also higher compared to that of Sundays, as less commuting take place on Sundays than any other day of the week. Table 4 also show that the noise levels in all the sampled locations in the study area varies spatially from risk levels to extremely dangerous levels when the values of the noise levels are compared with the allowable risk exposure levels in Table 1. This could aggravate the attendant health challenges

status of the urban households. Such health problems could include temporary or permanent deafness, high blood pressure, headaches, sleep disorder, auditory-fatigue, lack of concentration at work, etc.

The relationship between the mean noise levels (MNL) and traffic flow rate (TFV) in Uyo metropolis is shown in Table 5. The Table reveals a proportional relationship between traffic flow rate and mean noise levels, as locations with higher traffic flow rate emits more noise compared to locations with lower traffic flow rate. This is due the fact that increased in flow rate leads to corresponding increase in traffic speed and vice – versa.

Table 5: Temporal Features of Noise Levels from Vehicular Traffic in Uyo Metropolis

S/N	Locations	Morning (7 - 10am)		Afternoon (12 – 3pm)		Evening (4 – 7pm)	
		MNL dB	TFV	MNL dB	TFV	MNL dB	TFV
1.	Abak Rd (by Plaza)	64.08	1810	62.08	1874	57.53	1259
2.	Abak Rd (by IBB)	81.75	2713	84.08	2765	73.35	2458
3.	Abak Rd (by Ekom-Imam Junction)	77.55	2832	77.85	2765	77.40	2806
4.	Aka Rd (by Plaza)	62.23	1536	62.65	1942	52.83	1326
5.	Aka Rd (by IBB)	71.10	2239	79.65	3003	67.18	2174
6.	Oron Rd (by Plaza)	62.50	1514	73.25	3212	55.40	1368
7.	Oron Rd (by Edet Akpan)	85.48	3572	85.95	3727	80.50	3159
8.	Oron Rd (by Mbiabong Park)	77.75	2967	77.98	3078	78.53	2921
9.	Oron Rd (by Udo-Udoma Ave.)	68.78	1791	76.40	1956	61.15	1259
10.	Oron Rd (by Gibbs Str.)	70.83	2182	75.50	2215	67.83	1826
11.	Nwaniba Rd (by Oron Rd)	83.53	2867	84.08	3159	72.70	2193
12.	Nwaniba Rd (by Water fountain)	75.60	2370	77.78	2644	78.03	2131
13.	Ikpa Rd (by Ikot Ekpene Rd)	81.63	3024	85.63	3247	79.40	2863
14.	Ikpa Rd (by Uniyomaingate)	72.73	2600	74.20	2904	77.40	2772
15.	Ikot Ekpene Rd (by Eka/Udi Str.)	78.78	2670	81.48	2930	76.00	2499
16.	Ikot Ekpene Rd (by Itam junction)	77.35	1850	81.08	1891	73.80	1543
17.	Barracks Rd (by Plaza)	54.45	1505	72.80	2055	51.35	1334
18.	Barracks Rd (by Uyo Village Rd)	41.48	800	59.18	1221	42.80	743

Source: Author’s fieldwork 2021.

Where: TFV = Traffic Flow Rate

MNL = Mean Noise Levels

When the flow rate is higher, it suggests that vehicles increase their speed. This is interpreted as the higher the speed, the higher the noise generated from vehicles. It is based on the observed principle that free flow of traffic enhances the speed of the vehicles

which in turn increases the noise levels generated by the moving vehicles. Table 5 shows further that while the highest mean noise levels of 85.95dB is generated along Oron Road by Edet Akpan Avenue with the greatest traffic flow rate of 3727, the least

mean noise level of 41.48dB is generated along Barracks Road by Uyo Village Road with the list traffic flow rate of 540 vehicles obtain mostly during the morning peak period. It is evident in Table 5 that more noise is emitted during the afternoon period when most business organizations, offices and schools located along the road close for the day.

The descriptive interpretation of the variation of vehicular Traffic Flow Rate (TFV), Traffic

Concentration (TC) and Grand Mean Noise Level (GMNL) for each location in the study area is shown in Figure 3. It indicates that higher traffic flow rate (TFV) results in higher grand mean noise levels (GMNL). This is derived from the idea that, during free flow of traffic, vehicular velocity increases, and noise being a function of speed accounts for the higher noise level generated during free flow of traffic than heavy traffic congestion, which is associated with lower traffic flow rate.

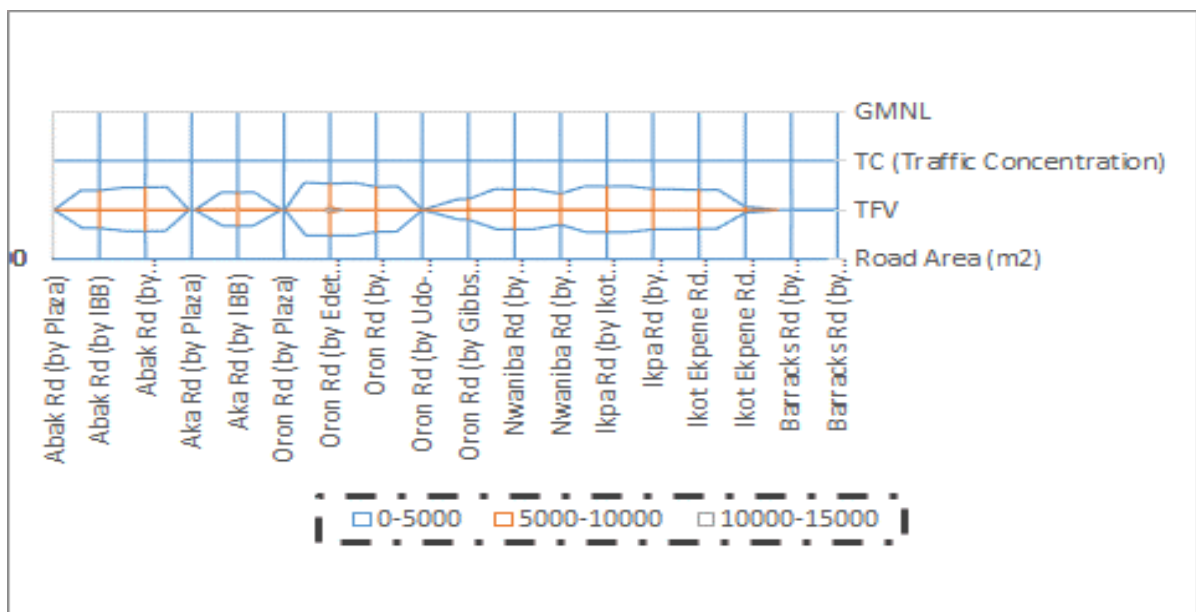


Figure 3: Traffic Flow Rate (TFV), Traffic Concentration (TC) and Grand Mean Noise Level (GMNL) in Uyo Metropolis

The plausible reason for the low noise levels during a congested traffic situation is that at such occasions, the capacity of the road way becomes too insufficient for the total number of vehicles struggling to use the road. This usually results in vehicles moving very slowly. This implies that at a higher concentration, speed is low resulting in smaller traffic flow rate. The period of high traffic concentration is identified with frequent ignition and cutting of ignition of

vehicles engine and most times vehicles remain in fixed positions thereby enhancing further congestion. Whenever motion is possible during period of heavy traffic congestion, vehicles do so in a *bumper – to – bumper* mode which results in low noise level compared to periods with high free flow of vehicles. Table 6 is One-way ANOVA used to evaluate vehicular traffic flow rate for the study.

Table 6: One-way ANOVA on Geospatial and temporal variation in traffic rate in Uyo Metropolis

	Sum of Squares	Df	Mean square	F	Sig.
Morning	8466455.500	15	564430.36	6254.10	0.015
Between Groups	180.500	27	90.25		
Within Groups					
Total					
Afternoon	7297394.50	15	486492.96	289.41	0.047
Between Groups	3362.00	2	1681.0		
Within Groups	7300756.50	17			
Total					
Evening	6294561.50	15	419637.43	4980.86	0.012
Between Groups	168.50	2	84.25		
Within Group	6294730	17			
Total					

Result shows that spatio-temporal vehicular traffic flow rate in Uyo Metropolis is statistically significant at $p < 0.05$ for morning, afternoon and evening. In addition,

a significant variation in the spatio-temporal levels of noise generated by vehicular traffic in Uyo metropolis was obtained as shown in Table 7.

Table 7: Analysis of variance result for geospatial and temporal variation in noise levels generated by vehicular traffic in Uyo Metropolis

		Sum Squares	of Df	Mean square	F	Sig.
Morning Groups	Between Groups	34229.546	15	2281.97	24.51	0.0228
	Within	186.245	2	93.12		
	Total	34415.791	17			
Afternoon Groups	Between Groups	17148.391	15	1143.23	21.45	0.0243
	Within	106.580	2	53.29		
	Total	17254.971	17			
Evening Groups	Between Groups	17254.971	15	1150.33		
	Within	100.278	2	50.14	22.94	0.0212
	Total	17355.249	17			

To establish the relationship between traffic flow rate (Tfv), traffic concentration (Tc) and noise levels (Nl) generated from vehicular traffic in Uyo metropolis, the study deployed multiple regression analysis; the result is contained in Table 8. The upper section of Table 9 reveals that about 80.9% of the variation in the noise level is caused by traffic

flow rate and traffic concentration in Uyo metropolis while other sources of the urban noise levels accounts for about 19.1%. This confirms findings by Robinson and Bamford (1976); Esin (2000) and Esin and Afahakan (2017) that urban vehicular traffic accounts for over 80% of urban noise levels.

Table 8: Result for regression analysis for the relationship between traffic flow rate (Tfv), traffic concentration (Tc) and noise levels (Nl) generated from vehicular traffic in Uyo Metropolis

Model	R	R-square	Adjusted R-square	Std. Error of the Estimated square	
1	0.899	0.809	0.783	4.58770	

Model	Unstandardized Coefficients		Standard Coefficient	t	Sig.
	B	Std Error	Beta		
1 (Constant)	52.192	15.590		3.348	0.004
tfv	0.004	0.001	0.801	4.286	0.001
tc	- 0.11	0.018	- 0.120	- 0.641	0.531

Dependent Variable: Nl

Independent Variable: Tfv, Tc

From Table 8, the model can be fitted as follows;

$$Nl = 52.192 + 0.004Tfv - 0.11Tc + \mu \tag{4}$$

$$SE(\alpha_i)(15.59)(0.001)(0.18)$$

$$t\alpha_i(3.348)(4.286)(-0.641)$$

$$R^2 = 0.809;$$

$$Nl = 52.192 + 0.801Tfv - 0.120Tc + \mu \tag{5}$$

Equation (4) has regression coefficient of 0.004 for traffic flow rate. This implies that for every unit increase in traffic flow rate, the noise level will increase by 0.004dB, which depicts a direct and positive relationship between traffic flow rate and noise levels. Also, the regression coefficient of -0.11 for traffic concentration indicates that, for every unit increase in traffic concentration, the noise levels will decrease by 0.11dB. This

implies that there is an increase in noise levels in an area with free flow traffic than in a congested area. It could further be adduced from the standardized model in equation (5), that a unit standard deviation increase in traffic flow rate would results in an increase in noise level by 0.801dB; and given a unit standard deviation increase in traffic concentration, the noise level will decrease by 0.120dB. Since the coefficient of traffic

flow rate is greater than that of Traffic concentration, it therefore implies that traffic flow rate has a greater influence on the noise levels than traffic concentration.

The study infers that vehicular noise levels have spatial and temporal dimensions. This has been corroborated by the result of the analysis of variance, which revealed a significant variation in the geospatial and temporal rate of vehicular traffic and noise levels in the study area. This finding supports earlier findings by Odum and Aloba, 2014; Kinder, 2015; Esin and Afahakan (2017), which asserts that traffic rate varies from location to location depending on the time of the day and the nature of economic traffic predominant in respective locations. This has also been confirmed by Oyedepo and Saadu (2008). The study further revealed that the peak noise levels in Uyo metropolis ranges between 86-106dB, which is considerably above the ambient permissible noise levels of 60dB for commercial and residential areas. In addition, it is evident in the study that the traffic noise levels within Uyo metropolis range from 48-69db while the day-night levels ranged from 68-80dB. These observed traffic noise levels could constitute a - threat to sleep activities and other health function of the city-dwellers in the traffic areas.

The study further reveals that the noise emitted during heavy vehicular traffic congestion or concentration is lower than that obtainable during free flow of traffic. That is, higher traffic flow rate (TFV) results in higher grand mean noise levels (GMNL). This is in supports of the finding of Awosusi and Akindutire (2010) and Kheirbek et al. (2014). This is due to the fact that during free flow of traffic, vehicles high velocity, and the increased friction between the tyre of the

vehicle and the tarred road surface accounts for the higher noise level generated during free flow of traffic than in period with heavy traffic congestion with lower traffic flow rate which is characterized by frequent breaking and stopping of the vehicles. This finding is in line with that of Akpan, (1998) and Esin and Afahakan (2017) which observed that the level of noise from vehicles is influenced by the speed of the vehicle, the density of traffic flow and the nature of the surface which vehicles operate. In view of the above, and given the increasing influx of vehicles into Uyo metropolis, and the deteriorating nature of some roads in the study area, we can say that the intensity of noise from vehicular traffic might increase beyond human tolerance limit which could be hazardous to the health status of the residents of Uyo metropolis in the nearest future.

5.0 Conclusion

The geospatial and temporal levels of noise from vehicular traffic in Uyo metropolis was investigated, with the aim of examining the variation in the geospatial and temporal flow of vehicular traffic in Uyo metropolis and the variation in the geospatial and temporal levels of noise generated by vehicular traffic. The results show that noise level in 16 out of the 18 sites studied exceeded the acceptable limits for human well-being, and vehicular traffic is a significant contributor to the total noise levels generated within Uyo metropolis. The relationship between traffic flow rate, traffic concentration and noise levels generated by vehicular traffic in Uyo metropolis was established. The result indicates that the velocity vehicular motion and the rate of the traffic flow are directly proportional to the level of noise generated. The study also reveals that traffic congestion problem is predominant, even as there are too

many vehicles on the roads, which outweigh the roads infrastructural facilities in the study area. The study recommends expansion and building of more roads in the State.

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