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Research Article

A Statistical Analysis of the Day-time and Night-time Noise Levels in Ilorin Metropolis, Nigeria

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Abstract

Evaluation and analysis of noise pollution in Ilorin metropolis have been carried out. A statistical analysis of the day-time noise levels (L_D) and night-time noise levels (L_N) in 42-locations shows no significant different ($p>0.05$) at busy roads/road junctions, commercial centers and high density residential areas, but there is significant different ($p< 0.05$) at passengers loading parks and low density residential areas. The highest day-time (L_D) and night-time (L_N) noise levels were 89 dB(A) at Challenge junction and 85 dB(A) at Emir`s road, respectively. The lowest day-time (L_D) and night-time (L_N) noise levels were 43 dB(A) at Basin and 44 dB(A) at Airport, respectively. The noise levels in Ilorin city exceeded allowed values by the WHO at 37 of 42 measurement points. At 95% confidence level, test for significant difference of the means and variances of the day-time noise levels and night-time noise levels shows no difference in all the locations surveyed. At 90% confidence level, analysis of

variance for two factor experiment using F-distribution (carried out on the noise descriptors L_{10} and L_{90}) shows that noise exposure level differs significantly from one location to another.

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INTRODUCTION

The urban environment has always been an area of high population concentration in Nigeria, mainly because people tend to believe that the only hope of improving their standard of living is to live in an urban environment. Over the last two decades, urban noise exposure level in Nigeria has been increasing rapidly. Primarily, this is due to population growth and increase of certain noise sources. During the past 30 years, many environmental noise studies have been carried out in urban areas in different countries all over the World (Amando and Jose, 1998). All these investigations have shown clearly that road traffic is the predominant and most generalized noise source in urban areas (Nelson, 1998; Saadu *et al*., 1998; Ahamad *et al*., 2006). Braj and Jain (1995) reported the measurements of noise levels in residential, industrial and commercial areas in the capital city of India, Delhi that commercial areas have the highest noise levels, followed by industrial and residential areas. Noise intensity measurement was carried out in some selected points of traffic routes in the city of Lubin. The noise value levels showed variable intensity, the highest being observed in the morning and afternoon hours (Wojcik *et al*., 2001). An investigation to determine the level of noise pollution and its sources

was carried out in the city of Erzurum, Turkey. Noise measurements were taken in the morning, at noon and in the evening to determine noise pollution all over the city, particularly motor way transportation noise. The results showed that noise levels in Erzurum city centre exceeded allowed values at 96 of 126 measurements points (Hasan and Serkan, 2005).

Existing evidence indicating that noise pollution may have negative impacts on human health has justified research in order to provide better understanding of noise pollution problems and control (Georgiadou *et al*., 2004). Noise pollution has been stated as a serious health hazard, with noise related damage to humans ranging from annoyance to difficulty in falling asleep and high **blood pressure** (Saadu *et al*., 1998; Schwela and Zali, 1999; Ahamad *et al*., 2006). In comparison with other pollutants, the control of environmental noise has been hampered by in-sufficient knowledge of its effects on humans and of dose-response relationships, as well as by a lack of sufficient data, especially in **developing countries** like Nigeria. The effects of noise in **developing countries** are just as widespread as in developed countries and the long term consequences for health are the same (Schwela and Zali, 1999). Practical actions to limit and control the exposure to environmental noise are therefore essential.

The noise pollution situation in Ilorin metropolis is similar to that in many urban areas. The city is relatively large having rapid increase in population growth rate. The population has increased from 423,340 in 1980 to 902,131 in 2006 (NPC, 2006). The city has expanding continuously in all directions in the past two decades. Many significant changes have been experienced in terms of urbanization, industrialization, expansion of road network and infrastructure. The city has been subjected to persistent in road traffic and commercial activities due to overall increase in prosperity, fast development and expansion of economy. Very few studies have been carried out to investigate and assess noise pollution in Ilorin metropolis. Saadu (1988), carried out research on community and occupational noise survey and analysis in the city of Ilorin. Many recent survey changes in the demography and urban boundaries of the city have taken place; and consequently, further investigation of this

phenomenon is needed. Oyedepo and Saadu (2007) studied the changing noise climate of Ilorin metropolis. Therein, noise level in Ilorin metropolis was investigated and noise map was developed for the city.

The objectives of this investigation are to evaluate the environmental noise pollution in Ilorin metropolis and to find out if for such a large city as Ilorin, the day-time noise levels (L_D) and night-time noise levels(L_N) are the same in the selected locations

MATERIALS AND METHODS

Study Area

This research is based on the results of outdoor sound level measurements carried out in July 2005 at 42 different locations (12 commercial centers, 12 road junctions and busy roads, 6 passengers loading parks, 6 high density areas and 6 low density areas) in Ilorin metropolis, the capital city of Kwara State. Table 1 shows the locations of selected for the noise measurements in Ilorin metropolis. Figure 1 is an overview of Ilonin metropolis showing the locations of noise measurement for this study.

Experimental Procedure

Instrumentation for the field measurements consisted of precision grade sound level meter (according to IEC 651, ANSI S1.4 type), 1/2- in. condenser microphone and 1/3-octave filter with frequency range and measuring level range of 31.5 Hz-8 KHz and 35-130 dB, respectively. The instruments were calibrated by the internal sound level calibrator before making measurements at each site. All the instruments comply with IEC standards.

The measurements were made at street level (at road junctions, market centers, passengers loading parks and residential areas). The instrument was held comfortably in hand with the microphone pointed at the suspected noise source at a distance not less than 1 m away from any reflecting object. L_{Ai} (A-weighted instantaneous Sound pressure level) measurements were recorded at intervals of 30 sec for a period of 30 min, giving 60 m readings per sampling location. This procedure was carried out for morning (7:30 -8:00 am),

afternoon (1:00-1:30 pm), evening (4:00-4:30 pm) and night (8:30 -9:00 pm) measurements.

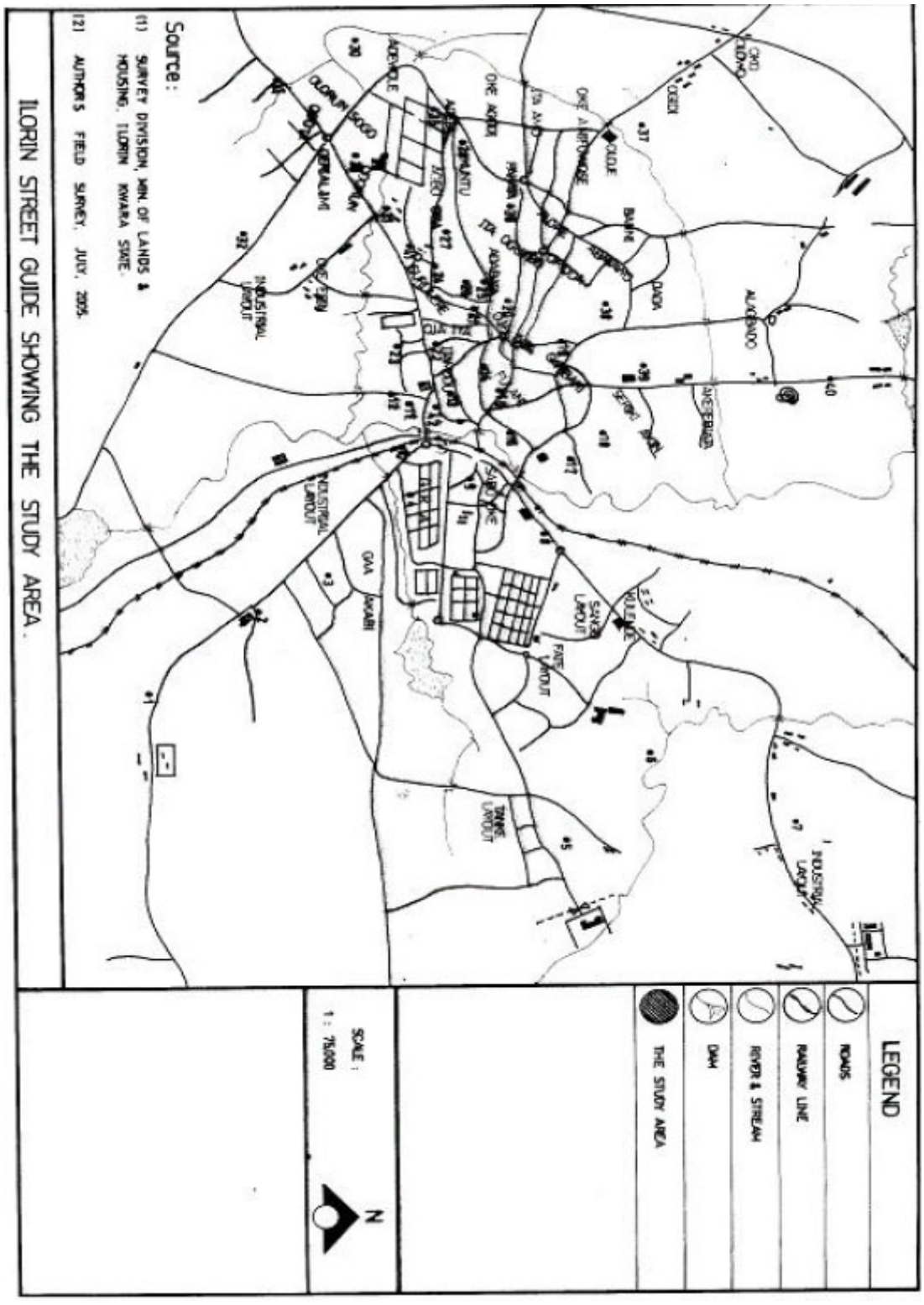

Fig. 1: Overview of Ilorin metropolis showing the locations of noise measurements. Throughout this study (Source: Survey Division, Min. of Lands and Housing, Ilorin, Kwara State)

Table 1: Locations selected for the noise level measurements in Ilorin Metropolis

Designation No.	Location	Designation No.	Location
1	Ita-Alamu	22	Ita-Amodu
2	Offa Garage	23	Taiwo Road
3	Gaa-Akanbi	24	Agbooba Junction
4	GRA	25	Baboko Garage
5	Tanke	26	Agaka
6	Basin	27	Oja-Titun
7	Jebba road	28	Kuntu
8	Maraba	29	Unilorin Junction
9	Yoruba road	30	Adewole
10	Challenge junction	31	Sawmill-Garage
11	Railway Station	32	Asa Dam Road
12	Unity road	33	Geri Alimi
13	Niger	34	Airport
14	Ago market	35	Adeta
15	Emir's road	36	Pakata
16	Opo malu	37	Oloje
17	Ipata market	38	Okelele
18	Oja-Gboro	39	Shao Garage
19	Gambari	40	Sobi Road
20	Oja-Oba	41	General Hospital Round-about
21	Gegele	42	Balogun Fulani

From these readings, commonly used community noise assessment quantities like the exceedence percentiles L_{10} and L_{90}, the A-weighted equivalent sound pressure level, L_{Aeq}, the daytime average sound level, L_D, the day-night average sound level, L_{DN}, the noise pollution level, $L_{NP}$and the traffic noise index, TNI were computed. These noise measures are defined as follows (Saadu *et al*., 1998):

$$L_{Aeq} = 10\log_{10}\left[\frac{1}{N}\sum_{i=1}^{N}\left(\text{anti}\log\frac{L_{Ai}}{10}\right)n_i\right] \quad (1)$$

$$L_D = 10\log_{10}\left[\frac{1}{2}\left(\text{anti}\log\frac{L_{AeqM}}{10} + \text{anti}\log\frac{L_{AeqA}}{10}\right)\right] \quad (2)$$

$$L_{DN} = 10\log_{10}\left[\frac{1}{24}\left(15\times \text{anti}\log\frac{L_D}{10} + 9\times \text{anti}\log\frac{L_N+10}{10}\right)\right] \quad (3)$$

$$L_N = 10\log_{10}\left[\frac{1}{2}\left(\text{anti}\log\frac{L_{AeqE}}{10} + \text{anti}\log\frac{L_{AeqN}}{10}\right)\right] \quad (4)$$

$$L_{NP} = L_{Aeq} + (L_{10} - L_{90}) \quad (5)$$

$$TNI = 4(L_{10} - L_{90}) + (L_{90} - 30) \quad (6)$$

Where:

L_{Ai}	=	The ith A-weighted sound pressure level reading dB.
N	=	The total number of readings.
L_{Aeq}	=	The A-weighted equivalent sound pressure level.
L_{AeqM}	=	The equivalent sound pressure for the morning measurement.
L_{AeqA}	=	The equivalent sound pressure level for the afternoon measurement.
L_{AeqE}	=	The equivalent sound pressure level for the evening measurement.
L_{AeqN}	=	The equivalent sound pressure level for the night measurement.
L_N	=	Night time noise level.

L_D	=	Day time noise level.
L_{10}	=	The noise level exceeded 10% of the time.
L_{90}	=	The noise level exceeded 90% of the time.
L_{NP}	=	Noise pollution level.
L_{DN}	=	Day-night noise level.
TNI	=	The traffic noise index.

Analysis

The outdoor noise measurements carried out in the month of July, 2005 at 42 locations in Ilorin metropolis are to be analyzed.

In Table 2, the day-time noise and night-time noise levels for busy roads/road junctions are presented to illustrate the full dataset.

Three different statistical tests were made on the full dataset. Using the one-tailed test, a null hypothesis of the first test is:

$$H_o: \mu = 0 \qquad (7)$$

That is, is the total of the difference in the day-time noise levels and night-time noise levels significantly different from zero? This is a test of the differences within pairs of data and the number of degrees of freedom is (n-1) where there are n pairs of data to be compared. Here;

$$t = \frac{|\bar{d} - \mu|}{s(\bar{d})} \text{ With } \mu = 0$$

Where:

d=The difference

In the second test, we test for the difference between the two means and the null hypothesis is:

$$H_o: \mu_1 = \mu_2 \qquad (9)$$

Here the pooled estimate of the standard deviation $\bar{S}(x)$ defined as follows:

Table 2: Day-time noise levels, L_D (X_1) and night-time noise levels, L_N (X_2) for busy roads/road junctions. Where X_1 and X_2 are in dB(A)

X_1	X_2	d	d^2
89	84	5	25
79	79	0	0
71	71	0	0
76	77	-1	1
78	79	-1	1
78	77	1	1
83	85	-2	4
74	74	0	0
81	83	-2	4
75	75	0	0
73	68	5	25
73	72	1	1
$\bar{X}_1 = 78$	$\bar{X}_2 = 77$	$\bar{d}_2 = 0.5$	

$$\bar{S}(x) = \sqrt{\frac{SS_{x1} + SS_{x2} + \ldots\ldots\ldots + SS_{xm}}{n_1 + n_2 + \ldots\ldots\ldots\ldots n_m - m}} \qquad (10a)$$

$$= \sqrt{\frac{SS_{x1} + SS_{x2}}{n_1 + n_2 - 2}} \qquad (10b)$$

Where:

m = 2 pairs of datasets

Thus, the t-test for the difference between the two means is:

$$t = \frac{|\bar{X}_1 - \bar{X}_2|}{\bar{S}(x)\sqrt{\left(\frac{1}{n_1}\right) + \left(\frac{1}{n_2}\right)}} \quad (11)$$

Finally, a test on the variance of the dataset for day-time noise levels and night-time noise levels is made. All three test are made with $\alpha = 0.05$, i.e., the probability of making an error by saying the null hypothesis is false when it is actually true. On the other hand, $(1- \alpha)$ is the probability of making the right decision when the null hypothesis is true, or the confidence level (Adedayo, 2000; Lipson and Sheth, 1973).

RESULTS

In Table 3, the results for the test on the differences within the paired dataset of day-time and night-time noise levels are presented for each location surveyed. The Table 3 shows that at busy roads road junctions, commercial centers and high density residential areas, there are no significant differences ($p>0.05$) between the day-time noise levels and night-time noise levels. Since the calculated t-statistic is less than the student's $t_{0.05, n-1}$ at $\alpha = 0.05$. However, significant differences ($p<0.05$) are noted for the passengers loading parks and low density residential areas. This implies that, dwellers at road junctions/busy roads, commercial centers and high density residential areas are exposed to relatively the same day-time noise levels and night-time noise levels. But the day-time noise levels at passengers loading parks are higher (with mean 77 dB(A)) than the night-time noise levels (with mean 75 dB(A)). This can be justified by the fact that at night both the passengers and commuter bus drivers are not at the car parks. The major sources of noise at night at passengers loading parks are from music players and human conversation. At low density residential areas, the day-time noise levels are also higher (with mean 52 dB (A)) than night-time noise levels (with mean 51 dB(A)).

Table 3: Relevant parameters for the determination of the t-statistic for the difference in the day-time noise levels and night-time noise levels

Locations	$\bar{d}$	Ss_d	$S^2(d)$	$S^2(\bar{d})$	t	$t_{0.05,n-1}$
Busy roads/ Road junctions	0.500	62	5.636	0.4697	0.685	1.796
Commercial Centers	0.600	126	14.000	1.4000	1.183	1.833
Passengers loading Parks	2.500	191	38.200	6.3670	2.523	2.015
High density Residential areas	-2.500	115	23.000	3.8330	1.957	2.015
Low density Residential areas	0.667	160	32.000	5.3330	2.309	2.015

Table 4: Relevant parameters in the determination of the t-statistic for the means of the day-time noise levels and night-time noise levels

Parameters	Busy roads/ Road junctions	Commercial centers	Passengers loading parks	High density residential areas	Low density residential areas
$\bar{X}_1$	78.000	76.000	77.000	64.000	52.000
$\bar{X}_2$	77.000	75.000	75.000	67.000	51.000
SS_{x1}	284.000	332.000	64.000	131.000	177.000
SS_{x2}	312.000	344.000	119.000	166.000	111.000
$S^2_{(x1)}$	25.820	36.890	12.800	26.200	35.400
$S^2_{(x2)}$	28.360	38.220	23.800	33.200	22.200
$S^2(X)$	27.090	37.560	18.300	29.700	28.800
$S(X)$	5.205	6.128	4.278	5.450	5.367
t	0.471	0.365	0.810	-0.953	0.323
$t_{0.05,2n-2}$	1.717	1.734	1.812	1.812	1.812

Table 5: Relevant parameters in the determination of F-statistics for the variance of day-time noise levels and night-time noise levels

Parameters	Busy roads/ Road junctions	Commercial centers	Passengers loading parks	High density residential areas	Low density residential areas
$S^2_{(x1)}$	25.820	36.890	12.800	26.200	35.400
$S^2_{(x2)}$	28.360	38.220	23.800	33.200	22.200
$\frac{S^2_{(x1)}}{S^2_{(x2)}} = F$	0.910	0.965	0.539	0.789	1.595
$F_{0.05,(n1-1)(n2-1)}$	2.820	3.180	5.050	5.050	5.050

Apart from the fact that these locations are sparsely populated, most dwellers come home in the night to take their rest (sleep). Hence, the night-time noise levels are lower than the day-time noise levels.

An analysis of the means of the day-time noise levels and night-time noise levels for each location appears in Table 4 where it is shown that in all the locations, there is no significant difference ($p>0.05$) between the means of the

day-time noise levels and night-time noise levels. Hence, the hypothesis of equality is accepted.

Variance estimates indicated in Table 5 have been compared for the day-time noise levels and night-time noise levels in all the locations surveyed for the relative sizes of dispersions.

The null hypothesis is:

$$H_a : \sigma_1^2 \leq \sigma_2^2 \text{ or } \frac{\sigma^2_1}{\sigma^2_2} \leq 1$$

with an alternative hypothesis

$$H_o : \sigma_1^2 > \sigma_2^2 \text{ or } \frac{\sigma^2_1}{\sigma^2_2} > 1$$

For all the locations surveyed, the null hypothesis is accepted for there is no significant difference ($p>0.05$) in the day-time noise levels and night-time noise levels. The dispersion of day- time noise levels is less than or equal to that of night- time noise levels.

DISCUSSION

Influence of the Characteristics of the Locations and Period of the Day on Measured Sound Levels (L_{Aeq})

The environmental sound levels measured at a given location depend on a number of specific variables. In particular, many authors have found that the observed sound levels are mainly related to road traffic characteristics and especially traffic volume, vehicle horns, rolling stock and tires, unmuffled vehicles, etc. (Saadu, 1998; Amando and Jose, 1998). Several studies have demonstrated that the urban conditions of a given area are also a very important factor influencing the environmental noise levels (Nelson, 1998).

Table 6: Commercial centers noise levels

Site	Period of the day	Noise level descriptors (dB (A))							
		L_{Aeq}	L_{10}	L_{90}	TNI	L_{NP}	L_D	L_N	L_{DN}
Oja-Oba market	Morning	82	87	71	105	98			
	Afternoon	84	88	74	100	98	83		
	Evening	85	89	78	92	96			
	Night	76	81	67	93	90		83	89
Oja- Agomarket	Morning	69	73	62	76	80			
	Afternoon	71	75	66	72	80	70		
	Evening	78	82	71	85	89			
	Night	66	66	53	75	79		75	81
Oloje market	Morning	76	81	65	99	92			
	Afternoon	72	76	65	79	83	74		
	Evening	71	74	66	68	79			
	Night	59	62	53	59	68		68	76
Oja-Titun market	Morning	68	71	59	77	80			
	Afternoon	76	79	63	97	92	74		
	Evening	74	77	62	92	89			
	Night	51	54	43	57	62		71	78
Ipata market	Morning	73	78	64	90	87			
	Afternoon	74	79	64	94	89	74		
	Evening	66	72	57	87	81			
	Night	72	56	40	74	88		69	77
Oja-Gboro market	Morning	78	71	59	77	80			
	Afternoon	75	79	63	97	92	72		
	Evening	76	77	62	92	89			
	Night	76	54	43	57	62		76	83
Gegele market	Morning	77	80	63	101	94			
	Afternoon	80	84	66	108	98	79		
	Evening	84	87	75	93	96			
	Night	69	74	60	86	83		81	87
Gambari market	Morning	79	81	68	90	92			
	Afternoon	86	90	77	99	99	84		
	Evening	83	86	73	95	96			
	Night	74	73	66	64	81		81	88
Agaka	Morning	78	80	70	80	88			
Shopping	Afternoon	83	86	76	86	93	81		
center	Evening	82	84	75	81	91			
	Night	75	76	63	85	88		80	87
Yoruba road	Morning	47	60	51	57	56			
Shopping	Afternoon	68	70	60	70	78	65		
center	Evening	69	74	59	89	84			
	Night	47	50	43	41	54		66	72
Station	Morning	78	80	73	71	85			
shopping	Afternoon	75	79	69	79	85	77		
center	Evening	76	78	73	63	81			
	Night	72	74	66	68	80		75	81
Taiwo road	Morning	66	69	59	69	76			
shopping	Afternoon	75	79	69	79	75	73		
center	Evening	74	74	65	71	86			
	Night	69	73	61	79	81		72	79
Mean	Morning	73	76	64	83	84			
	Afternoon	77	80	68	88	89	76		
	Evening	77	80	68	84	88			
	Night	67	66	55	70	76		75	82

Table 7: Traffic noise levels at major road junctions and busy roads

Site	Period of the day	Noise level descriptors(dB (A))							
		L_{Aeq}	L_{10}	L_{90}	TNI	L_{NP}	L_D	L_N	L_{DN}
Challenge Junction	Morning	89	94	75	121	108			
	Afternoon	88	93	74	120	107	89		
	Evening	86	94	74	124	106			
	Night	81	87	65	123	103		84	92
Ita- Amodu Junction	Morning	77	81	72	78	86			
	Afternoon	81	86	71	101	96	79		
	Evening	81	84	72	90	93			
	Night	76	80	70	80	86		79	85
Unilorin mini-campus round-about	Morning	70	75	63	81	82			
	Afternoon	72	77	63	89	86	71		
	Evening	72	78	60	102	90			
	Night	69	71	60	74	80		71	77
General Hospital Junction	Morning	74	79	69	79	84			
	Afternoon	77	82	69	91	90	76		
	Evening	77	81	70	84	88			
	Night	76	80	62	102	94		77	83
Agbooba - Surulere Junction	Morning	78	81	71	81	88			
	Afternoon	77	80	73	71	84	78		
	Evening	81	85	71	97	95			
	Night	77	81	72	87	86		79	85
Unity road	Morning	78	81	72	78	87			
	Afternoon	78	83	73	83	88	78		
	Evening	78	82	73	79	87			
	Night	77	76	66	76	87		77	84
Emir's road	Morning	80	82	71	85	91			
	Afternoon	85	89	71	113	103	83		
	Evening	87	92	70	128	109			
	Night	82	86	64	122	104		85	91
Asa Dam road	Morning	72	77	64	86	85			
	Afternoon	75	76	65	89	86	74		
	Evening	74	77	66	80	85			
	Night	73	64	49	79	88		74	80
Sobi road	Morning	81	84	71	93	94			
	Afternoon	81	83	71	89	93	81		
	Evening	85	88	74	100	99			
	Night	76	77	63	89	90		83	89
Pakata road	Morning	74	77	68	74	83			
	Afternoon	75	79	63	97	91	75		
	Evening	75	80	66	92	89			
	Night	74	73	52	106	95		75	81
Jebba road	Morning	72	76	54	112	94			
	Afternoon	75	78	53	123	100	73		
	Evening	69	74	58	116	93			
	Night	68	72	46	120	94		68	75
Adeta Junction	Morning	73	75	68	66	80			
	Afternoon	72	73	59	85	86	73		
	Evening	70	74	64	74	80			
	Night	74	79	55	121	98		72	79
Mean	Morning	77	80	68	86	89			
	Afternoon	78	82	67	96	93	78		
	Evening	78	82	69	97	93			
	Night	75	77	60	98	92		77	83

Tables 6-10 present the equivalent continuous A-weighted sound pressure levels (L_{Aeq}) measured at each location surveyed. It is observed that there is variation in the noise level with period of the day and nature of the location. There are high noise levels (L_{Aeq}) in the day time (7:30 am-2.30 pm) compare with the night time (8:30-9:00 pm) except in the residential areas where

majority of the residents are not at home during the working days of the week, hence the noise level is low in residential areas in afternoon time. Figure 2 shows an example of the results obtained for these measurements. For commercial centers and road junctions, the noise levels rise from morning and reach the peak in the afternoon and descend in the night to low level. The high noise levels at these locations can be justified as a result of morning rushing hours of office workers, business men and market women to resume work at office and to open shop for customers.

Table 8: Passengers loading parks (Garage) noise levels

		Noise level descriptors (dB (A))							
Sites	Period of the day	L_{Aeq}	L_{10}	L_{90}	TNI	L_{NP}	L_D	L_N	L_{DN}
Maraba garage	Morning	74	79	63	97	90			
	Afternoon	81	81	59	117	103	79		
	Evening	72	75	62	84	85			
	Night	69	67	54	76	82		71	80
Shao garage	Morning	76	71	60	74	87			
	Afternoon	71	74	64	74	81	74		
	Evening	72	76	66	76	82			
	Night	62	65	55	65	72		69	77
Offa garage	Morning	79	83	71	89	91			
	Afternoon	74	78	66	84	86	72		
	Evening	81	86	73	95	94			
	Night	73	77	66	80	84		79	85
Baboko garage	Morning	80	84	74	84	90			
	Afternoon	82	88	74	100	96	81		
	Evening	83	86	77	83	92			
	Night	81	86	71	101	96		82	88
Saw-mill garage	Morning	81	81	72	78	90			
	Afternoon	78	80	72	74	86	80		
	Evening	76	79	72	70	83			
	Night	71	75	62	84	84		74	82
Geri-Alimi garage	Morning	79	80	71	77	88			
	Afternoon	75	77	65	83	87	78		
	Evening	76	80	73	71	83			
	Night	73	77	62	92	88		74	82
Mean	Morning	78	80	69	82	89			
	Afternoon	77	80	67	89	90	77		
	Evening	77	80	71	80	87			
	Night	72	75	62	83	84		75	82

Table 9: Residential area noise levels (high density areas)

Site	Period of the day	Noise level descriptors (dB (A))							
		L_{Aeq}	L_{10}	L_{90}	TNI	L_{NP}	L_D	L_N	L_{DN}
Opomalu	Morning	64	68	58	68	74			
	Afternoon	66	70	59	73	77	65		
	Evening	66	69	59	69	76			
	Night	65	68	58	68	75		66	72
Okelele	Morning	62	63	57	51	68			
	Afternoon	56	58	52	46	62	60		
	Evening	71	75	69	63	82			
	Night	66	70	61	67	75		69	75
Kuntu	Morning	63	73	57	91	79			
	Afternoon	60	63	52	66	71	62		
	Evening	68	67	56	70	79			
	Night	65	60	50	60	75		67	73
Niger	Morning	64	67	60	58	71			
	Afternoon	77	80	61	107	96	74		
	Evening	76	75	62	84	89			
	Night	76	80	68	86	88		76	82
Balogun fulani	Morning	60	63	57	51	66			
	Afternoon	62	66	56	66	72	61		
	Evening	61	63	52	66	72			
	Night	55	56	52	38	59		59	66
Gaa-Akanbi	Morning	66	69	62	60	73			
	Afternoon	56	60	51	57	65	63		
	Evening	65	69	60	66	74			
	Night	57	60	52	54	65		63	66
Mean	Morning	63	67	59	63	72			
	Afternoon	63	66	55	69	74	64		
	Evening	68	70	60	70	79			
	Night	64	66	57	62	73		67	83

Table 10: Residential area noise levels (low density areas)

Sites	Period of the day	Noise level descriptors (dB (A))							
		L_{Aeq}	L_{10}	L_{90}	TNI	L_{NP}	L_D	L_N	L_{DN}
Tanke	Morning	59	55	46	52	68			
	Afternoon	51	47	40	38	64	57		
	Evening	57	53	43	53	67			
	Night	54	55	53	31	56		56	63
GRA	Morning	61	58	46	64	71			
	Afternoon	57	60	46	72	67	59		
	Evening	55	59	47	65	61			
	Night	56	59	54	44	52		56	53
Basin	Morning	45	48	41	39	52			
	Afternoon	41	43	38	28	46	43		
	Evening	46	49	43	37	52			
	Night	55	56	55	29	56		53	59
Adewole	Morning	57	54	43	57	68			
	Afternoon	47	51	38	60	60	54		
	Evening	51	52	43	49	60			
	Night	45	47	38	44	54		49	57
Ita-Alanu	Morning	49	52	43	49	58			
	Afternoon	49	54	45	51	58	49		
	Evening	48	52	43	49	57			
	Night	49	51	45	39	55		49	55
Airport	Morning	51	52	39	61	64			
	Afternoon	43	41	33	35	51	49		
	Evening	44	44	32	50	56			
	Night	44	40	33	31	51		44	52
Mean	Morning	54	53	43	54	64			
	Afternoon	48	49	40	47	58	52		
	Evening	50	52	42	51	60			
	Night	51	51	46	36	58		51	57

M: Morning; A: Afternoon; E: Evening; N: Night

At passengers loading Parks, majority of travelers going long distance, travel with commercial vehicles in the day time (between 7:00-10:00 am), hence, there is high A-weighted day noise levels at loading parks. The noise levels in the afternoon time (1.00-1.30 pm) at residential areas are generally low compare with that of evening and night times. This is because, majority of the residents are not available at home in the afternoon time. Some are in offices, markets or shops while children are in their schools by this time of the day during the week.

The mean values of A-weighted equivalent sound level, L_{Aeq} for the sites surveyed with the period of the day are: Commercial centers (M: 73 dB(A), A: 77dB(A), E: 77dB(A), N: 67dB(A)); Road junctions (M:77 dB(A), A: 78 dB(A), E: 78 dB(A), N: 75 dB(A));Passenger loading parks (M: 78 dB(A), A: 77dB(A), E: 77 dB(A), N: 72 dB(A)); high density areas (M: 63 dB(A), A:

63dB(A), E: 68dB(A), N: 64 dB(A)); and low density areas (M: 58 dB(A), A: 48 dB(A), E: 50 dB(A), N: 51 dB(A)).

High noise levels (L_{Aeq}) exposure in the city occurs mostly in the day time at major road junctions. This is followed by commercial centers and passengers loading parks. In these locations, apart from traffic noise, other intrusive noise sources include noise from record player, loud speaker, hawking and human conversation contribute majorly to environmental noise pollution.

The Traffic Noise Index (TNI) and noise pollution level (L_{NP}) are also shown in Tables 6-10. The average TNI ranges from 70 to 84 dB(A) at commercial centers; from 86 to 98 dB(A) at road junctions/busy roads; 80 to 89 dB(A) at passengers loading parks; 62 to 70 dB(A) at high density residential areas and 36 to 54 dB(A) at low density residential areas. Road junctions/busy roads and low density residential areas have the highest and lowest annoyance responses due to traffic noise, respectively. It should be noted that a TNI of 74 dB(A) has been reported to be associated with less than 3% annoyance in social survey (Ahamad *et al*., 2006).

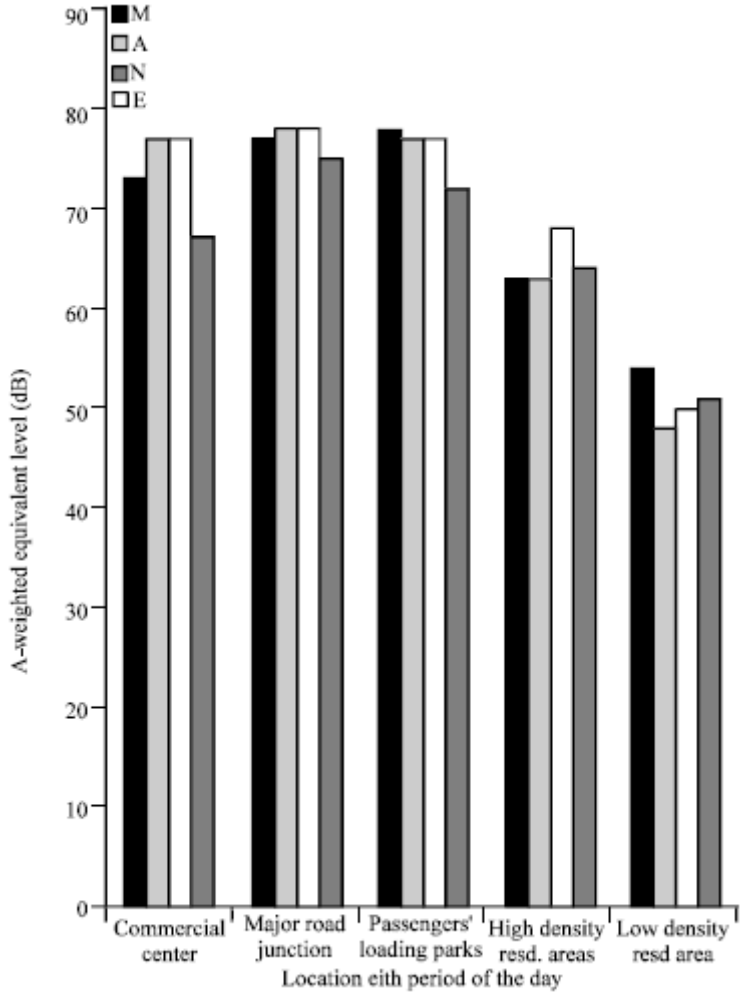

Fig. 2: Variation of the equivalent sound level L_{Aeq} with location and period of the day

Similarly, the highest average L_{NP} is recorded at road junctions/busy roads (i.e., 93 dB(A)) and the lowest L_{NP} is at low density residential areas. (i.e., 58 dB(A)).

In all the locations surveyed, the night-time noise levels are very comparable to those reported for the day-time noise levels. Both the day-time and night-time noise levels in Ilorin city are very much higher than the levels reported for living rooms. The bed room noise levels of 25-30 dB(A) reported by Davis and Masten (2004) has been exceeded in all locations of Ilorin metropolis during the night-time, resulting in more possible sleep disturbance due to traffic noise. It should be noted that the World Health Organization (WHO) recommends a noise level of less than 35 dB (A) based on the continuous equal energy concept for the restorative process of sleep (Mufuruki, 1997), while the day

time noise limits of about 55 L_{Aeq} has been recommended as a general health goal for out door noise level in residential areas. At night, an out door noise level of about 45 L_{Aeq} is required to meet sleep criteria (Gerard, 1998).
The noise levels for both day-time and night-time are higher than those reported by Saadu (1988), at all the locations chosen for this study in Ilorin metropolis. This is basically due to increase in population density, commercial activities and traffic volume in the city.

To ascertain the significant difference in the noise level exposure in all the sites surveyed throughout the day (from morning to night time), analysis of variance for two- factor experiment, using F-distribution was carried out on the noise descriptors (L_{10} and L_{90}). At 90% confidence level, the mean square ratio (MSR) calculated for L_{10} is 38.23 while the tabulated value of mean square ratio is 2.36 (Lipson and Sheth, 1973). Similarly, at the same confidence level, the MSR calculated for L_{90} is 16.07 and the tabulated value remain the same as 2.36. Since in the two cases, the mean square calculated is greater than the mean square tabulated, the noise levels exposure differ significantly from one location to another. The t-statistics analysis for difference in the day-time and night-time noise levels shows that there is significant difference in the day-time shows that there is significant differences ($p<0.05$) and night-time noise levels at passengers loading parks and low density residential areas, but there is no significant difference ($p>0.05$) in the day-time and night-time noise levels at road junctions/busy roads, commercial centers and high density residential areas.

CONCLUSION

Environmental noise measurements were made at 42 different locations in Ilorin metropolis. A statistical analysis carried out on the day-time noise levels (L_D) and night -time noise levels (L_N) shows that the day-time noise levels and night-time noise levels differ significantly ($p<0.05$) at passengers loading parks and low density residential areas. The means of the day-time noise levels and night-time noise level shows no significant difference ($p>0.05$) in all the

locations. Estimates of the variance were also analyzed. The night-time noise levels are comparable to the day-time noise levels in all the sites surveyed. Analysis of variance for two-factor experiment, using F-distribution was carried out on the noise descriptors (L_{10} and L_{90}). At 90% confidence level, the analysis shows that noise exposure level differs significantly ($p<0.05$) from one location to another.

It was also observed that, the A-weighted sound levels (L_{Aeq}) measured vary with the condition of the location and period of the day. Due to traffic characteristics, especially traffic volume, vehicle horns, vehicle-mounted loudspeakers, unmuffled vehicles, record player and hawking, there is high mean L_{Aeq} at road junctions/busy roads (78 dB(A) or more), passengers loading parks (78 dB(A)) and commercial centers (77 dB(A) or more). Average daily noise exposure level (L_{Aeq}) in Ilorin metropolis varies from 48 dB (A) (at Low density residential areas) to 78 dB (A) (at road junctions/busy roads). In all the locations surveyed, the night-time noise levels are very comparable to those reported for the day-time noise levels. Also, the noise levels are very much higher than the levels reported for living rooms.

RECOMMENDATIONS

In this survey, there is high noise levels observed which constitutes a threat to sleep activities and other health functions of the city dwellers. As a result, there is need for noise control measures in Ilorin metropolis. These include technical, planning behavioral and educational solutions. Since transport infra-structures can be recognized as major sources of noise, technical actions on the transport systems can produce interesting results. Possible technical controls include changes in road profiles, low noise pavements (porous and porous elastic) type, effective repairs to the silencers and vehicle suspensions so as to reduce exhaust and rolling stock noise, reductions, limitations or restrictions on traffic (types of vehicles, speed, hours of access etc.) and building of acoustic barriers along the sides of heavily traveled highways running through residential areas. Transportation and land planning (private versus public transportation, bus lanes, parking areas, shuttle buses and pedestrian areas) are important components of the plan. Since noise also results from the citizen’s behavior

(driver, music player, hawkers etc), information and education campaigns should be well disseminated and should correspond to general aims and action plans. There is a need to establish environmental noise impact criteria levels for various land use purposes. These criteria levels would enable impacts to be determined. The authorities should pass laws to check excesses of the sources of high noise levels, other professionals such as town planners, architects and environmental engineers as well, should have the problems of environmental noise pollution in mind when sitting new roads, shopping centers, schools, hospitals and both commercial and residential houses in general.

NOTATIONS

d	:	Difference of pair of noise descriptors (day-time noise levels, L_D and night-time noise levels, L_N).
H_o	:	Null hypothesis.
H_a	:	Alternative hypothesis.
n	:	Sample size.
S	:	Estimate of standard deviation of the means of samples of size n.
SS^2	:	Estimate of variance of a sample.
SSx	:	Sum of squares of deviations from the mean of a variate X.
X	:	A variate such as noise descriptors (L_D and L_N).
t	:	Student’s t distribution.

F	:	Fisher test for variance ratio distribution.
α	:	Level of significance.
μ	:	Population mean.

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