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Road Traffic Noise-induced Sleep Disturbances in Some Cities in Eastern Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study, was conducted between April 2011 and July 2012, to estimate the degree of impact of road traffic noise on the exposed population in terms of sleep disturbances in daytime and nighttime periods in order to suggest ways of minimizing the impact if it appears adverse. Acoustical and social surveys were conducted. From acoustical survey, noise level data were obtained, while in social survey, responses of how road traffic noise affects city dwellers during sleep were obtained as well. This is to correlate acoustical (objective) data with social (subjective response) data to help estimate the degree of impact of the road traffic noise on the people exposed to it. Five (5) cities were randomly chosen after pilot study. These are Calabar, Uyo, Umuahia, Owerri and Port Harcourt cities. The cities were found to be of huge road traffic volume, with enormous environmental noise pollution indicators. A precision sound level meter (SLM), Bruel and Kjaer (B&K), type 732 was used after calibration, to obtain noise level data, while a questionnaire carefully designed by these authors, was used to generate subjective response data from respondents. Five thousand (5000) copies of the questionnaire were distributed carefully to 5000 persons, 2500 each for both high and low road traffic noise pollution zones. Response rates were 93.5% (high noise zone) and 94.8% (low noise zones). One hundred (100) measurement sites were chosen in all (50 sites each for both high and low noise zones). Results obtained show

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that the degree of sleep disturbance during daytime range between 93.8% to 95.8%, and during nighttime was 98.5 to 98.8%. From these findings, it is very clear that people living along busy roads in the cities under study are really suffering from serious sleep disturbances both at night and day times.

Keywords: Road traffic; sleep; noise levels; high noise zone; low noise zone; measurement sites.

1. INTRODUCTION

Road traffic noise pollution has been generally, found to be the most widespread and most dreadful disturbance to human health, worldwide [1,2,3]. It is clear that intense noise can awake a large number of people, keep them from going to sleep, or disturb their sleep Disturbance to sleep by road traffic noise depends on the type, intensity, duration and repetition of the noise as well as the age or state of health of an individual, among other factors. Sleep disturbance is a major environmental noise pollution effect. It is estimated that 80 – 90% of the reported cases of sleep disturbance in noisy environments are those caused by outdoor noise (noise from outside the building or house) [5,6].

Primary sleep disturbance effects have been discovered to include difficulty in falling asleep (increased sleep latency time), awakenings, and alterations of sleep stages or depth [7]. Exposure to nighttime noise pollution also induces after-effects (effects that take place after the individual is awake). These after-effects include reduced perceived sleep quality, increased fatigue, depressed mood, decreased performance, among others. [8–10]. Many field studies have been conducted on sleep disturbance for road traffic noise [9,11,12,13]. In Japan, a field study was conducted for 3,600 women (20–80 years) living in eight (8) roadside zones with different road traffic noise. Results showed that the women had difficulty in falling asleep, waking up during sleep, waking up too early, and feelings of sleeplessness one or more days a week. All these effects correlated significantly with average road traffic volumes during nighttime. The study showed that road traffic noise in excess of 30 dB L_{Aeq} (night-time) induced sleep disturbance [14], and this is consistent with the results of earlier researchers [15]. Meta-analyses of field and laboratory studies showed that there is a relationship between a single nighttime event sound exposure level (L_{AE}) and the percentage of people awakened or who showed sleep changes [8,16,17]. These studies showed that the number of awakenings per night for each L_{AE} value is proportional to the number of nighttime sound events or road traffic volume [3]. The aims of the study were therefore, (1) to estimate the degree of impact of road traffic noise on the exposed population in terms of sleep disturbances in daytime and nighttime periods; (2) to suggest some noise control approaches to reduce the noise-induced health effects in our cities.

2. MATERIALS AND METHODS

2.1 Materials for Data Collection

A precision sound level meter (SLM), Bruel and Kjaer (B&K), type 732 was used to measure noise level data, while materials for social data collection: a well designed questionnaire with a coefficient of concordance of reliability of 0.72 (72%) was used for the generation of subjective response noise data.

2.2 Methods for Data Collection

Acoustical and subjective response noise data were obtained for a period of over one year. This period of noise data gathering adequately covered both dry and wet seasons in Nigeria.

2.2.1 Acoustic noise data

The following noise levels were measured during daytime and nighttime periods: background noise levels (BNLs), sound pressure levels (SPLs) (as various motor vehicles were moving past the measurement point); noise levels inside sitting rooms and bedrooms of respondents during noise events (during day and night periods and noise levels from frontage (facades) of residential houses of respondents during noise events (day and night times); Road traffic volume (i.e motor vehicle counts) taken according to types e.g motorcycles/tricycles, cars, buses, trucks/trailers and other heavy motor vehicles were also obtained as they passed the measurement points. Other traffic parameters also measured were velocity (km/hr) of the moving motor vehicle by use of speedometer, and distances (in metres) between measurement points and road centerline. A speedometer or speed meter is a gauge that measures and displays the

instantaneous speed (velocity) of a moving motor vehicle. In carrying out acoustical measurements, measurement sites were selected in such a way that none was near airports, factories, rail lines, construction sites/factories, or any other sources of heavy noise levels other than motor vehicles. This is to avoid undue influence on road traffic noise levels by other sources. Measurement sites were also chosen to reflect roads with high and low road traffic noise, in order to help evaluate and correlate subjective noise data (noise responses) with acoustic noise data (noise levels). Distances between measurement points (façades of residential buildings) and road centerline were 10 -15 metres (using measuring tape), for outdoor noise levels, while distances between road centerline and sitting rooms/bedrooms range from 15 – 20 m, for indoor noise levels. Indoor noise measurements were made atleast 1.2 – 1.5 m from windows and doors, to prevent undue reflection of sound wave as prescribed by ISO [18] and IEC [19]. Sound level meter was held on a tripod stand with a microphone directly pointing toward the passing motor vehicle, far away from the body and 3.5m from reflecting and absorbing materials or surfaces, and about 1.5 – 2.0 m high from the ground corresponding to the ear position of an average human being [18,19].

2.2.2 Subjective noise data

Subjective noise reactions data of respondents exposed to road traffic noise were collected by use of a well constructed road transportation noise pollution questionnaire (RTNPQ). The questionnaire contains a number of subjective questions under various sections. Section on demographic/socio-economic information elicit data on respondent's sex, age, marital status, educational level, occupation, occupational status, income level, among others. A section on sleep disturbance effects of road transportation noise pollution contains questions such as: does road traffic noise awake you from sleep during daytime and nighttime? (Yes/No); and if "Yes", to what degree? Options given are: (a) little (b) moderate (c) severe (d) very severe (e) extremely severe; does road traffic noise make it difficult for you to fall asleep after you are awakened by it?, (Yes/No); do you fall sick or have any health problem due to night sleep interruption? (Yes/No); if yes, what kind of sickness or problem do you experience or suspect likely to occur? Options given were (increased blood pressure, increased heart rate, increased body fatigue, depressed mood, mental fatigue, reduced perceived sleep quality, decreased task performance, sleepiness and annoyance). Other questions posed include: do you habitually feel sleepy when you wake up in the morning? Options given were (a) No (b) Little (c) Moderate (d) Much (e) Very much (f) Extremely much); do you wake up too early in the morning due to your interrupted night sleep by road traffic noise? ((a) No (b) sometimes (c) quite often (d) wake up normal); what time of the day does road traffic noise affect your sleep most? Options were ((a) No time at all (b) All through the day (c) 7 am – 7 pm (d) 7 pm – 10 pm (e) 10 pm – 12 midnight (f) 12 midnight – 7 am), and what source of noise causes your sleep disturbances most? Options were (aircraft, motor vehicle, train, household appliances, electric motor generator, domestic animals, insects (mosquitoes), musical systems, people in the house, neighbours, church/mosque, shopping mall, playground, entertainment centres (disco, hotel, motel), vehicle horns/sirens, and snoring from bed fellows or roommate.

Five Nigerian cities were randomly chosen for this study, namely Calabar, Uyo, Umuahia, Owerri and Port Harcourt. Five thousand (5000) persons were given copies of the questionnaire (2500 copies at high noise zone and another 2500 copies at low noise zone). Statistics of the questionnaire distribution and percentage response rates are as shown in Table 3. One hundred (100) measurement sites were randomly chosen (50 sites at high noise zone and another 50 sites at low noise zone). Description of measurement sites is shown in Tables 4 – 8 for Calabar, Uyo, Umuahia, Owerri and Port Harcourt cities respectively. Respondents at high noise sites form the experimental group while those at low noise sites form the control group in this study. The questionnaire was distributed to those who have basic reading and writing skills in English Language; also from 15 years of age and above, and lived at the present location for atleast three (3) years. These precautions were taken to reduce undue human bias on noise assessment on the part of the respondents.

- Selection of measurement locations: Measurement locations (sites) were randomly selected after a pilot survey was conducted, to reflect roads with high and low traffic noise pollution levels. As a noise safety criterion in Nigeria, high noise sites (busy roads) are those with mean A-weighted sound pressure levels of 85 dB(A) and above, while low noise sites

(quiet roads) are those with mean A-weighted sound pressure levels below 85 dB(A). High noise pollution sites have heavy motor vehicular traffic with dense traffic composition or mix, while low noise pollution sites have less traffic volume and low noise level as specified above. A noise level of 85 dB(A) and above in Nigeria causes community complaints, annoyance, hearing loss, communication disturbances and other physio-psychological health hazards.

- Duration and time of the measurement: Measurement of noise data were taken between April 2011 and July 2012 (18 months). Measurements were taken during noise events between 7am and 10pm (day hours), and 10 pm and 7 am (night hours), on working days (Monday to Friday), covering the 100 measurement sites. Noise levels recorded during night hours (when people sleep) were to compare with the allowable noise exposure limits (L_{Deaf}) of 65 dB(A) for good sleep, resting/relaxation and comfort at night.
- Survey: The questionnaires were randomly distributed within the selected survey areas. Serious effort was made to collect them back at a spot through persuasion by the data collectors (enumerators) hired for this purpose. Over 80% of questionnaires distributed was obtained at the spot through this method. Questionnaires not collected at the spot were later got back at second and subsequent visits within a month. This approach was adopted in order to have a high response rate which this kind of social survey requires.

2.3 Data Analysis

The following expression was used to generate % awakened data.

$$\%Aw = 7.1 \times 10^{-6} L_{AE}^{3.5} \quad [1] \qquad (1)$$

where L_{AE} = indoor A-weighted sound exposure level (in dB(A) taken inside bedrooms/sitting rooms of building.

%Aw = Percentage of awakened response data.

Analysis: A few residential houses situated along some busy roads as well as quiet roads (low noise sites) were chosen randomly at each survey areas of Calabar, Uyo, Umuahia, Owerri and Port Harcourt cities. With the help of a precision sound level meter (SLM) set at A-weighted response, noise levels were taken in some bedrooms/sitting rooms of each of the houses chosen. Five (5) to ten (10) houses were randomly chosen as representative measurement sites from high and low noise sites of each survey city respectively. These bedroom/sitting room noise levels recorded were the indoor A-weighted sound exposure levels (L_{AE}) values in Eqn. 1. When individual L_{AE} value was applied in Eqn. 1, corresponding %Aw value was generated, which made plotting of Figs. 1-5 possible. %Aw is a function of L_{AE}, the higher the L_{AE} value, the more the %Aw value.

Nigerian roads are characterized by heavy vehicular traffic with dense traffic composition (mix) such as trucks/trailers, buses, cars and motorbikes/motor-tricycles. These noise sources are serious threat to health and welfare of city dwellers. They cause serious annoyance, sleeplessness, hearing impairment, discomfort, cardiovascular disorders and other health threatening abnormalities in Nigeria. In daytime and nighttime periods Nigerian cities bubble with commercial, industrial and other socio-economic activities, especially at high noise zones, and city dwellers whose residential quarters are with little or no adequate sound insulation tend to suffer noise-induced health problems and degradation. People find it difficult to sleep even at night at high noise sites and have after-effects in the daytime. Reckless driving and use of horns/sirens and high speeds by some motor vehicle drivers do not help matters. L_{Deaf} is expressed as SPL-14.5 dB(A) where SPL = A-weighted sound pressure level (in dB(A)). L_{Deaf} gives an idea of how deafening a sound is to the human ear [20]. SPL is sound level directly taken from the scale of SLM during noise events.

3. RESULTS

Tables 1 and 2 and Figs. 1 – 5 are the results obtained in this study. Table 1 is the summary of road transportation mean sound pressure levels (SPLs) measured and corresponding deafening levels (L_{Deaf}) in dB(A) obtained inside sitting rooms/bedrooms of some respondents residing along high and low road traffic noise pollution sites in the cities under study. Table 2 shows daytime and nighttime degree of sleep disturbance at road transportation high noise pollution sites.

Table 1. Summary of road transportation mean sound pressure levels (SPLs) measured and corresponding Deafening levels (L_{Deaf}) in dB(A) obtained inside sitting rooms and bedrooms of some respondents residing along high and low road traffic noise pollution sites in the cities under study at an average road-building distance of between 15 m and 20 m

S/N	Cities	High road pollution sites				Low road pollution sites			
		Daytime		Nighttime		Daytime		Nighttime	
		SPL	L_{Deaf}	SPL	L_{Deaf}	SPL	L_{Deaf}	SPL	L_{Deaf}
1	Calabar	85.5-92.0	71.0-77.5	82.7-85.4	68.2-70.9	80.5-84.3	66.0-69.8	78.2-80.0	63.7-65.5
2	Uyo	82.9-96.5	68.4-82.0	80.2-88.0	65.7-73.5	76.6-80.1	62.1-65.6	75.6-78.2	61.1-63.7
3	Umuahia	80.4-92.6	65.9-78.1	78.3-84.5	63.8-70.0	75.4-80.2	60.9-65.7	70.3-76.5	55.8-62.0
4	Owerri	79.1-89.4	64.6-74.9	76.1-80.3	61.6-65.8	72.6-75.0	58.1-60.5	70.4-73.7	55.9-59.2
5	Port Harcourt	92.6-99.0	78.1-84.5	86.5-89.2	72.0-74.7	84.4-86.7	69.9-72.2	78.6-82.3	64.1-67.8

Table 2. Daytime and nighttime degree of sleep disturbance at road transportation high noise pollution sites

S/No	Response ratings	Calabar (n = 486)		Uyo (n = 472)		Umuahia (n = 454)		Owerri (n = 464)		Port Harcourt (n = 461)	
		No. of response	%R	No. of response	%R	No. of response	%R	No. of response	%R	No. of response	%R
Daytime responses											
6	ESD	188	38.7	181	38.4	177	39.0	183	39.5	180	39.0
5	VSD	93	19.2	88	18.6	106	23.3	138	29.7	85	18.5
4	SD	74	15.2	73	15.5	73	16.1	59	12.3	76	16.5
3	MD	60	12.4	60	12.7	47	10.4	39	8.4	53	11.5
2	LD	41	8.4	41	8.7	32	7.0	26	5.6	41	8.9
1	ND	30	6.2	29	6.1	19	4.2	21	4.5	26	5.6
	Total	486	100.0	472	100.0	454	100.0	464	100.0	461	100.0
Nighttime responses											
6	ESD	210	43.3	203	43.0	187	41.1	192	41.4	196	42.5
5	VSD	142	29.2	123	26.1	123	27.4	137	29.6	132	28.7
4	SD	85	17.5	71	15.0	71	15.6	84	18.1	70	15.2
3	MD	28	5.7	44	9.3	45	9.9	35	7.5	37	8.1
2	LD	14	2.8	24	5.1	21	4.7	11	2.3	20	4.3
1	ND	7	1.5	7	1.5	6	1.3	5	1.1	6	1.2
	Total	486	100.0	472	100.0	454	100.0	464	100.0	461	100.0

ESD (Extremely severe disturbance); VSD (Very severe disturbance); SD (Severe disturbance); MD (Moderate disturbance); LD (Little disturbance); ND (No disturbance)

Table 3. Statistics of questionnaire distribution at study areas

S/N	Study areas	Number of questionnaires distributed		Valid responses		Percentage rate of valid responses (%)	
		$HNPS_S$	$LNPS_S$	$HNPS_S$	$LNPS_S$	$HNPS_S$	$LNPS_s$
1	Calabar	500	500	486	465	97.2	93.0
2	Uyo	500	500	472	480	94.4	96.0
3	Umuahia	500	500	454	478	90.8	95.6
4	Owerri	500	500	464	476	92.8	95.2
5	Port Harcourt	500	500	461	471	92.2	94.2
Total		2500	2500	2337	2370	93.5	94.8

Table 4. Codes, measurement sites and GPS readings for Calabar study area

Road transportation high noise pollution sites (HNPSs)			Road transportation low noise pollution sites (LNPSs)		
Codes	**Measurement sites**	**GPS**	**Codes**	**Measurement sites**	**GPS**
HCA 1	Mbukpa Road	$5^{o}10^{1}N,7^{o}05^{1}E$	LCA 1	New Airport Road	$5^{o}43^{1}N,7^{o}35^{1}E$
HCA 2	Mayne Avenue	$5^{o}15^{1}N,7^{o}45^{1}E$	LCA 2	Anantigha Road	$5^{o}40^{1}N,7^{o}48^{1}E$
HCA 3	Calabar Road	$6^{o}0^{1}N,7^{o}25^{1}E$	LCA 3	Edibe-Edibe Road	$5^{o}20^{1}N,7^{o}33^{1}E$
HCA 4	Mount Zion Road	$6^{o}17^{1}N,7^{o}30^{1}E$	LCA 4	Jebs Road	$6^{o}15^{1}N,7^{o}40^{1}E$
HCA 5	Ekpo Abasi Street	$6^{o}20^{1}N,7^{o}45^{1}E$	LCA 5	Iman Street	$6^{o}17^{1}N,8^{o}10^{1}E$
HCA 6	Etta Agbo Road	$5^{o}50^{1}N,7^{o}50^{1}E$	LCA 6	MCC Road	$5^{o}15^{1}N,7^{o}20^{1}E$
HCA 7	IBB Way	$5^{o}35^{1}N,7^{o}40^{1}E$	LCA 7	Otop Abasi Street	$5^{o}19^{1}N,7^{o}35^{1}E$
HCA 8	Atimbo Road	$6^{o}40^{1}N,7^{o}20^{1}E$	LCA 8	Atekong drive	$6^{o}20^{1}N,8^{o}15^{1}E$
HCA 9	Ndidem UsangIso Road	$6^{o}55^{1}N,7^{o}55^{1}E$	LCA 9	Diamond Hill	$6^{o}50^{1}N,8^{o}25^{1}E$
HCA 10	Murtala Mohammed Highway	$5^{o}18^{1}N,7^{o}50^{1}E$	LCA 10	Old Odukpani Road	$5^{o}55^{1}N,7^{o}19^{1}E$

Table 5. Codes, measurement sites and GPS readings for Uyo study area

Road transportation high noise pollution sites (HNPSs)			Road transportation low noise pollution sites (LNPSs)		
Codes	**Measurement sites**	**GPS**	**Codes**	**Measurement sites**	**GPS**
HUY 1	Ikpa Road	4º30^{1}N,7º35^{1}E	LUY 1	IBB Road	4º41^{1}N,7º40^{1}E
HUY 2	Ibom Plaza	4º45^{1}N,7º20^{1}E	LUY 2	Uruan Road	4º50^{1}N,7º36^{1}E
HUY 3	Oron Road	4º40^{1}N,7º40^{1}E	LUY 3	Nasarawa Road	4º51^{1}N,7º43^{1}E
HUY 4	UruaEkpa Road	5º15^{1}N,7º20^{1}E	LUY 4	Nkemba Street	4º45^{1}N,7º25^{1}E
HUY 5	Aka Road	4º50^{1}N,7º42^{1}E	LUY 5	Barracks Road	4º30^{1}N,8º05^{1}E
HUY 6	Ikot Ekpene Road	4º55^{1}N,7º36^{1}E	LUY 6	Iboko Street	5º15^{1}N,8º17^{1}E
HUY 7	Abak Way	5º06^{1}N,8º02^{1}E	LUY 7	Esuene Street	4º50^{1}N,7º40^{1}E
HUY 8	NwanaIba Road	5º15^{1}N,8º20^{1}E	LUY 8	Brook Street	5º09^{1}N,7º48^{1}E
HUY 9	Aka Etinan Road	4º45^{1}N,7º38^{1}E	LUY 9	Umoren Street	4º45^{1}N,7º51^{1}E
HUY 10	UkanaOffot Road	4º29^{1}N,7º47^{1}E	LUY 10	UdoUdoma Street	4º55^{1}N,7º36^{1}E

Table 6. Codes, measurement sites and GPS readings for Umuahia study area

Road transportation high noise pollution sites (HNPSs)			Road transportation low noise pollution sites (LNPSs)		
Codes	**Measurement sites**	**GPS**	**Codes**	**Measurement sites**	**GPS**
HUM 1	Umuwaya Road	5º20^{1}N, 7º15^{1}E	LUM 1	Niger Road	5º30^{1}N, 7º20^{1}E
HUM 2	Owerri Road	5º24^{1}N, 7º20^{1}E	LUM 2	Ibeku Road	5º20^{1}N, 7º25^{1}E
HUM 3	Aba Road	5º30^{1}N, 7º25^{1}E	LUM 3	Calabar Road	5º22^{1}N, 7º22^{1}E
HUM 4	Bende Road	5º28^{1}N, 7º21^{1}E	LUM 4	Warri Street	5º26^{1}N, 7º23^{1}E
HUM 5	Okwuro Road	5º26^{1}N, 7º20^{1}E	LUM 5	Kaduna Street	5º21^{1}N, 7º27^{1}E
HUM 6	Umuahia Road	5º31^{1}N, 7º30^{1}E	LUM 6	AkanuIbiam Road	5º23^{1}N, 7º24^{1}E
HUM 7	School Road	5º20^{1}N, 7º23^{1}E	LUM 7	Azikiwe Road	5º25^{1}N, 7º281E
HUM 8	Bank Road	5º22^{1}N, 7º25^{1}E	LUM 8	Afara Road	5º24^{1}N, 7º30^{1}E
HUM 9	Amakama Road	5º26^{1}N, 7º27^{1}E	LUM 9	Okigwe Road	5º31^{1}N, 7º21^{1}E
HUM 10	Uzuakoli Road	5º23^{1}N, 7º21^{1}E	LUM 10	Finbarrs Road	5º28^{1}N, 7º26^{1}E

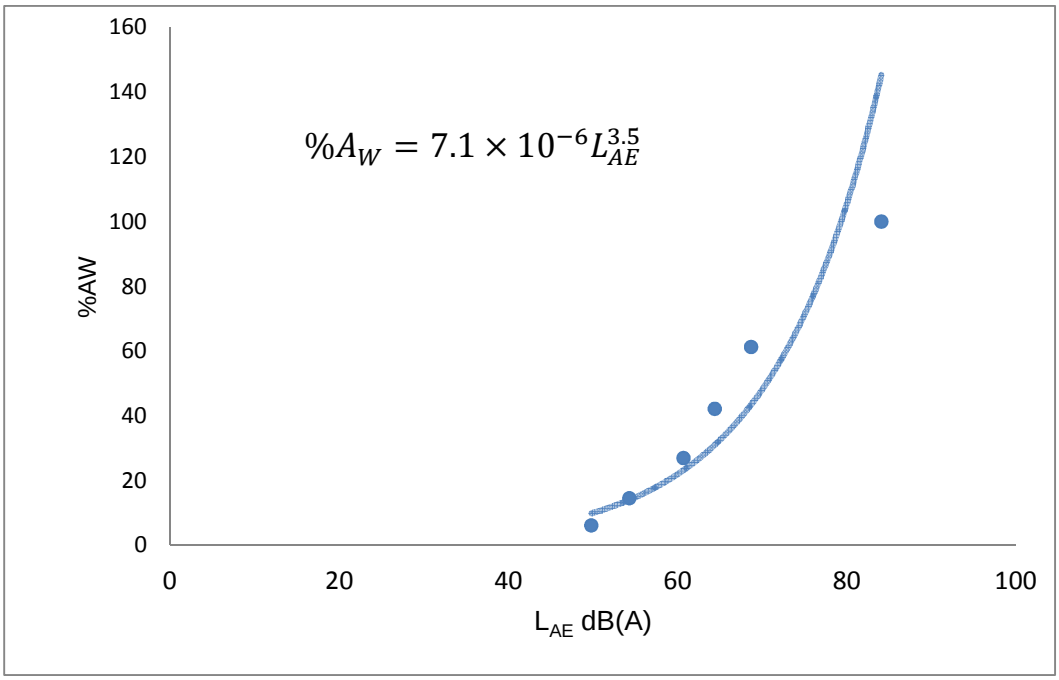
Table 7. Codes, measurement sites and GPS readings for Owerri study area

Road transportation high noise pollution sites. (HNPSs)			Road transportation low noise pollution sites. (LNPSs)		
Codes	**Measurement sites**	**GPS**	**Codes**	**Measurement sites**	**GPS**
HOW 1	Amajeke Road	$5^{o}35^{1}N$, $6^{o}55^{1}E$	LOW 1	School Road	$6^{o}21^{1}N$, $7^{o}50^{1}E$
HOW 2	MCC Road	$6^{o}20^{1}N$, $7^{o}15^{1}E$	LOW 2	World Bank Road	$6^{o}25^{1}N$, $6^{o}45^{1}E$
HOW 3	Douglas Road	$6^{o}15^{1}N$, $7^{o}20^{1}E$	LOW 3	Tetlow Road	$6^{o}51^{1}N$, $6^{o}55^{1}E$
HOW 4	Orlu Road	$5^{o}50^{1}N$, $6^{o}45^{1}E$	LOW 4	Royce Road	$7^{o}40^{1}N$, $6^{o}10^{1}E$
HOW 5	Imsu Road	$5^{o}40^{1}N$, $6^{o}30^{1}E$	LOW 5	West End Road	$7^{o}36^{1}N$, $6^{o}15^{1}E$
HOW 6	Fire Service Road	$5^{o}25^{1}N$, $6^{o}47^{1}E$	LOW 6	Ikenegbu Road	$6^{o}40^{1}N$, $6^{o}25^{1}E$
HOW 7	Mbaise Road	$6^{o}50^{1}N$, $7^{o}15^{1}E$	LOW 7	Prisons Road	$6^{o}50^{1}N$, $6^{o}36^{1}E$
HOW 8	Nekede Road	$7^{o}10^{1}N$, $7^{o}20^{1}E$	LOW 8	Asumpta Road	$6^{o}55^{1}N$, $6^{o}20^{1}E$
HOW 9	Wedtharl Road	$5^{o}25^{1}N$, $6^{o}50^{1}E$	LOW 9	Mbari Road	$7^{o}25^{1}N$, $7^{o}30^{1}E$
HOW 10	Okigwe Road	$6^{o}26^{1}N$, $7^{o}20^{1}E$	LOW 10	Lagos Street	$6^{o}45^{1}N$, $7^{o}05^{1}E$

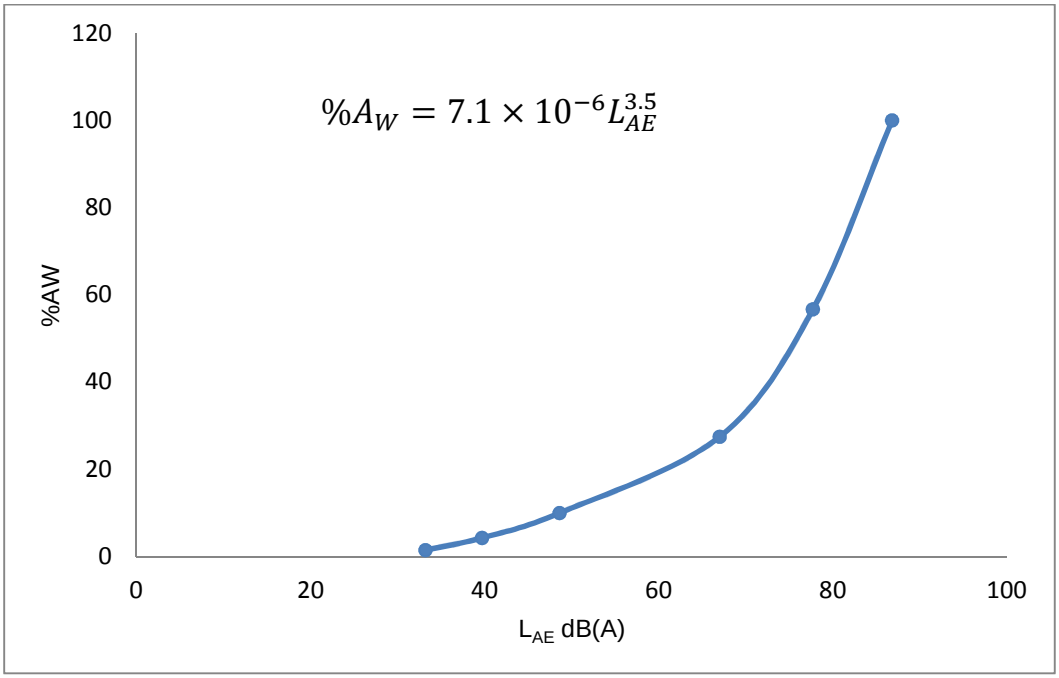
Table 8. Codes, measurement sites, and GPS readings for Port Harcourt study area

Road transportation high noise pollution sites. (HNPSs)			Road transportation low noise pollution sites. (LNPSs)		
Codes	**Measurement sites**	**GPS**	**Codes**	**Measurement sites**	**GPS**
HPH 1	Rumola Road	$4^{o}30^{1}N$, $6^{o}25^{1}E$	LPH 1	Agip Road	$4^{o}25^{1}N$, $6^{o}50^{1}E$
HPH 2	Choba Road	$4^{o}20^{1}N$, $6^{o}15^{1}E$	LPH 2	Shell Gate Road	$4^{o}30^{1}N$, $6^{o}45^{1}E$
HPH 3	NTA Road	$4^{o}25^{1}N$, $6^{o}20^{1}E$	LPH 3	Mile 1 Market Road	$4^{o}32^{1}N$, $6^{o}40^{1}E$
HPH 4	Atillery Road	$4^{o}15^{1}N$, $6^{o}21^{1}E$	LPH 4	Refinery Way	$4^{o}40^{1}N$, $6^{o}55^{1}E$
HPH 5	Rumokoro Road	$4^{o}35^{1}N$, $6^{o}40^{1}E$	LPH 5	Borokiri	$4^{o}45^{1}N$, $6^{o}36^{1}E$
HPH 6	Bori camp Road	$4^{o}40^{1}N$, $6^{o}50^{1}E$	LPH 6	Airport Road	$4^{o}35^{1}N$, $6^{o}30^{1}E$
HPH 7	Slaughter Road	$4^{o}25^{1}N$, $6^{o}30^{1}E$	LPH 7	Garrison Road	$4^{o}33^{1}N$, $6^{o}52^{1}E$
HPH 8	Eleme Road	$4^{o}20^{1}N$, $6^{o}26^{1}E$	LPH 8	Oroworoko Street	$4^{o}46^{1}N$, $6^{o}45^{1}E$
HPH 9	Water Line	$4^{o}50^{1}N$, $6^{o}45^{1}E$	LPH 9	Port Harcourt Road	$4^{o}55^{1}N$, $6^{o}25^{1}E$
HPH 10	Ada George Road	$4^{o}36^{1}N$, $6^{o}35^{1}E$	LPH 10	Bulletin Street	$4^{o}50^{1}N$, $6^{o}48^{1}E$

Figs. 1 – 5 show daytime and nighttime noise awakening reaction curves for road traffic high noise pollution sites in Calabar, Uyo, Umuahia, Owerri and Port Harcourt cities respectively, plotted using Microsoft excel software.

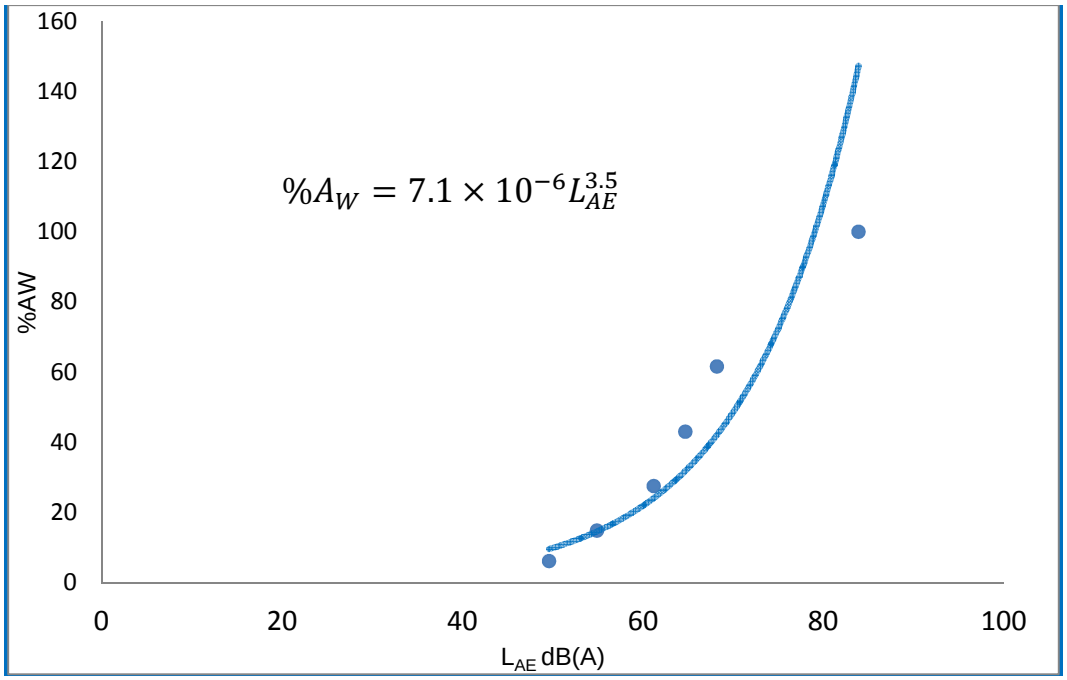


(a) (Daytime)

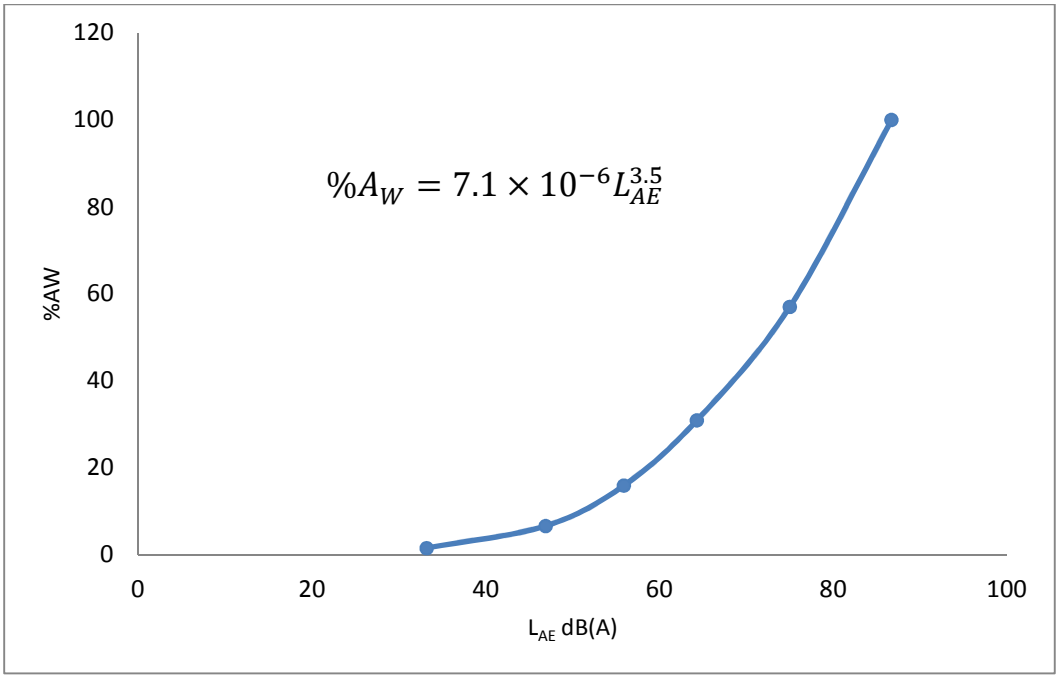


(b) (Nighttime)

Fig. 1. Daytime (a) and nighttime (b) awakening reaction curves for Calabar high road traffic noise pollution sites

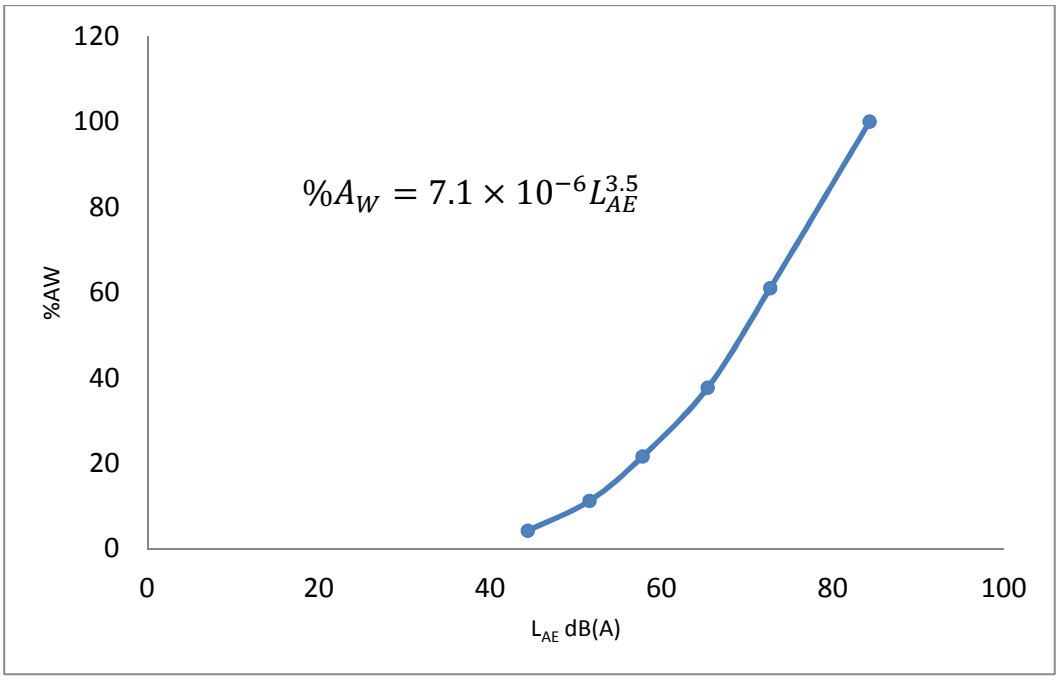


(a) (Daytime)

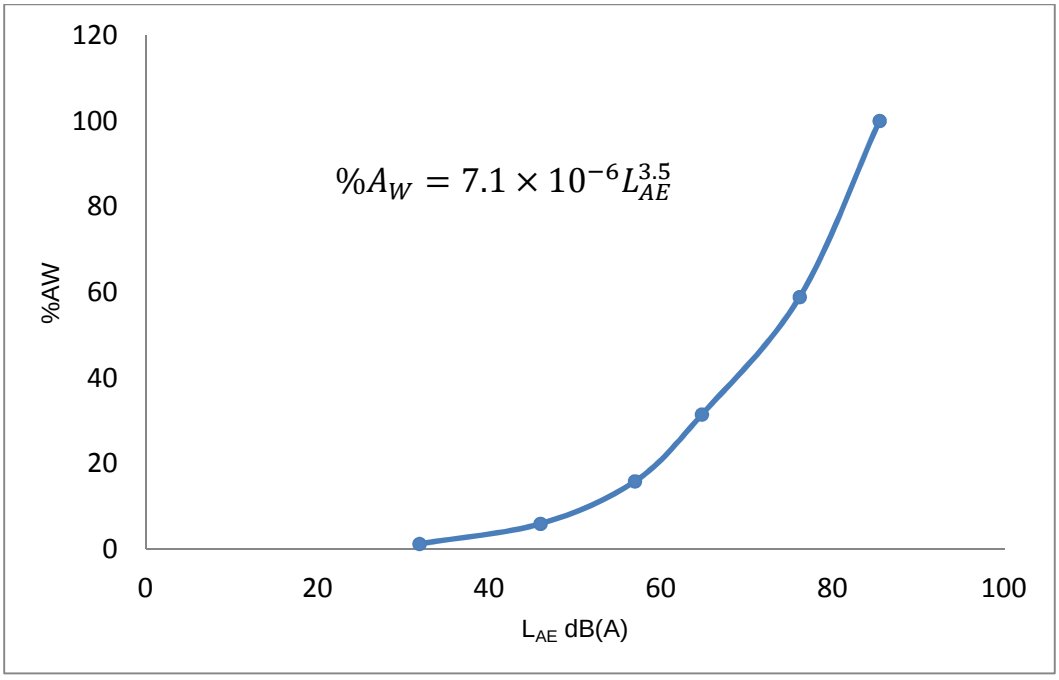


(b) (Nighttime)

Fig. 2. Daytime (a) and nighttime (b) awakening reaction curves or Uyo high road traffic noise pollution sites

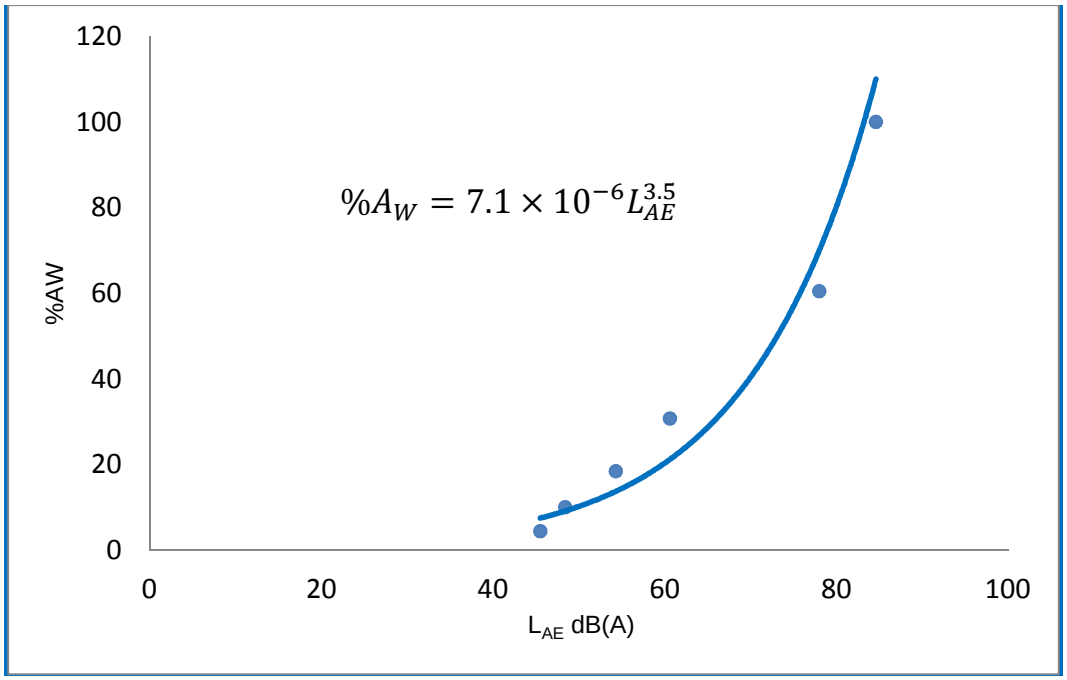


(a) (Daytime)

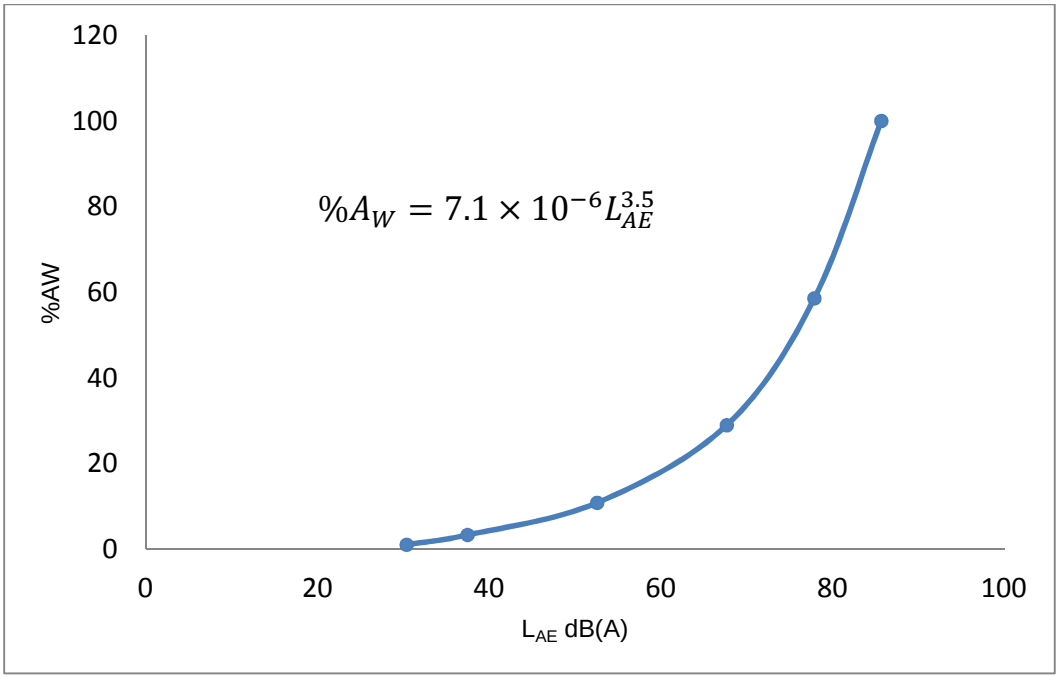


(b) (Nighttime)

Fig. 3. Daytime (a) and nighttime (b) awakening reaction curves for Umuahia high road traffic noise pollution sites

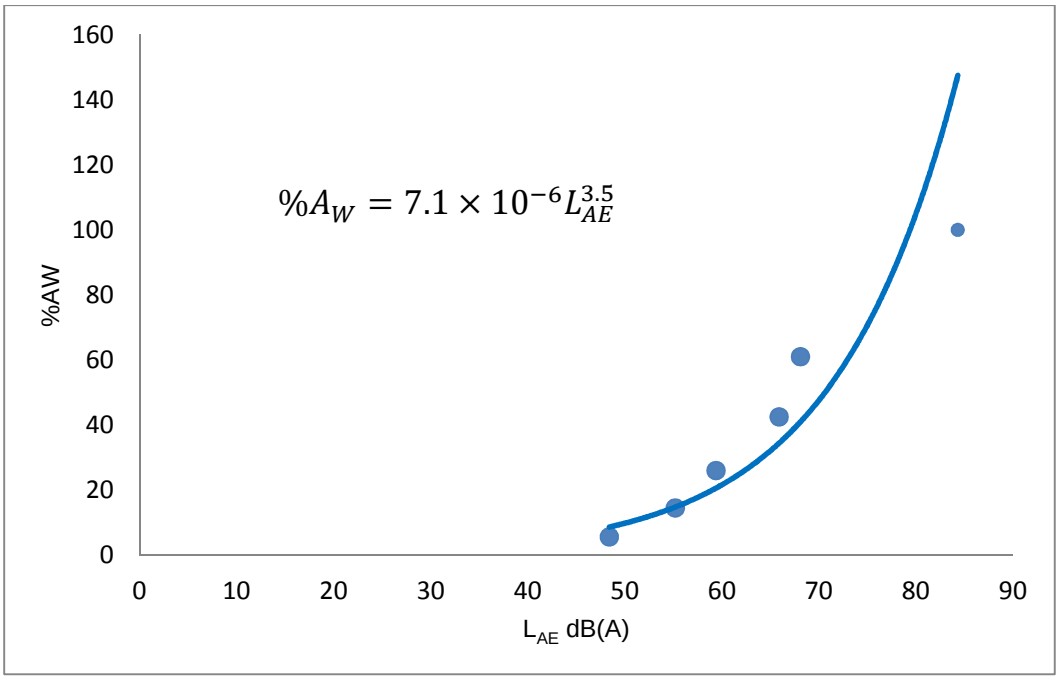


(a) (Daytime)

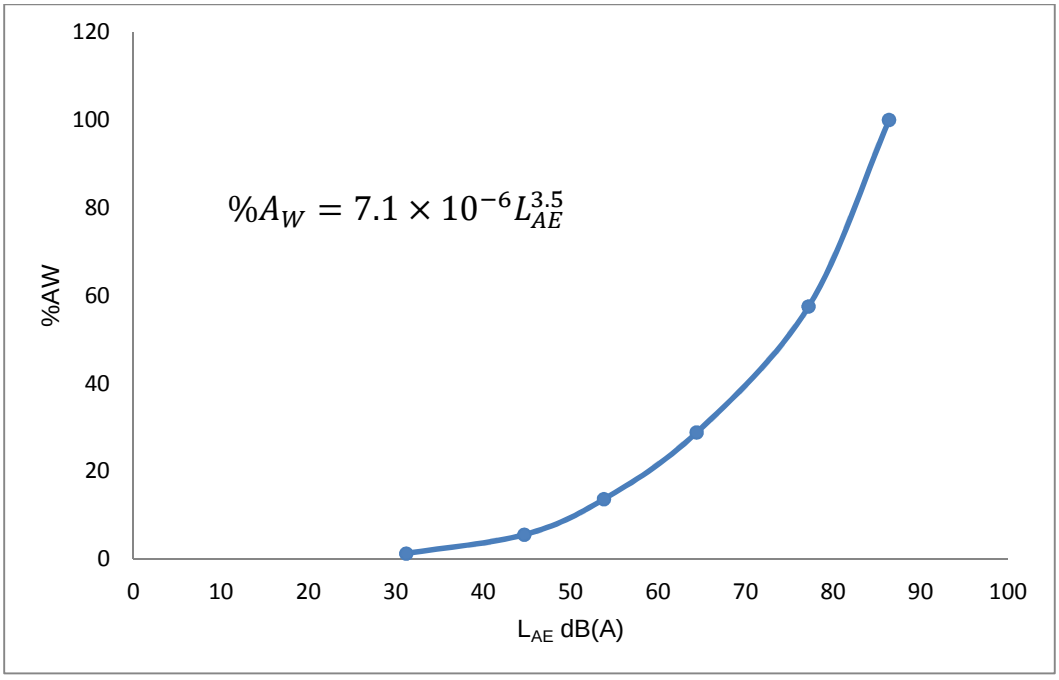


(b) (Nighttime)

Fig. 4. Daytime (a) and nighttime (b) awakening reaction curves for Owerri high road traffic noise pollution sites



(a) (Daytime)



(b) (Nighttime)

Fig. 5. Daytime (a) and nighttime (b) awakening reaction curves for Port Harcourt high road traffic noise pollution sites.

4. DISCUSSION

A closer look at Table 1 reveals that the mean sound pressure level (SPL) values measured are high and the deafening levels (L_{Deaf}) obtained exceeded the recommended value of 65dB(A) [20] for good hearing, sleep, resting/relaxation and comfort. A cursory look at Table 8 shows that there is sleep disturbances caused by excessive road traffic noise levels generated at road traffic high noise pollution sites in all the cities under survey. The percentage response (%R) of road traffic noise levels during daytime are found to be 93.8%, 93.9, 95.8, 95.5 and 94.4%, while %R at nighttime are 98.5%, 98.5, 98.7, 98.9 and 98.8%, in Calabar, Uyo, Umuahia, Owerri and Port Harcourt cities respectively.

Figs. 1 – 5 describe daytime and nighttime sleep disturbance logistic regression curves for road traffic high noise pollution sites in Calabar, Uyo, Umuahia, Owerri and Port Harcourt cities respectively. From the curves %AW is zero below indoor A-weighted noise exposure level (L_{AE}) of between 30 – 40 dB(A), and increases as L_{AE} increases. It is possible to predict from the curves the %AW of people awakened from night sleep based on the noise exposure levels, since %AW is a function of L_{AE} [3]. Given the same L_{AE} level it appears from the curves that the number of people awakened in the daytime is less than those awakened at night. The implication is that people react against high noise pollution at night more than in the daytime, since majority of the people expect noise free environment at night (when they need good sleep and more comfort) than in the daytime [3,5,11].

From the curves, people in the cities tend to have good sleep and comfort in the night than in the day as is expected. The number of people awakened in the day is higher than that in the night, given same noise level. A critical look at Table 1 show high noise data obtained. During daytime A-weighted sound pressure levels in the cities under survey range from 79.1 to 99.0 dB(A), while at night it was 64.6 to 85.4 dB(A), at high road pollution sites. Also deafening sound levels (L_{Deaf}) during daytime ranged from 64.6 to 84.5 dB(A), while at nights it was 61.6 to 74.7 dB(A), at high road pollution sites. Comparing these values with WHO guidelines values on sleep for both inside and outside bedrooms, we observe that most Nigerian city dwellers are really suffering from sleep disturbance, both daytime and nighttime. WHO guidelines values for sleep are as follows: Inside bedroom (indoors) sleep disturbance nighttime, 30 dB(A); Outside bedrooms (outdoors) sleep disturbance, daytime, 45 dB(A) [5]. The findings of this study appear to agree with earlier findings of other scientists in Nigeria [2,3,15] on this subject.

5. CONCLUSION

Road traffic noise problems in Nigerian cities arise as a result of characteristics of the cities; characteristics of road traffic (lack of traffic control); reckless behaviours of vehicle drivers (as they use horn/siren unprofessionally and drive with high speed); technical states of motor vehicles (ill-maintained motor vehicles cause intense noise); technical states of roads and road surfaces; and poor road planning/design. All these generate high traffic noise levels in Nigerian cities, including the cities under study. Efforts must be done to solve road traffic noise menace in our cities. Such efforts should include forbidding the use of horn/siren by law; limiting vehicle speed in residential areas; increasing awareness of city dwellers and vehicle drivers about health effect of high noise levels; design against road traffic noise; good planning of roads; periodical inspection for motor vehicle engine; vehicle parts and vehicle tyres; planting trees and grass in residential areas; making roads for big vehicles and buses far from residential areas; using traffic noise barriers; making good relationships between pedestrian and traffic; and setting noise level limits (in decibel) in our cities.It is shown in this study that Nigerian city dwellers suffer serious sleep disturbances due to road traffic noise, and therefore, there is a great need for these mitigatory measures to be implemented.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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