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Original Research Paper

Environmental Noise Pollution in Ilorin Metropolis, Nigeria

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ABSTRACT

This paper presents the results obtained from environmental noise measurements at selected locations in Ilorin metropolis. Forty two different locations throughout Ilorin were selected to establish background noise level, peak noise level and dominant noise sources at these locations. It was observed that, the A-weighted sound levels (L_{Aeq}), background noise level (L_{90}) and peak noise level (L_{10}) measured vary with the location and period of the day. Due to traffic characteristics, especially traffic volume, vehicle horns, vehicle-mounted loudspeakers, unmuffled vehicles, record players and hawking, there is high L_{Aeq}, L_{90} and L_{10} at road junctions (77 dBA, 66 dBA, 77 dBA), passengers loading parks (76 dBA, 66 dBA, 77 dBA) and commercial centres (73 dBA, 64 dBA, 74 dBA). Average daily noise exposure level (L_{Aeq}) in Ilorin metropolis varies from 46 dBA to 86 dBA. The result of this study shows that the major source of noise in Ilorin metropolis can be attributed to traffic noise. Other intrusive noise sources include noise from record players and hawking with loud speakers. Based on the recommendations of Committee on Environmental and Occupational Health (CEOH), World Health Organization (WHO) and Housing and Urban Development (HUD), only 6 locations out of 42 are under normally acceptable situation while the noise levels of other areas are not acceptable. Based on the noise descriptors (L_{Aeq}, L_D, L_N, L_{DN}, T_{NI} and L_{NP}), noise map is developed to identify locations with high noise exposure. The noise map developed reveals high noise exposure at the nucleus of the metropolis where commercial activities, high traffic volume and clustered buildings with high population exist. The result of this study is useful as reference and guideline for future regulations on noise limit to be implemented for urban areas in Nigeria.

INTRODUCTION

Environmental noise pollution, a form of air pollution, is a threat to health and well-being. Noise pollution has assumed alarming proportions and has become even more dangerous than water and air pollution. It is more severe and widespread than ever before, and it will continue to increase in magnitude and severity because of population growth, urbanization, and the associated growth in the use of increasingly powerful, varied, and highly mobile sources of noise. It will also continue to grow because of sustained growth in highway, rail, and air traffic, which remain major sources of environmental noise. The potential health effects of noise pollution are numerous, pervasive, persistent, and medically and socially significant. Noise produces direct and cumulative adverse effects that impair health and that degrade residential, social, working, and learning environments with corresponding real (economic) and intangible (well-being) losses. It interferes with sleep, concentration, communication and recreation. The aim of enlightened governmental controls should be to protect citizens from the adverse effects of airborne pollution, including those produced by noise. People have the right to choose the nature of their acoustical environment; it should not be imposed by others (Oyedepo & Saadu 2010).

The problem of environmental noise pollution has not been properly recognized despite the fact that it is steadily growing in developing countries. Davis & Masten (2004) stated three valid reasons as to why widespread recognition of noise pollution problem has not materialized in a similar fashion as have air and water pollution problems. These reasons are summarized in the definition and perception of noise as a subjective experience, short decay time, and difficulty to associate cause with effect when it comes to health impacts.

In contrast to many other environmental problems, noise pollution continues to grow and is accompanied by an increasing number of complaints from people exposed to the noise. The growth in noise pollution is unsustainable because it involves direct, as well as cumulative, adverse health effects. It also adversely affects future generations, and has socio-cultural, aesthetic and economic effects (Ozer et al. 2009, Yilmaz & Ozer 2005).

Many surveys addressing the problem of noise pollution in many cities throughout the world have been conducted (Singh & Daver 2004, Li et al. 2002, Morillas et al. 2002, Zannin et al. 2002, Alberola et al. 2005, Lebiedowska 2005, Pucher et al. 2005, Tansatcha et al. 2005), and have shown the scale of discomfort that noise causes in people's lives (Ali & Tamura 2003, Marius et al. 2005).

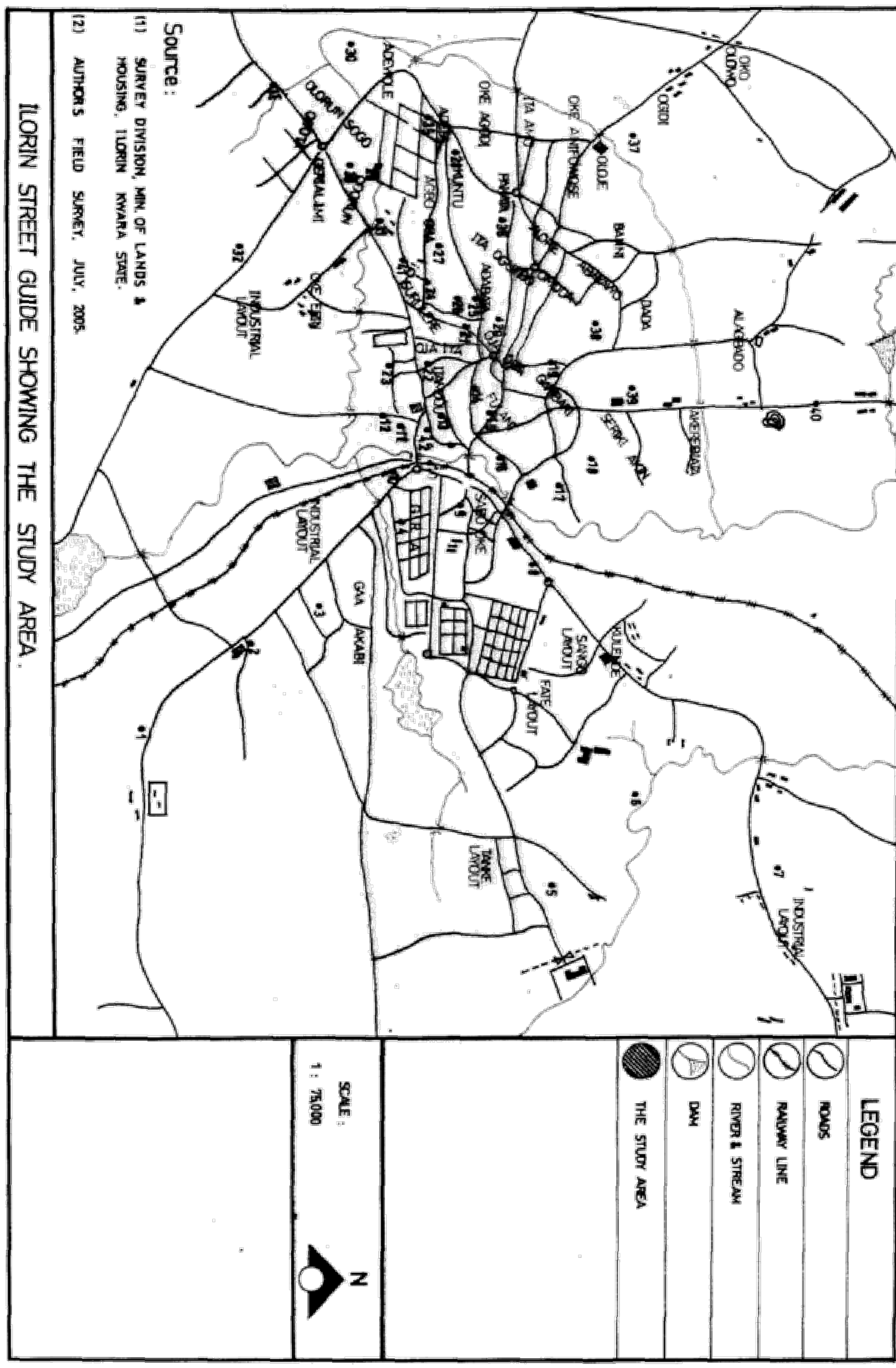


Fig. 1: Overview of Ilorin metropolis showing the locations of noise measurements throughout this study (Source: Survey Division, Min. of Lands & Housing, Ilorin, Kwara State).

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).

Depending on its duration and volume, the effects of noise on human health and comfort are divided into four categories; physical effects, such as hearing defects; physiological effects, such as increased blood pressure, irregularity of heart rhythms and ulcers; psychological effects, such as disorders, sleeplessness and going to sleep late, irritability and stress; and finally effects on work performance, such as reduction of productivity and misunderstanding what is heard (Marius et al. 2005, Quis 2001).

City noise levels can be investigated in three different ways as traffic and transportation; industrial activities; sport, marketing and entertainment facilities (Dursun et al. 2006). In comparison to other pollutants, the control of environmental noise has been hampered by insufficient knowledge of its effects on human and lack of defined criteria. Noise pollution is a significant environmental problem in many rapidly urbanizing areas. It is well established now that noise is a potential hazard to health, communication and enjoyment of social life. It is becoming an unjustifiable interference imposition upon human comfort, health and quality of life.

In Nigeria, the problem of noise pollution is wide-spread. Several studies report that noise level in metropolitan cities exceeds specified standard limits. A study by Ugwuanyi et al. (2004) conducted in Makurdi, Nigeria found that the noise pollution level in the city was about 3 dB(A) to 10 dB(A) above the recommended upper limit of 82 dB(A). Anomohanran et al. (2008) also found that the peak noise level at road junction in Abraka, Nigeria to be 100 dB(A). This noise level is higher than the recommended level of 60 dB(A) for commercial and residential areas. Ighoroje et al. (2004) investigated the level of noise pollution in selected industrial locations in Benin city, Nigeria. The average ambient noise level in Sawmills, Electro-acoustic market and food processing industrial areas was determined to be above 90 dB(A). This noise level is well above the healthy noise level of 60 dB(A).

The noise pollution is not a unique problem for developing countries like Nigeria only. Many researches have revealed that more than 130 million people in Europe suffer from exposure to noise levels above 65 dB(A) (Commission of the European Communities 2000). Bond (1996) reports that 16% of people in Europe are expose to 40 dB(A) or more of traffic noise in their bed rooms at night compare it with WHO's average estimates of 30 to 35 dB(A) for undisrupted sleep. WHO has proposed the time base guideline for L_{Aeq} for 16 h daytime and 8 h night-time. The environmental noise level of 70 dB(A) L_{Aeq}, 24 h was recommended by WHO for industrial, commercial, shopping and traffic areas, indoors and outdoors areas to prevent impairments.

In Nigeria, there is no legal framework upon which noise pollution can be abated. Federal Environmental Protection Agency (FEPA) in Nigeria only provided daily noise exposure limits for workers in industry (i.e., 90 dB(A) for 8 h exposure). In short, the Nigerian Government and her citizenry appear not to be conscious of the present and future impacts of noise induced health hazards in their environment. Unless and until measures are taken to control the level of noise, the ongoing urbanization and industrialization may complicate the problem so much that it becomes incurable.

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 expanded 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 road traffic and commercial activities due to overall increase in prosperity, fast development, and expansion of the economy.

The prime objectives of this investigation are (1) to evaluate the noise levels in strategic locations (i.e., commercial centres, busy roads/road junctions, passenger loading parks, and residential areas) in the city, (2) to identify the major source(s) of noise pollution in the city and (3) to develop the noise map of the city.

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 centres, 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 selected for the noise level measurements in Ilorin metropolis. Figs. 1 and 2 show an overview of Ilorin metropolis showing the locations of noise measurements for this study and the population growth of the city respectively.

Experimental procedure: Instrumentation for the field measurements consisted of precision grade sound level meter (according to IEC 651, ANSI S1.4 type), ½-in. condenser microphone and 1/3-octave filter with frequency range and measuring level range of 31.5Hz-8KHz and 35-130dB sound

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

respectively. The instruments were calibrated by the internal 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 centres, 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 seconds for a period of 30 minutes, giving 60 meter readings per sampling location. This procedure was carried out for morning (7:30-8:00 a.m.), afternoon (1:00-1:30 p.m.), evening (4:00-4:30 p.m.) and night (8:30-9:00 p.m.) measurements. 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).

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

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

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

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

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

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

Where, L_{Ai} is the i^{th} A-weighted sound pressure level reading dB, N is the total number of readings, L_{Aeq} is the A-weighted equivalent sound pressure level, L_{AeqM} is the equivalent sound pressure for the morning measurement, L_{AeqA} is the equivalent sound pressure level for the afternoon measurement, L_{AeqE} is the equivalent sound pressure level for the evening measurement, L_{AeqN} is the equivalent sound pressure level for the night measurement, L_N is night time noise level, L_D is day time noise level, L_{10} is the noise level exceeded 10% of the time, L_{90} is the noise level exceeded 90% of the time, L_{NP} is noise pollution level, L_{DN} is day-night noise level, TNI is the traffic noise index.

RESULTS AND DISCUSSION

Assessment of Noise Descriptors

Noise measurements were done when the effects on the noise sources of variable factors (e.g., wind speed, rainfall, etc.) were at minimum. All the data were obtained on weekdays and under suitable meteorological conditions, i.e., no rain. Measurements were recorded at interval of 30 seconds for a period of 30 minutes, giving 60 meter readings per location. The data were used to evaluate noise descriptors in the form of L_{Aeq}, L_{10}, L_{90}, TNI, L_{NP}, L_D, L_N and L_{DN}.

The average noise descriptors were determined per location. Table 2 shows the daily average values of noise descriptors for all the sites surveyed. The sites are designated with numbers 1 to 42.

From Table 2, location 10 has the highest values of L_{Aeq} (86 dBA), L_{10} (92 dBA), L_D (89 dBA), TNI (122 dBA), L_{NP}(106 dBA), L_{DN} (92 dBA) and second highest value of L_{90} (72 dBA) and L_N (84 dBA). Location 15 has the second highest values of L_{Aeq} (84 dBA), L_{10}(87 dBA), TNI (112dBA), L_{NP} (102 dBA), L_{DN} (91dBA) and highest value of L_N (85 dBA). These two locations are road junction/busy roads in the city surveyed. In order of high noise descriptors, next to these two locations are sites 20 and 25. The average values of noise descriptors of these locations are: L_{Aeq} (82 dBA), L_{10} (86 dBA), L_{90} (73 dBA), TNI (98dBA), L_{NP} (96dBA), L_D(83 dBA), L_N (83dBA), L_{DN}(89dBA) and L_{Aeq} (82 dBA), L_{10} (86 dBA), L_{90} (74 dBA), TNI (92dBA), L_{NP} (94dBA), L_D(81 dBA), L_N (82dBA), and L_{DN}(88dBA) respectively.

Locations 20 and 25 are commercial centres and passengers loading park respectively. The background noise levels (L_{90}) at these locations are higher than locations 10 and 15. This is due to intrusive noise sources from human conversation due to commercial activities, radio player,

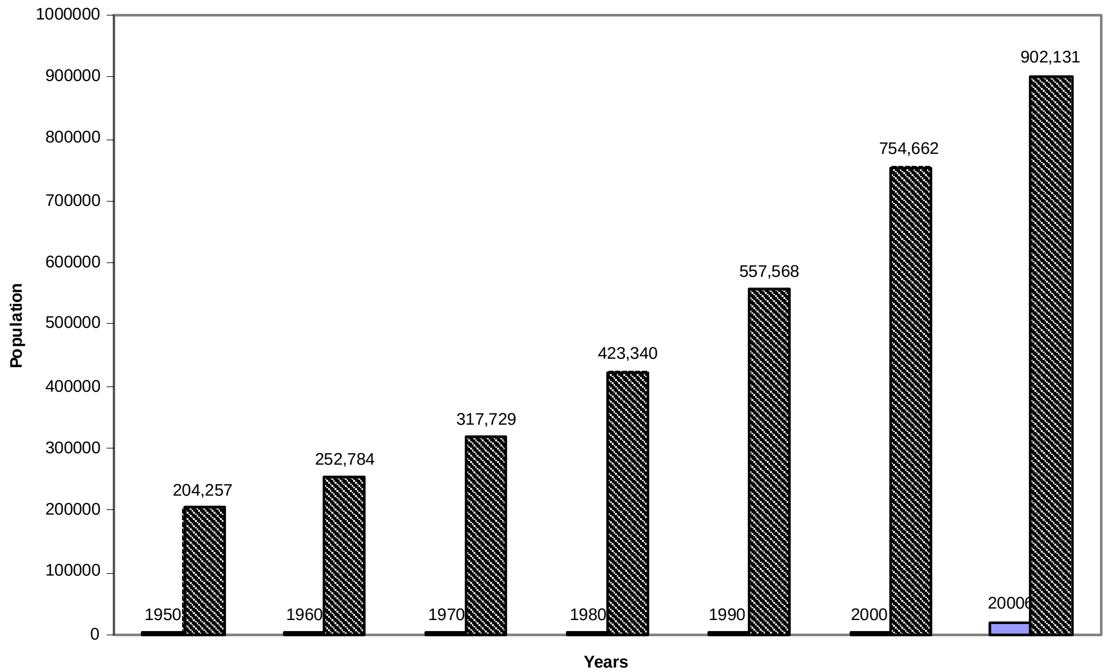


Fig. 2: The increase in population of Ilorin.

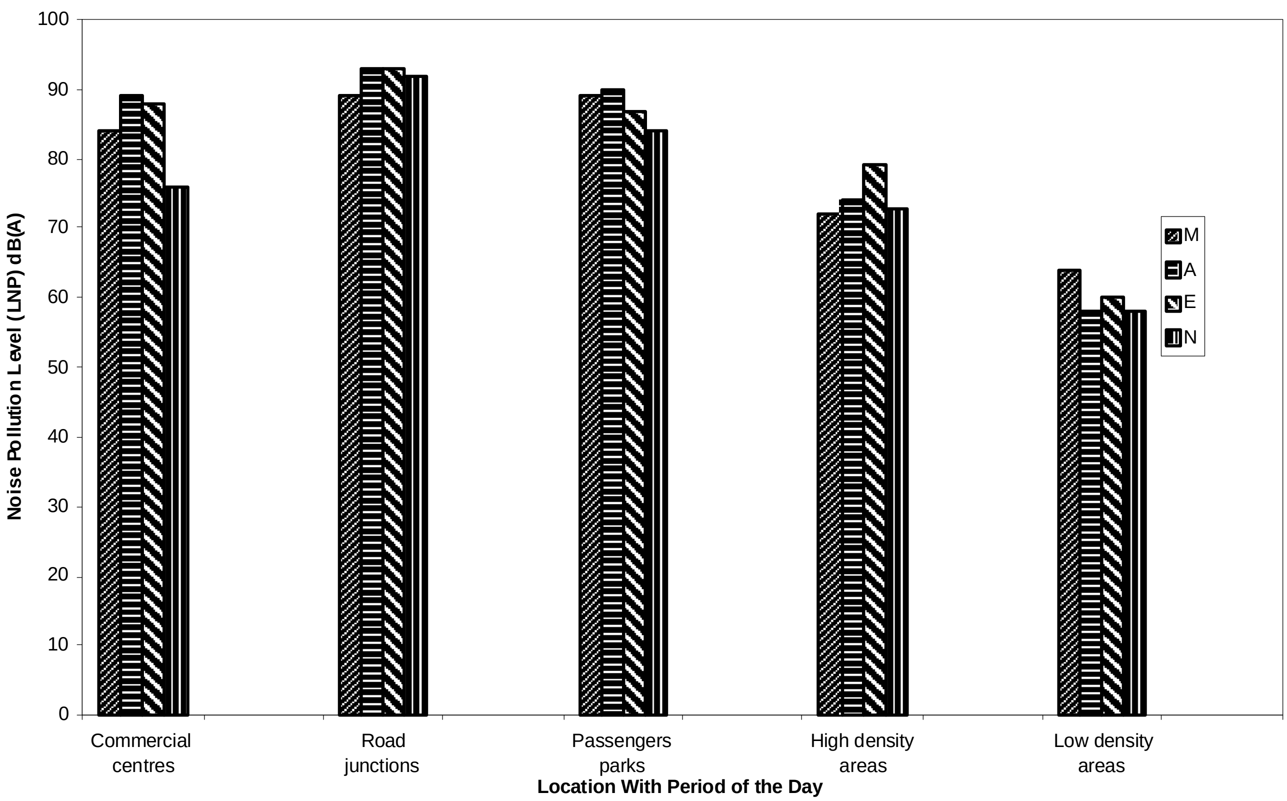
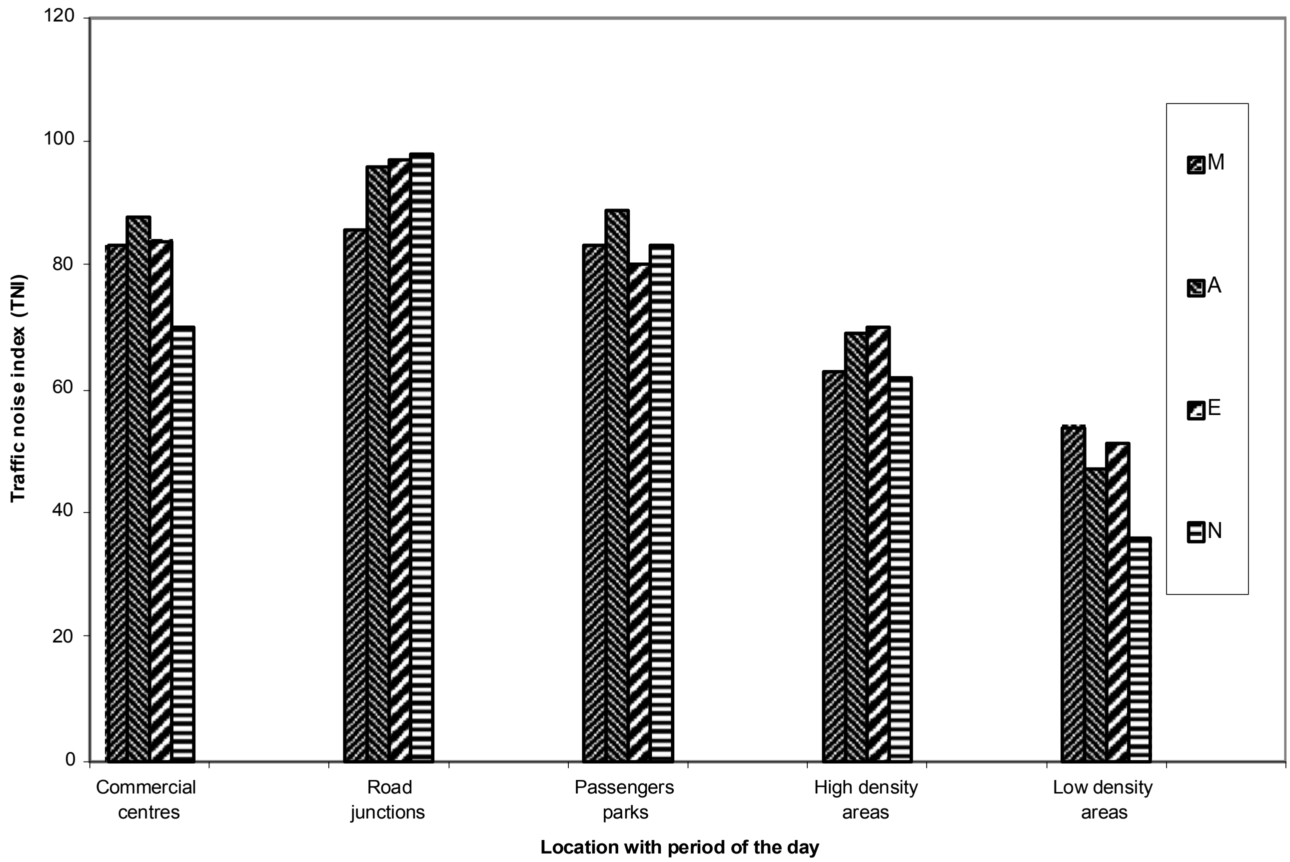


Fig. 3: Variation of noise pollution levels (LNP) with location and period of the day.



M – Morning, A – Afternoon, E – Evening, N – Night

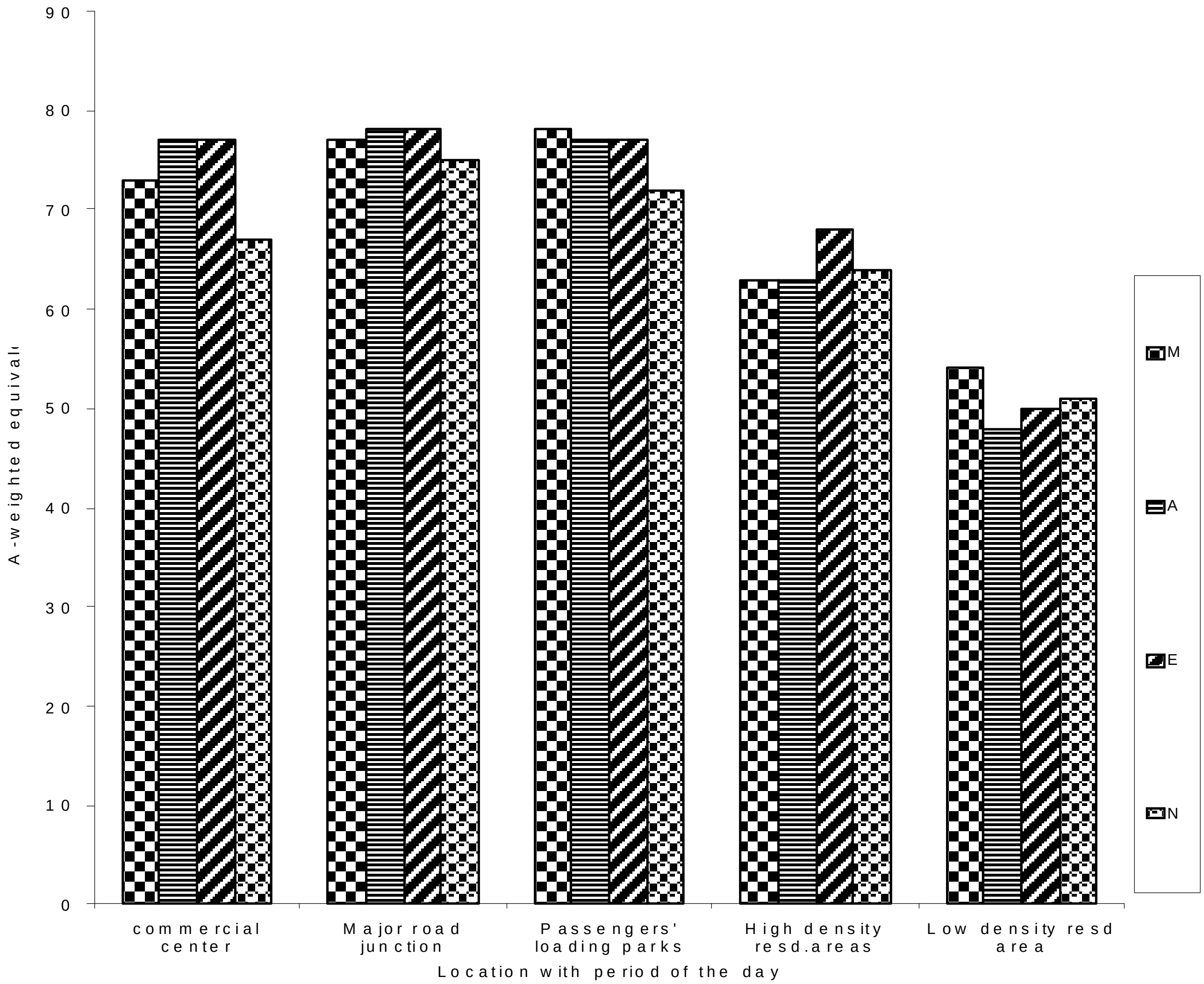
Fig. 4: Variation of the traffic noise index (TNI) with location and period of the day.

electric generator noise, etc. The lowest noise descriptor values were recorded at location 34 and 6 with values L_{Aeq} (46 dBA), L_{10} (44 dBA), L_{90} (34 dBA), TNI (44dBA), L_{NP} (56dBA), L_D(49 dBA), L_N (44dBA), L_{DN}(52dBA), and L_{Aeq} (47 dBA), L_{10} (49 dBA), L_{90} (44 dBA), TNI (33dBA), L_{NP} (52dBA), L_D(43 dBA), L_N (53dBA) and L_{DN}(59dBA) respectively. These locations are low density residential areas. Among the factors responsible for differences in noise levels in the centres surveyed include location site, presence of intrusive noise, traffic volume, commercial activities, etc.

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. (Oyedepo & Saadu, 2008, Oyedepo & Saadu 2009, Mansouri et al. 2006, Garcia & Garrigues 1998, Bruel & Kjaer 1998, Dai et al. 2005). Several studies have demonstrated that the urban conditions of a given area are also a very important factor influencing the environmental noise levels.

There is variation in the noise levels with the period of the day and the nature of the location. In general, there are high noise pollution levels (L_{NP}) in the daytime (7:30 a.m.-2:30 p.m.) compared with the night time (8:30 p.m.-9:00 p.m.), except in the residential areas where the majority of the residents are not always at home during the working days of the week; hence, the noise levels are low at residential areas (especially in low-density residential areas) in afternoon time. Figs. 3 to 5 show the variations of noise pollution levels (L_{NP}), traffic noise index (TNI) and equivalent pressure noise level (L_{Aeq}) with location and period of the day. At commercial centres, road junctions, passenger loading parks, and high-density areas, the noise descriptors L_{NP}, TNI and L_{Aeq} rise from morning and reach peak values in the afternoon and evening but descend in the night to low levels.

The high noise pollution levels in the morning and evening at these locations can be justified as a result of morning rush hour. The noise pollution levels in the afternoon time (1:00 p.m.-2:30 p.m.) at low-density residential areas are generally low. This is because the majority of the residents are not always available at home in the afternoon. Some



M – Morning, A – Afternoon, E – Evening, N – Night

Fig. 5: Variation of the equivalent sound level L_{Aeq} with location and period of the day.

are in their offices, markets, or shops while children are in their schools by this time of the day. Moreover, most of the low-density residential areas are developing areas, while some are government-reserved areas. The numbers of vehicles that ply on the roads in these areas are very low, and of course, there is a speed limit (40 km/h) for every vehicle that passes through these areas. Blaring of horns and movement of unmuffled vehicles are prohibited in some of these areas.

At the time of this measurement, the highest and lowest average noise pollution levels (L_{NP}), traffic noise index (TNI) and equivalent pressure noise level (L_{Aeq}) were 106 dB(A), 122 dB(A), 86 dB(A) at location 10 (road junction) and 52 dB(A), 33 dB(A), 46dB(A) at locations 6 and 34 (low-density residential area), respectively.

Locations 10 and 15 were found to be the noisiest sites with peak noise levels (L_{10}) of 92 dB(A) and 94 dB(A), respectively, compared to the peak noise value of 91.5 dB(A) in Markurdi (Ugwuanyi et al. 2004) and 100 dB(A) in Abraka (Anomohanran et al. 2008). The high noise pollution values of these sites may be as a result of the noise produced by music players and the proximity of these sites to the high traffic density of roads and presence of nearby rail stations. The high noise levels at road junctions confirm once more the previous findings of many authors pointing to the existence of a very close association between the sound levels measured at a given urban location and the road traffic volume flowing by that location (Dhananjay & Prashant 2007, Mansouri et al. 2008).

High noise levels exposure in the city occurs in the day

Table 2: Average noise descriptors at study locations.

Site	L_{Aeq} dBA	L_{10} dBA	L_{90} dBA	TNI dBA	L_{NP} dBA	L_D dBA	L_N dBA	L_{DN} dBA
1	49	52	44	47	57	49	49	55
2	77	81	69	87	89	72	79	85
3	61	65	56	59	69	63	63	66
4	57	59	48	61	63	59	56	53
5	55	53	46	44	64	57	56	63
6	47	49	44	33	52	43	53	59
7	71	75	53	118	95	73	68	75
8	74	76	60	94	90	79	71	80
9	58	64	53	46	68	65	66	72
10	86	92	72	122	106	89	84	92
11	75	78	70	70	83	77	75	81
12	78	81	71	79	87	78	77	84
13	73	76	63	83	86	74	76	82
14	71	74	63	77	82	70	75	81
15	84	87	69	112	102	83	85	91
16	65	69	59	70	76	65	66	72
17	71	71	56	86	86	74	69	77
18	76	70	57	81	81	72	76	83
19	81	83	71	87	92	84	81	88
20	82	86	73	98	96	83	83	89
21	78	81	66	97	93	79	81	87
22	79	83	71	87	90	79	79	85
23	71	74	64	75	80	73	72	79
24	78	82	72	84	88	78	79	85
25	82	86	74	92	94	81	82	88
26	80	82	71	83	90	81	80	87
27	67	70	57	81	81	74	71	78
28	64	66	54	72	76	62	67	73
29	71	75	62	87	85	71	71	77
30	50	51	41	53	61	54	49	57
31	77	79	70	77	86	80	74	82
32	74	74	61	84	86	74	74	80
33	76	79	68	81	87	78	74	82
34	46	44	34	44	56	49	44	52
35	72	75	62	87	86	73	72	79
36	75	77	62	92	90	75	75	81
37	70	73	62	80	81	74	68	76
38	64	67	60	57	72	60	69	75
39	74	76	60	94	90	79	71	80
40	81	83	70	93	94	81	83	89
41	76	81	68	89	89	76	77	83
42	60	62	54	54	67	61	59	66
Mean	70	73	61	79	82			
Min.	46	44	34	33	52	43		
Max.	86	92	74	122	106	89		

time at road junctions/major roads. This is followed by passengers loading parks and commercial centres. In these locations, apart from traffic noise, other intrusive noise sources include noise from record players, loud speakers, hawking and human conversation contribute majorly to environmental noise pollution.

In this study, some of the locations show a significant difference between L_{90} average and L_{90} maximum. Site 25 (a passenger loading park) illustrates the highest difference with L_{90} as 74 dB(A) compared to L_{90} average of 60 dB(A). This means some of the stations around the location noted a much higher background noise level exposure. This indicates that people located around the location will experience much higher background noise level which could lead to human annoyance, reduce the life quality or might affect health and psychological well being. Site 20 (commercial centre) and site 10 (road junction) also noted considerable difference in L_{90}. They both have values of 73 dB(A) and 72 dB(A) respectively. The high background noise level at these locations may be a result of intrusive noise from unmuffled vehicles, blaring of horns, record players, hawking and human conversation. Sites 10 and 15 (road junctions) were found to be the noisiest sites with a peak noise level of 88 dB(A) and 84 dB(A) respectively.

The U.S. Department of Housing and Urban Development (HUD) (Girardet 1992), recommends the following noise levels for residential areas, measured outdoors.

LAeq ≤ 49 dB(A) - clearly acceptable

49 < LAeq ≤ 62 dB(A) (or LDN ≤ 65 dB(A)) - normally acceptable

62 < LAeq ≤ 76 dB(A) (or 65 < LDN ≤ 75 dB(A)) - normally unacceptable

LAeq > 76 dB(A) (or 75 dB(A) < LDN) - clearly unacceptable

Considering the criteria from HUD, only 9 locations representing 21.4% out of the 42 locations surveyed, can be classified as normally acceptable, while 14 locations representing 33.3% can be classified as clearly unacceptable. A widely accepted scientific fact is that living in black acoustic zones, where the equivalent sound level is higher than 65 dB(A) (Alberola et al. 2005) put an urban population in a high risk status for numerous subjective effects of noise, including psychological, sleep and behavioural disorder.

Most of the countries, keeping in view the alarming increase in environmental noise pollution, have come up with permissible noise standards. The US Federal Highway Administration (FHWA) in April 1972 published interim noise standards for various land use as given in Table 3. The World Health Organization (WHO) has suggested a standard guideline value for average outdoor noise levels of 55 dB(A), applied during normal daytime (16 hours) in order to prevent significant interference with the normal activities of local communities, and is considered as serious annoyance, while a value of 50 dB(A) as moderate annoyance. Table 4 shows the WHO Guideline values for community noise listing also critical health effects ranging from annoyance to hearing impairment.

The result of this study shows that noise levels (L_{10}) in all the passenger loading parks surveyed (ranges from 72-86 dB(A)) are higher than the recommended values by FHWA (i.e., 60 dB(A)). In other locations, such as developed areas and residential areas the measured noise values (L_{10}) can be classified as normally acceptable. Out of 12 developed areas (commercial centres) surveyed only 5 locations having noise level higher than 75 dB(A), out of 6 high density residential areas, only 2 locations recorded noise levels higher than 70 dB(A) and out of 6 low density residential areas, only 1 location had noise levels higher than 55 dB(A).

Based on the National Guidelines for Environmental Noise Control by Federal-Provincial Advisory Committee on Environmental and Occupational Health (CEOH), a generally acceptable road traffic noise level L_D for residential areas should be less than 55 dB(A) and for night, L_N should not be greater than 50 dB(A). An area with environmental noise level less than 55 dB(A) is usually considered as a comfortable environment with little or no annoyance so that no negative physical and mental influence will be caused to essential activities such as working leisure and sleeping (Ahamad et al. 2006, Panadya 2003). Among all the locations surveyed, only the low density residential areas like locations 1 and 34 are acceptable in terms of the noise levels as per recommendations of CEOH and WHO. If the standard of HUD is considered, the dwelling areas like locations 1, 4, 5, 6, 30 and 34 are under normally acceptable situation and the noise levels of the other areas are still not acceptable. It may, therefore, be stated that the locations that fall under commercial centres, road junctions/major roads, passenger loading parks and high density residential areas do not satisfy the recommended noise limit requirements according to these standards.

To ascertain the significant difference in the noise level exposure in the sites surveyed throughout the daytime period (from morning to evening 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. Similarly, at the same confidence level, the MSR calculated for L_{90} is 167 and the tabulated value remain the same at 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.

Traffic Volume Measurement

One of the most important characteristics of a traffic stream is its volume which can be defined as the number of vehicles passing through a section of a road in a unit time, usually one hour. Another parameter closely related to traffic volume is the rate of flow which is also used to describe the number of vehicles passing a point on a section of highway or a lane in a period of time less than one hour, usually fifteen minutes or five minutes. The peak hour factor, which is a measure of consistency of demand, can be defined as the ratio between the number of vehicles counted during the peak hour and four times the number of vehicles counted during the highest fifteen consecutive minutes or twelve times if counted during the highest five consecutive minutes.

The peak hour factor is used to determine the critical volume used in the design of major urban streets. It is used to determine the geometry of such urban streets in terms of lanes, their width and at times to impose speed limits (Highway Capacity Manual 2000, Normann 1962).

Tables 5 and 6 show traffic volume count obtained in some selected heavy and lightly busy roads in Ilorin in the year 2005 (Jimoh & Yusuf 2006). The morning and evening peak periods were determined and hence applied for computation of PHF as given in Table 7.

Volume of traffic for both heavy and lightly busy roads in Ilorin with peak volume occurs in the morning and evening for all the roads. Baboko Junction (1180), has the highest peak followed by Taiwo road (1079) and Challenge Junction (1033), and all occurring in the afternoon between 4:00 p.m.-5:00 p.m. and 5:00 p.m.-6:00 p.m. However, Emir’s road (882), Geri Alimi road (774) and Jebba road (898) are fairly busy roads with peak volumes occurring in the morning and evening from 9:00 a.m.-10:00 a.m., 3:00 p.m.-4:00 p.m. and 4:00 p.m.-5:00 p.m. respectively. Traffic along these roads is fairly uniform. The peak hour volumes and peak hourly rates of flow of Emir’s road, Geri-Alimi road, Taiwo road and Baboko Junction are much higher than the corresponding values for Asa Dam and Jebba roads. High PHF for Asa Dam and Jebba roads is as a result of large number of heavy trucks whose passenger car equivalent values are relatively higher (that is 3) than that of passengers cars (1). Substantial portions of the two roads are suburban and hence mostly carry through traffic while the other arterials are completely urban. This implies that factors like directional distribution of vehicles, lane distribution of vehicles and traffic composition affect the traffic stream volume.

The PHF is normally distributed for major arterials in Ilorin and usually falls between 0.85 and 0.96 with mean and standard deviation in the range 0.854-0.931 and 0.03-0.07 respectively. The corresponding averages are close to the values reported for selected American urban intercessions (Normann 1962).

The traffic mix of Ilorin, like other urban cities in Nigeria comprises of the following composition, cars (90-93%), lorries (5-7%), buses (2-5%) and heavy trucks (1-2%). According to Dai et al. (2005), traffic noise heavily relies on

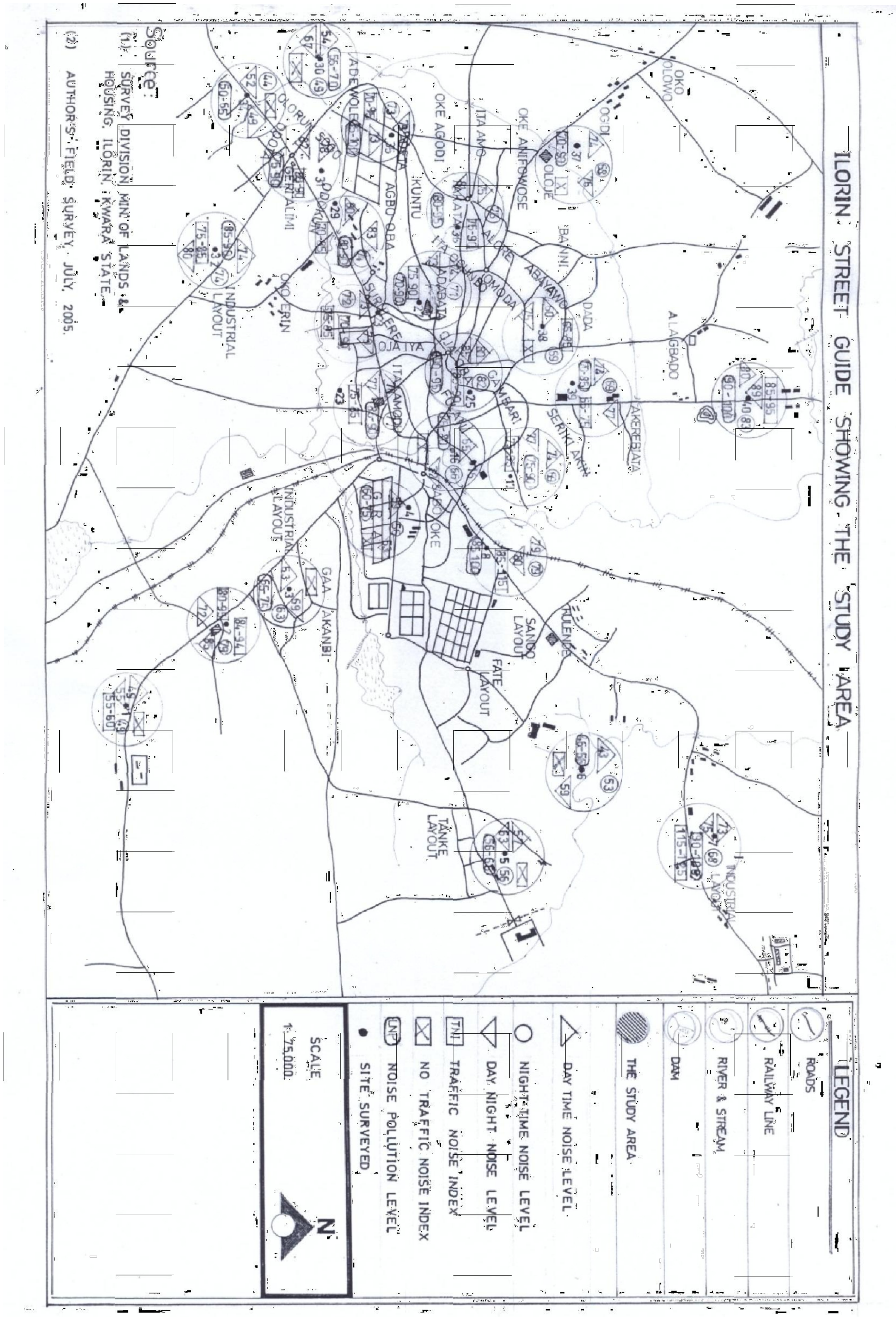


Fig. 6: Noise map for Ilorin metropolis.

traffic flow to which the noise levels are measured. In their work, a relationship for traffic noise and traffic flow was established. Establishment of such a relationship is significant for engineers and researchers to evaluate the traffic noise intensity of a specified road with a given traffic flow. On the other hand, if the traffic noise level of a road is specified, as per the regulations set forth by the government or organizations, the maximum allowable traffic flow for this road can also be determined with the relationship.

Noise Map for Ilorin Metropolis

Noise maps describe spatial distributions of noise levels. They allow an efficient visualization of the noise distributions in areas where the land uses are sensitive to noise. Noise mapping is a very efficient noise assessment method in urban areas (Coelho & Alarcao 2006). Before proposing noise control policies, noise maps are needed to examine noise level regulation and identify primary noise source (Tsai et al. 2009). A noise map is considered as a tool to improve or to preserve the quality of the environment regarding noise pollution, allowing a comprehensive look at the problem of multiple sources and receivers. Noise map is also an excellent tool for urban planning. According to Santos & Valado (2004), the use of noise maps techniques as a planning tool allows:

- Quantification of noise in the studied area
- Evaluation of the population exposition
- Creation of a database, for urban planning with localisation of noisy activities and mixed and sensible zones
- Modelling of different scenarios of future evolution
- Prediction of impact noise of projected infrastructure and industrial activities
- Improvement of the enforcement of regional or national plans to decrease new noise resource as well as to protect new noise sensitive and tranquillity needed areas.
- Monitoring of noise reduction schemes and their effectiveness during the enforcement process
- Monitoring changing trends in environmental noise
- Provision of a research platform for studying the effects of noise on the human body

In this work, noise mapping and, of course, noise abatement plans drawn for noise levels of different land use zones, including commercial centres, major road junctions, passenger loading parks, residential areas (high density and low density) are presented. The results are compared with related noise regulation standards. All the data collected at the 42 sites were used to develop a noise map for Ilorin metropolis. A noise map based on the noise descriptors: daytime noise level (L_D), night-time noise level (L_N), day-night noise level (L_{DN}), traffic noise index (TNI), average weighted equivalent noise level (L_{Aeq}) and noise pollution levels (L_{NP}) has been developed.

Fig. 6 shows the noise map of Ilorin metropolis. The noise map reveals that the nucleus of the city is characterized by a high noise exposure level. The daytime noise level is 84 dB(A), the night-time noise level is 81 dB(A), the day-night time noise level is 91 dB(A), the TNI is in the range of 85-115 dB(A), and the noise pollution level is in the range of 90-105 dB(A). The outskirt area of the city is basically low-density residential areas and developing sites. The highest daytime noise level is 74 dB(A), the night-time noise level is 68 dB(A), the day-night noise level is 76 dB(A), traffic noise pollution is 80-95 dB(A), and noise pollution level is 90-100 dB(A). Generally, the suburbs of the city are characterized by low noise, but due to major roads that pass through some of these locations, traffic noise contributes as a major source of environmental noise pollution in some of the outskirt locations. In the centre of the city, there are concentrations of shops, markets, and clustered buildings with high population and traffic volume. All these are responsible for high noise exposure levels; therefore, the residents living or trading in these areas are exposed to noise levels of 80-90 dB(A) or more every day. This is very dangerous to the health of the people in these areas. According to the World Health Organization, generally 60dB(A) sounds can result in temporary hearing impairment and 100 dB(A) sounds can cause permanent impairment. The noise levels of Ilorin metropolis are similar to those reported for other cities around the world in Jordan, Spain, Brazil, Turkey and India (Ahamad et al. 2006, Garcia & Garrigues 1998, Zannin et al. 2002, Dai et al. 2005, Ali & Tamura 2003).

This work is an eye-opener to see and understand the importance of noise map for Nigerian urban areas as it enables one to know areas that are noisy and ones with low noise. Also, the category of people in the urban areas exposed to different noise sources and noise exposure dose based on their occupation is known with the help of the noise map. Furthermore, the noise map has the potential to enable data to be accessible to the general public in a way that is comprehensible. This could have the effect of raising people's awareness of noise as a pollutant and, thus, creating the climate necessary for the implementation of a noise-reduction program.

CONCLUSION

In this study, environmental noise analyses at selected locations were presented to represent typical equivalent noise level (L_{Aeq}), background noise level (L_{90}), traffic noise index (TNI), noise pollution level (L_{NP}), L_{10}, L_D, L_N and L_{DN} at 42-selected sites in Ilorin metropolis. It is interesting to see that where locations of the monitoring stations are near the busy roads/road junctions, commercial centres and passengers loading parks the equivalent noise level, background noise

Table 3: FHWA noise standards (Dhananjay & Prashant 2007).

S/No.	Land use	Noise level L_{10}	Description of land use category
1	A	60 dBA (Exterior limit)	For parks and open spaces
2	B	70 dBA (Exterior limit)	Residential area, Hotels, Schools, Libraries, Hospitals etc
3	C	75 dBA	Developed areas
4	D	55 dBA (Interior limit)	Residential area, Hotels, Libraries

Table 4: WHO guidelines for community noise (Mansouri et al. 2006).

Environment	Critical health effect	Sound level dB(A)	Time hours
Outdoor living areas	Annoyance	50 - 55	16
Indoor dwellings	Speech intelligibility	35	16
Bedrooms	Sleep disturbance	30	8
School classrooms	Disturbance of communication	35	During class
Industrial, commercial and traffic areas	Hearing impairment	70	24
Music through earphones	Hearing impairment	85	1
Ceremonies and entertainment	Hearing impairment	100	4

Table 5: Traffic trend for Ilorin urban arterials (heavy busy roads and junctions).

	Traffic volume on roads							
	Jebba Road		Taiwo Road		Baboko Junction		Challenge Junction	
Time of the day	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2
7:00–8:00	587	607	480	506	642	558	500	624
8:00–9:00	810	800	708*	670	700	760	897*	701*
9:00–10:00	816*	806*	699	747*	804	876	762	700
10:00–11:00	747	787	647	627	936	900	443	459
11:00–12:00	441	487	540	564	851	931*	341	351
12:00–13:00	492	446	500	540	837	909	250	292
13:00–14:00	643	673	418	422	984	900	431	361
14:00–15:00	753	789	542	514	998	1058	499	529
15:00–16:00	692	668	589	713	1004	1080*	722	800
16:00–17:00	812*	898*	945	974	1180*	1018	987*	1033*
17:00–18:00	736	688	998*	1079*	799	919	762	729
18:00–19:00	507	533	970	938	700	886	477	511

*Morning and evening peak volume.; Source: (Jimoh & Yusuf 2006)

Table 6: Traffic trend for Ilorin urban arterials (light busy roads).

	Traffic volume on roads							
	Asa Dam Road		Geri Alini Road		Unityn Road		Emir's Road	
Time of the day	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2
7:00–8:00	251	227	667	639	390	402	432	440
8:00–9:00	300	346	662	666*	598	626*	686	656
9:00–10:00	535*	401*	668*	620	621*	572	800*	882*
10:00–11:00	296	350	432	400	462	440	667	639
11:00–12:00	280	252	446	489	427	453	511	557
12:00–13:00	272	200	337	353	401	433	360	398
13:00–14:00	269	249	330	356	306	271	438	400
14:00–15:00	250	308	572	500	280	322	552	584
15:00–16:00	290	298*	726*	774*	500*	584*	563*	607*
16:00–17:00	320*	288	580	612	477	447	480	460
17:00–18:00	200	156	502	474	380	360	394	418
18:00–19:00	96	144	406	440	260	298	300	302

*Morning and evening peak volume.; Source: (Jimoh & Yusuf 2006)

Table 7: PHF values for the respective urban arterials.

Location	Morning peak PHF	House of occurrence	Afternoon peak PHF	House of occurrence
Jebba Road	0.876	9:30–10:30	0.864	16:30–17:30
Taiwo Road	0.966	8:45–9:45	0.982	16:45–17:45
Baboko Junction	0.946	10:45–11:45	0.917	15:45–16:45
Challenge Junction	0.928	8:15–9:15	0.905	16:00–17:00
Asa Dam Road	0.936	9:00–10:00	0.895	15:45–16:45
Geri-Alimi Road	0.919	8:30–9:30	0.957	15:00–16:00
Unity Road	0.952	8:15–9:15	0.945	15:15–16:15
Emir's Road	0.961	9:00–10:00	0.943	14:45–15:45

Source: (Oyedepo & Saadu 2010)

level and peak noise level are higher compared to monitoring station near residential areas.

It was also observed that, the A-weighted sound levels (L_{Aeq}), background noise level (L_{90}) and peak noise level (L_{10}) measured vary with the location and period of the day. Due to traffic characteristics, especially traffic volume, vehicle horns, vehicle-mounted loudspeakers, unmuffled vehicles, record players and hawking, there is high LAeq, L_{90} and L_{10} at road junctions (77 dBA, 66 dBA, 77 dBA), passengers loading parks (76 dBA, 66 dBA, 77 dBA) and commercial centres (73 dBA, 64 dBA, 74 dBA). Average daily noise exposure level (LAeq) in Ilorin metropolis varies from 46 dBA to 86 dBA. The noise assessment of Ilorin metropolis indicated that the noise levels in the city is escalating at a very fast rate with growing population and heavy traffic accumulation. Noise levels obtained at different locations of the city *viz.* commercial, residential, road junctions/busy roads and passengers loading parks are found to be exceeding the noise level/limits prescribed by World Health Organization (WHO). It was also observed that higher noise level in the city is due to rapid and unplanned urbanisation resulting in greater influx of people from all parts of the region and country, improper management of city roads and traffic, lack of sufficient parking space and exponential growth of both private and public vehicles in the city.

Based on the recommendations of CEOH, WHO and HUD, only 6 locations out of 42 are under normally acceptable situation while the noise levels of other areas are not acceptable.

This investigation reveals that noise levels at 30 of 42 measurement points exceeded the recommended limit of 60 dB(A) by values of 1-27 dB(A). Hence, the present status of noise pollution in Ilorin metropolis poses a severe health risk to the residents. Furthermore, discomfort and irritation being caused by the pollution can drastically reduce productivity, both in public service and private sectors. In addition, some areas may soon reach the threshold of pains and lead to permanent loss of hearing and death.

This study shows that majority of people most likely exposed to high noise level in Ilorin metropolis include the policemen, traders and commuter drivers as the main source of noise pollution in the city is traffic noise.

The sources of noise pollution identified in this paper also exposed the common channels of environmental pollution through noise and its effects on the public in Ilorin metropolis which is most significantly similar throughout the Nigerian cities and the world, in general. The challenges posed by noise pollution on human health and the environment have not yet received full attention which it deserves. Though, generally statutory and policy provisions regulating noise on pollution in Nigeria as well as the world over have lofty aims and are quite salutary, however, there is need for proper implementation.

RECOMMENDATIONS

Due to the ignorance of Nigerians on the fact that there exists a close nexus between noise pollution and sustainable city, little or no attention is paid to the control of noise pollution in Nigeria. The execution and implementation of the law as regards environmental pollution is never implemented. It is observed that the persistence of this problem could endanger the future stability of human health and could aggravate the human health catastrophe in the fast growing cities in Nigeria.

Due to the possible adverse effects of high noise levels on the populace a number of action plans can be taken to abate the environmental noise pollution in Nigeria. These include: technical, planning, behavioural and educational solutions. Since, transport infrastructures 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 or 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 travelled highways running through residential areas. Transportation and land planning (private versus public transportation, bus lanes, parking areas, shuttle buses, pedestrian areas) are important components of the plan. Since, noise also results from the citizen's behaviour (driver, music player, hawker, etc.), information and education campaigns usually produce good results in the long term. Information on the different actions and on the results should be well disseminated and should correspond to general aims and action plans. There is a need to implement the established 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 siting new roads, shopping centres, schools, hospitals and both commercial and residential houses, in general. Most valuable step to decrease noise pollution in big city like Ilorin, is preparation of noise maps. Noise maps are very powerful tools for communicating results of assessment of environmental noise to the general public and also for the government (local and national) to devise noise correction measures. The noise map itself with the values of noise descriptors provide baseline data for town planners, engineers and other professionals and researchers for the planning and execution of their projects. Based on the importance of noise map as a tool to abate noise pollution in urban areas and for sustainable urban cities in Nigeria, it is, therefore, recommended that noise map should be made available for Nigerian urban cities. Most of the cities in Nigeria have not presented noise pollution maps. It is suggested that noise maps should be developed for every big city in Nigeria to serve as a noise control measure. The noise map developed in this work is based on the use of hand; other fast, efficient and accurate method with electronic computer can be embarked upon for future work. Also, development of noise mapping software for Nigerian urban centres is recommended for future work.

Conclusively, aggressive implementation of the existing laws, policies and guidelines on environmental pollution will go a long way in addressing the problem of noise pollution and brings about sustainable urban development in Nigeria.

REFERENCES

Ahamad, J., Abbas, A. and Reem, S. 2006. Evaluation of traffic noise pollution. J. of Environmental Monitoring and Assessment., 120: 499-525.

Alberola, J., Flindell, H. and Bullmore, J. 2005. Variability in road traffic noise levels. European Commission, Environmental Noise Directive 2002/49/EC, Off. J. European Communities, L189; 12-25.

Ali, S. A. and Tamura, A. 2003. Road traffic noise levels: Restrictions and annoyance in greater Cario, Egypt. Appl. Acoust., 64(8): 815-823.

Anomohanran, O., Iwegbue, C.M.A., Oghenerhoro, I.O. and Egbai, I.J.C. 2008. Investigation of environmental noise pollution level of Abraka in Delta State, Nigeria. Trends in Applied Sciences Research, 3(4): 292-297.

Bond, M. 1996. Plague by noise. New Scientist, 16: 14-15, 649, November.

Bruel and Kjaer 1998. Technical Documentation 2238 and 2260, Integrating and Logging Sound Level Meter.

Coelho, J. L.B. and Alarcao, D. 2006. Noise mapping and noise action plans in large urban areas. Techni. Acoustica.

Commission of the European Communities 2000. Directive of the European Parliament and of the Council Relating to the Assessment and Management of Environmental Noise, COM 468 Final, 2000.

Dai, L., Cao, J., Fan, L. and Mobed, N. 2005. Traffic noise evaluation and analysis in residential areas of Regina. J. of Environmental Informatics, 5(1): 17-25.

Davis, M.L. and Masten, S.J. 2004. Principle of Environmental Engineering and Science. McGraw-Hill International.

Dhananjay, K.P. and Prashant, B.N. 2007. Assessment and ANN modeling of noise levels at major road intersections in an Indian intermediate city. J. of Research in Science, Computing and Engineering, 4(3): 39-49.

Dursun, S., Ozdemir, C., Karabork, H. and Kocak, S. 2006. Noise pollution and map of Konya city in Turkey. J. Int. Environmental Application & Science, 1(1-2): 63-72.

Garcia, G. and Garrigues, J. 1998. 24-hour continuous sound-level measurement conducted in Spanish urban areas. Noise Control Engg. J., 46(4): 159-166.

Georgiadou, E., Kourfidis, K. and Ziomas, I. 2004. Exploratory traffic noise measurements at five main streets of Thessaloniki, Greece. Global NEST. International Journal (Toronto, Ont.), 6(1): 53-61.

Girardet, H. 1992. Cities: New directions for sustainable urban living. London, The Gaia Atlas. In World Health Organization (1999) Towards a New Planning Process: A guide to Reorienting Urban Planning Towards Local Agenda, pp. 21.

Highway Capacity Manual 2000. Highway Research Board Special Report 95.

Ighoroje, A.D.A., Marchie, C. and Nwobodo, E.D. 2004. Noise induced hearing impairment as an occupational risk factor among Nigerian traders. Nigeria J. of Physiological Sciences, 9(1-2): 14-19.

Jimoh, Y.A. and Yusuf, I.T. 2006. Introducing virtual peak hour factor as a cost reduction strategy in traffic data collection. USEP Journal of Research Information in Civil Engineering, 3(1): 155-170.

Lebiedowska, B. 2005. Acoustic background and transport noise in urbanised areas: A note on the relative classification of the city soundscape. Trans. Res., Part D, Transport and Environment, 10(4): 341-345.

Li, B., Tao, S. and Dawson, R.W. 2002. Evaluation and analysis of traffic noise from the main urban roads in Beijing. Appl. Acoust., 63(10): 1137- 1142.

Mansouri, N., Pourmahabadian, M. and Ghasenkhani, M. 2006. Road traffic noise in downtown area of Tehran. Iranian J. of Environmental Health, Science and Engineering, 3(4): 267-272.

Marius, A., Tijunelis, M.D., Fitzsullivan, B.A., Sean, O., Henderson, M.D. 2005. Noise in the ED. Am. J. Emerg. Med., 23(3): 332-335.

Morillas, J.M.B., Escobar, V.G., Sierra, J.A.M., Gomez, R.V. and Carmona, J.T. 2002. An environmental noise study in the city of Caceres, Spain. Appl. Acoust., 63(10): 1061-1070.

NPC 2006. Nigeria Population Census, Nigeria.

Normann, O.K. 1962. Variation of Flow at Intersections as Related to Size of City of Facility and Capacity Utilization. Highway Research Record, pp. 61-66.

Oyedepo, S.O. and Saadu, A.A. 2010. Comparative analysis of noise descriptors in some selected areas in Ilorin Metropolis, Nigeria. Noise Control Engg. J., 58(6): 646-657.

Oyedepo, S.O. and Saadu, A.A. 2008. Changing noise climate of Ilorin Metropolis. Environmental Engineering Science, 26(5): 797-807.

Oyedepo, S.O. and Saadu, A.A. 2009. Evaluation and analysis of noise levels in Ilorin metropolis, Nigeria. J. of Environ. Monit. Assess., 160: 563-577.

Ozer, S., Yilmaz, H., Yesil, M. and Yesil, P. 2009. Evaluation of noise pollution caused by vehicles in the city of Tokat, Turkey. Scientific Research and Essay, 4(11): 1205-1212.

Panadya, G.H. 2003. Assessment of traffic noise and its impact on community. International Journal of Environmental Studies, 60(6): 595-602.

Pucher, J., Korattyswaropam, N., Mittal, N. and Ittyerah, N. 2005. Urban transport crisis in India. Transp. Policy, 12(3): 185-198.

Quis, D. 2001. Annoyance from road traffic noise: A review. J. Environ. Psychol., 21: 101-120.

Saadu, A.A., Onyeonwu, R.O., Ayorinde, E.O. and Ogisi, F. O. 1998. Road traffic noise survey and analysis in some major urban centers in Nigeria. Noise Control Engg. J., 46(4): 146-158.

Santos, L.C. and Valado, F. 2004. The municipal noise map as planning tool. Acustica, Guimaraes, Portugal, Paper ID: 162.

Singh, N. and Daver, S. C. 2004. Noise pollution - Sources, effects and control. Journal of Human Ecology (Delhi, India), 16(3): 181-187.

Tansatcha, M., Pamanikabud, P., Brown, A.L. and Affum J.K. 2005. Motorway noise modelling based on perpendicular propagation analysis of traffic noise. Appl. Acoust., 66(10): 1135-1150.

Tsai K.T., Lin, M.D. and Chen, Y.H. 2009. Noise mapping in urban environments: A Taiwan study. Applied Acoustics, 70: 964-972.

Ugwuanyi, J.U., Ahemen, I. and Agbendeh, A.A. 2004. Assessment of environmental noise pollution in Markurdi Metropolis, Nigeria. J. Pure Appl. Sci., 6(2): 134-138.

Yilmaz, H. and Ozer, S. 2005. Evaluation and analysis of environmental noise pollution in the city of Erzurum, Turkey. Int. J. Environ. Pollut., 23(4): 438-448.

Zannin, P.H.T., Diniz, F.B. and Barbosa, W.A. 2002. Environmental noise pollution in the city of Curitiba, Brazil. Appl. Acoust., 63: 351-358.

Zannin, P.H.T., Calixto, A., Diniz, F. and Ferreira, J.A.C. 2002. Survey of urban noise annoyance in a large Brazilian city: The importance of subjective analysis in conjunction with objective analysis. Environmental Impact Assessment Review, 22: 245-255.