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Human Auditory Communication Disturbances Due To Road Traffic Noise Pollution in Calabar City, Nigeria

*E. O. Obisung, M. U. Onuu And A. I. Menkiti
Department Of Physics University Of Calabar, Nigeria.

ABSTRACT
Study on auditory communication disturbances due to road transportation noise in Calabar Urban City, Nigeria was carried out. Both subjective (psycho-social) and objective (acoustical) measurements were made for a period of twelve months. Questionnaire/interview schedules containing pertinent questions were administered randomly to 500 respondents of age 15 year and above, who were also with a good level of literacy skills (reading writing) and leaving in houses sited along or parallel to busy road, with heavy traffic volume for at least three (3) years. The questionnaires provided the psycho-social responses of respondents used in this study, their reactions to road traffic noise effect on communication activities (listening to radio, listening and watching television, verbal communication between individuals, speech communication and telephone/GSM communication). Acoustical measurements were made at the facades of respondents' houses facing the road using precision digital sound level meter, Bruel and Kjaer (B & K) type 732 following ISO standards 1996. The meter read the road traffic noise levels at measurement sites (facades of respondents' houses). From the results obtained in this study residents of Calabar City suffer serious communication interferences as a result of excessive road traffic noise levels. The noise indices used for this study were L_{Aeq} and L_{dn}. Noise levels obtained were over 93 dB(A) (daytime) and 60 dB(A), (nighttime) for L_{Aeq} and 80 dB(A) for L_{dn}. These far exceeded the recommended theoretical values of 45-55 and 70 dB(A), for $L_{Aeq}$and L_{dn} respectively. A-weighted sound pressure level (SPL_S) range between 87.0 and 100.0 dB(A). In this study it was also observed that over 98% of the respondents reported their television watching/radio listening disturbed, 99% recorded telephone/GSM disturbed, and 98% reported face-to-face verbal conversation disturbed, and 98% reported speech communication disturbed. The background noise levels (BNLs) of measurement sites range from 54.5 to 63.4 dB(A).It appears residents suffered from communication disturbances in the day time more than in the night time as the study revealed. The correlation coefficients between social responses and acoustical responses for television watching/radio listening, telephone/GSM conversation, face-to-face verbal conversation and speech communication disturbances were respectively +0.73, +0.67, + 0.66, and +0.69. In all, Calabar residents are seriously suffering from intense auditory communication interferences daily due to intense road transportation noise pollution.
Keywords: Auditory communication, road transportation noise, psycho-social measurements, acoustical measurements.

I. INTRODUCTION

Noise, generally as unwanted sound, can seriously damage physiological, psychological and sociological health of individual exposed to it. Noise pollution can cause serious communication disturbances, such as (speech communication, verbal face-to-face conversation, radio/television listening, and telephone/GSM communication interferences), sleep disturbance, annoyance, hearing impairment and other health problems, depending on the level of sound or how loud and persistent it is, and the health of the individuals exposed to the noise [1,2]. The dominant form of unwanted sound is from transportation sources principally, motor vehicles (motorcycles, cars, buses and trucks), as well as aircraft and train [1,3].

Road transportation noise is very disrupting in nature as it causes serious harmful health effect on human, increasing on daily basis [4,5,6]. Growing industrialization and urbanization of Calabar city have increased the number of motor vehicles in Calabar city, and the increase in traffic volume has had the effect of increasing road traffic noise levels proportionality [7,8]. Nearly all Calabar urban population is becoming increasingly exposed to road traffic noise, so that almost, no one seems to escape the scourge of intense community noise in this city. Several studies conducted on the impacts of road traffic noise on community residents revealed that over 75% of entire population of any city are subjected to annoying level of road transportation noise, and there is serious noise nuisance in most communities due to road traffic noise [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]

From studies so far conducted by other experts it is shown that communication interferences have been a major psycho-social problem caused by excessive traffic noise, that is, noise from motor vehicles, aircraft, and train [20, 21, 22, 23]. In this study the focus is on measurement of road traffic noise, analysis and interpretation of the social and acoustical data generated, comparison of the road traffic noise levels obtained with the permissible, standard noise levels, investigation and assessment of the road traffic noise impact on the Calabar city residents in respect of their radio/television listening, telephone/GSM communication, speechconversation, and face-to-face verbal conversation between two individuals, and recommendation of some noise control strategies/methodologies as means of mitigating excessive road traffic noise and improving acoustic health of Calabar urban population.

II. DESCRIPTION OF STUDY AREA

Calabar is the capital city of Cross River State, one of the 36 states of Nigeria. It is located between longitude 7° N and 4°N and latitudes 5° 15' E and 90° 30'E. The population of the city by 1991 National Census was over 320,000 people and by 2006 census was over 400,000 people. Calabar city is industrialized and urbanized, therefore, heavy environmental traffic congestion, unbearable environmental noise pollution are constant features.

III. MATERIALS AND METHODS

3.1Materials and Methods for social data collection:

For social survey a well constructed questionnaire was administered. The questionnaire contained standard questions to help elicit appropriate information about respondents' reactions to road traffic noise effects on their communication activities. Questionnaire had two sections. A and B. Section A described some socio-demographic and economic information of respondents such as sex, marital status, age, educational level, occupationand income level.

In section B some direct pertinent questions on how road traffic noise affects respondents' communication activities were asked. Such questions as, does road traffic noise disturb your (i) listening to radio/television? (ii) Face-to-face verbal conversation? (iii) Speech communication? And (iv) telephone/GSM conversation? Respondents were asked to respond to these questions by YES or NO. If YES, they were asked to describe the extent of the noise disturbance (No disturbance, Little, Moderately Severe, Severe, Very Severe, Extremely Severe). The respondents were asked to describe Calabar city generally, in terms of road traffic noise pollution (nuisance). The options given were (Extremely Comfortable, Very Comfortable, Comfortable, Uncomfortable, Very Uncomfortable, or Extremely Uncomfortable). What time of the day does road traffic noise disturb your communication activities most?. The options given were (7am-10am, 10am-7pm, 7pm-10pm, 10pm-12 midnight, 12 midnight - 7am, or NO Disturbance).

The field surveys covered ten (10) measurement sites carefully chosen to represent the residential areas with high volume of road traffic in Calabar city. For easy reference the measurement sites were coded as follows:-Mbukpa Road/Chalmer street (C1); Mayne Avenue/Ekpo Abasi street (C2), Calabar Road/Barracks Road (C3), IBB Way/Atimbo Road (C4), Ibesikpo street/lman street (C5), Goldie street/Eta Agbor Road/Orok-orok street (C6), Eyo Ita street/Edibe Edibe-Road (C7), Murtala Mohammed Highway/MCC Road (C8), Effio-Ette junction Area (C9) and University of Calabar Area (C10).

The measurement sites were chosen in such a manner that none is near another, none is near industry, construction sites, market places, airports or any other major noise sources. This is to prevent noise from these sources interfering with road traffic noise under consideration. Only houses sited along or parallel to the road were used in this study. This is to have better correlation between social responses and acoustical measurements.

Ten (10) house-holds were randomly selected at each of the 10 measurement sites, giving a total of 100 house-holds used for this study. At each household 5 persons (including men, women and youths, boys/girls) were randomly chosen, giving a total of 500 respondents involved in the study. This constituted the sample size (n = 500) for this work.

Five hundred (500) copies of questionnaire were distributed with 50 copies distributed at each of the 10 measurement sites. A total of 486 valid copies were collected while 14 copies were invalid due to the following reasons.- three (3) copies were not returned, four (4) lacked complete desired data, one (1) copy was with incorrect/unwanted data, three (3) copies were returned blank, while three (3) were from respondents who did not live upto 3 years in the present location. As a whole, a percentage return rate of 97.2% was obtained with 95.8% for men, 98.4% for women and 98.0% for youth (boys/girls). This is considered very good for any social survey in Nigeria.

Questionnaires were randomly distributed to only those who have some level of literacy skills (reading and writing) from age 15 years and above, and who lived in their present residences for at least three years. This is a fairly long enough period for any sincere person to assess noise impact on his/her health and daily activities. Those who had no literacy skills were orally interviewed using same information items on the questionnaire. Table 8 shows questionnaire distribution patterns, while Table 9 shows distribution of respondents (sample) based on demographic variables (as sex, age, educational level, income level) to indicate how representative the sample is for general population.Measurement sites were classified into six categories of noiseexposure levels, >95, 85-95, 65-75, 55-65 and < 55 dB(A) with > 95 as most disturbed level and < 55 as least disturbed level. The criteria as summarized in table 11 and 12 were developed to ascertain noise risk area (NRA) in Calabar City for proper assessment of the degree of noise exposure in the city.

3.2 Materials/Methods for Acoustical Data Collection

Acoustical measurements were also made at the facades of respondents' house facing the road using a precision digital sound level meter, Bruel and Kjaer (B & K) type 732 following ISO standards (ISO 1996). The sound level meter was placed on a tripod stand away from the holder's body, and about 1.5 metre high from the ground to correspond to the ear position of an average person. Microphone of meter was pointed directly at the noise source, avoiding sound reflecting structures on the sound transmitting path. The meter was set at "fast" frequency response and at A-weighting network to approximate the time constant of human hearing. Sound levels from motocycles, cars, buses and trucks/trailers were taken individually as they passed and recorded in data sheets.

The measurement points were a distance of 10-15 metres from the road centerline and 2-3 metres from the house of respondents following ISO standards (ISO, 1996). The ground cover at every measurement site was sand.

The number of motor vehicles (and their composition) that passed in front of respondents' houses was counted and recorded at each of these measurement sites throughout the measurement period into data sheets. Sound levels were measured at each measurement site every 15 minutes (sampling time) as motor vehicle passed the measurement points for period of about 24hours covering morning, evening and night time. Stopwatch/stop clock was used to measure the sampling time while measuring tape was used to measure distances stated above.From the noise data obtained it was possible to compute for day-night A-weighted noise level L_{dn} or L_{Aeq} 24 hrs).

Background noise levels (BNLs) and A-weighted sound pressure levels (SPLs) were measured and recorded at each measurement site to establish correlation between acoustical and noise response data following standard statistical procedure and using standard correlation coefficient formula. BNLs and SPLs were measured -[1] directly from sound level meter.

Acoustical measurements were made about twelve (12) months during working days at morning, afternoon and night time. Five (5) persons (enumerators) were involved in the field measurements.

IV. ANALYSIS AND EVALUATING OF RESULTS

4.1 Acoustical Analysis:

To analyze and evaluate results of this study the following noise rating descriptor's/indices were used.

Energy mean A-weighted noise exposure level (LAeq): LAeq is generally given as shown in Eqns 1, 2 and 3

$$L_{Aeq}, THe\ LAeq1Hr = 10LOg_{10} \sum_{i=1}^{n} fi \times 10^{\left(Li/_{10}\right)} dB(A)$$

(1)

$$L_{Aeq}, 15hr = L_d = 10LOg_{10} \left[\frac{1}{15} \sum_{i=1}^{n} fi \times 10^{\left(Li/_{10}\right)}\right] dB(A)$$

(2)

$$L_{Aeq}, 9hr = L_n = 10LOg_{10} \left[\frac{1}{9} \sum_{i=1}^{n} fi \times 10^{\left(Li/_{10}\right)}\right] dB(A)$$

(3)

where: L_i = Band pressure level (SPL)

f_i = Fraction of observation time that L_i is present

L_d = 15 hours L_{Aeq} for daytime (7am - 10pm)

L_n = 9 hour L_{aeq} for nighttime (10pm - 7am)

Energy Mean A-weighted noise exposure level ($L_{A(SE)}$ specifically for road surface vehicles (motorcycles, cars, buses, trucks) is expressed as shown in Eqn 4.

$$L_{A(SE)} = 39 + 10 \log_{10} Q + 22 \log_{10} \left(\frac{V}{88}\right) dB(A) \qquad (4)$$

Q =Traffic volume (number of vehicles per hour) during recording time

V =Average speed of vehicle (km/hr). In this work V= 65km/hr because this falls within the a llowed speed limit in Calabar City.

This noise measure is specifically used for road transportation noise analysis where traffic density, composition of traffic (motorcycles, cars, buses, trucks) and road geometry (nature of road) are considered altogether (24).

Day-Night A-weighted sound level (L_{dn}): L_{dn} is expressed as in Eqns 5 and 6

$$L_{dn} = 10Log_{10}\left[\frac{1}{24}\sum_{i=1}^{n} fi \times 10^{(Li/10)}\right] dB(A) \qquad (5)$$

L_{dn} = L_{Aeq}, 15hr + L_{Aeq}, 9hr- 10 dB (A) (6)

L_{dn}<70dB(A), and L_{eq}< 45dB(A) are acceptable for normal verbal conversation, listening to radio, watching television, telephone conversation, speech communication, sleep, rest/relaxation, and so cause annoyance, or any health effects (e.g. hearing impairment) and complaints in residential communities (7, 25, 26, 27, 28, 29, 30).

4.2 Social data analysis

The correlation between the acoustical data and social reaction data was expressed in Eqn 7 [31]

$$r = \frac{(N\sum xy)-\sum x)(\sum y)}{\sqrt{[N(\sum x^2)-(\sum x)^2[(N\sum y^2)-(\sum y^2)]}} \qquad (7)$$

Where x = Noise levels (sound pressure levels (SPL,) in decibel) obtained at measurement sites using sound level meter (acoustical data).
y= Respondents' reactions on communication disturbance obtained at measurement sites using questionnaires (social reaction data)
r =Pearson product moment correlation coefficient

V. RESULTS AND DISCUSSION

The results of this work are presented in Tables 1 to 12 and Figures1 inclusive. In Table 1, respondents' reactions to what source of noise disturbs communication (verbal conversation, listening to radio and watching television, speech communication, and telephone/GSM conversation) most, 26.1% of the respondents reported road traffic noise source (motor vehicles) as the most disturbing source, followed by aircraft, 18.3%, and diesel (electric) generators with 13.2%. Percentage most disturbed persons for road traffic noise source is higher than the one for aircraft in this study because the measurement sites chosen for this study were carefully selected in such a way that they were not directly under the aircraft flying path in order not to unduly influence the road traffic noise levels obtained at these sites. Field studies carried out by other researchers [32] contrary to the above results, reported that at a given exposure level aircraft noise causes a higher disturbing effect than road vehicle noise. Table 2 shows respondents' reactions on the time of the day that road traffic noise disturbs communication activities most in Calabar city. From the table we can observe that 40.7% of the respondents had their communication activities disturbed most between 10am and 7pm, followed by 22.5% between 7pm and 10pm, and 18.7% between 10pm and 12 midnight period. This implies that between 7am and 10pm (daytime period) road traffic noise levels were very high, over 74% of respondents had their communication activities seriously disturbed during the day time period, while over 25% of the respondents had their communication disturbed during night time in Calabar city. It could be shown that these results may be attributed to a reasonably high level of urbanization and industrialization of this city which brings about heavy traffic density (volume) especially during daytime period. Table 3 shows the summary of the statistics of the types and number of vehicles recorded for one hour at each measurement site and calculated noise levels. In table 3, it is observed that the values of L_{Aeq} and L_{dn} recorded far exceeded the recommended theoretical values at almost all the measurement sites, the various values of the noise indices where generated using their respective equations contained in this work. L_{Aeq}, 1hr ranged from 90.4 to 98.5 dB(A) and L_{dn} from 79.4 to 80.9 dB(A). Ld from 32.9 to 84.8; L_n from 75.0 to 79.6 dB(A) and $L_{A\ (SE)}$ from 85.7 to 89.2 dB(A) (daytime), 84.9 to 87.4 dB(A)(night time).Table 3 also shows that 20.3% of overall traffic volume recorded in all measurement site for the one hour recording period during daytime constituted heavy duty vehicles (trailers, tankers, trucks, etc), 25.5% for buses, 30.2% for cars, taxi cabs and private cars) and 24.0% for motorcycles/ tricycles. Also in table3 during night period 16.0%, 24.6%, 35.5% and 23.9% constitute heavies/trucks, buses, cars and motorcycles/ tricycles respectively. Table 4 shows statistics of respondents assessments of road traffic noise nuisance on their communication activities. In the daytime 44.3% reported that the city was uncomfortable for their communication efforts, while 9.6% assessed the city comfortable. In all, from table 4, 83% assessed the city not communication friendly in the daytime, while 61.5% assessed the city communication friendly in the .nighttime. This is because noise emitting events are much heavier in the daytime than in the nighttime in Calabar city as shown in Table 3. Tables 5-9 show acoustical and social response data obtained atmeasurement sites and calculated correlation coefficients. From the tables we observe that respondents' reactions to road transportation menace is high, about +0.73, +0.67, +0.66 and +0.69 on television/radio listening, telephone/GSM conversation, face-to-face verbal conversation between individuals, and speech communication disturbances respectively, indicating that respondents are not comfortable with the amount of noise they are exposed to.

Table 9 shows questionnaire distribution patterns at measurement sites, while table 10 (a-j) describes the respondents distribution based on ten (10) economic/demographic variables (sex, age, marital status, educational level, income level, occupation, occupational status, motor vehicle ownership, house ownership, duration of residence, respectively). Table 11 defines the noise risk area (NRA) criteria used for this study.

Table 12 shows summary of social (subjective) reactions of respondents to television/radio listening, telephone/GSM conversation, face-to-face verbal conversation between individuals, and speech communication disturbances as a function of various noise levels (L_{Aeq}, L_{dn}respectively. From the table, percentage EXTREMELY SEVERE DISTURBANCE (%ESD) reports of respondents on television watching/radio listening, telephone/GSM conversation, face-to-face verbal conversation between individuals, and speech communication were over 47%, 60%, 48% and 48% respectively, occurring at $L_{Aeq} \geq 95$ dB(A) and $L_{dn} \geq 85$ dB(A). The percent VERY SEVERE DISTURBANCE (%VSD) reports on the activities communication activities were over 29%, 20%, 20%, 29%, and 29% respectively, occurring at L_{Aeq}86-95 dB(A). and L_{dn} 76-85dB(A).The % SEVERE DISTURBANCE(%SD) reports on the activities were over 11%, 10%, 12% and 10% respectively, occurring at L_{Aeq}76-85 dB(A), and L_{dn} 66-75 dB(A). The % MODERATELY SEVERE DISTURBANCE (%MSD) reports over 6% in each case, respectivelyoccurring at L_{Aeq} 66- 75 dB(A). and Ldn 56-65dB(A)The % LITLE DISTURBANCE (%LD) reports on the communication activities above were over 3%, 1%, 2% and 3% respectively, occurring at L_{Aeq} 55-65 dB(A), L_{dn} 46-55 dB(A). Finally, the % NO DISTURBANCE (% ND) reports on the communication activities were ≤45 dB(A).

From this analysis we can quickly observe that over 98% of respondents reported their television watching/radio listening disturbed, 99% reported their telephone/GSM conversation disturbed, although in this case network problems may also contribute to the disturbance. About 99% reported their face-to-face verbal communication between individuals disturbed, while 98% reported their speech communication disturbed in varying degrees.

Fig. 1 shows the relationship between A-weighted noise exposure levels (L_{Aeq}) and road traffic volume. We can see from this curve that noise level increases as the traffic volume increases, implying that more noise damage or noise disturbance results. It is found that the more the traffic volume the more developed or industrialized or urbanized a city is likely to be [33]. Fig 1 also shows that the residents are disturbed more in the daytime than at night.

VI. CONCLUSION

The results so far obtained have shown that communication activities of people are seriously hampered by excessive road traffic noise in Calabar city as correlation between social and acoustical data on the four variables used in this study namely, telephone watching/radio listening, telephone/GSM conversation, face-to-face verbal conversation, and speech communication disturbances were +0.73, +0.67, +0.66 and +0.69 respectively. From these results we can observe that road transportation noise level is high, hence, the reaction of disapproval from the respondents. The effect is worst in the daytime than nighttime as shown in Fig. 1, since during this period of the day there was more heavy traffic congestion which causes the free use of horns and sirens by drivers, especially tanker, trailer and heavy duty vehicle drivers. Noise emitted by horns/sirens is more alarming and contribute very meaningfully to high road traffic noise levels in urban cities, which in turn adversely, affect auditory communication.

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Table 1: Respondents' reactions to what source of noise disturbs communication most

S/N	NOISE SOURCES	% REACTION
1.	Household appliances (e.g. television, radio, fan, airconditioner.	8.2
2.	Disco/cinema centres/hotels	1.6
3.	Neighbourhood	6.2
4.	Motor vehicles (e.g motorcycles, cars, buses, trucks)	26.1
5.	Aircraft	18.3
6.	Electric generators/plant	13.3
7.	Industrial machines	2.2
8.	People (ie. Adults, children in same compound)	7.6
9.	Playground	2.6
10.	Domestic animals/birds	3.7
11.	Market Place	0.6
12.	Church/Mosque	2.0
13.	Shopping centres/supermarkets	7.4

Table 2: Respondents' reactions on the time of the day road traffic noise disturbs communication activities most.

S/N	Time of the Day	% Reaction	
1.	7a.m-10a.m	11.5	
2.	10.am-7p.m	40.7	
3.	7.pm-10p.m	22.5	
4.	10p.m-12 midnight	18.7	
5.	12 midnight - 7a.m	6.6	

Table 3: Statistic of man measured and calculated road transportation noise level/indices obtained at high sound measurement aites in Calabar City and correspond ding mean road traffic volume per hour (VPH) during recording time taken at 15 meter distance from facades of respondents houses during daytime and nighttime periods.

sites	Measured noise level dB(A) BNL	SPL day	SPL night	Calculated noise levels dB(A) $L_{eq,1hr}$	$L_{eq,15hr}$ (Ld)	$L_{eq,24hr}$(Ldn)	$L_{eq,9hr}$(Ln)	L_A(SE) day	L_A(SE)night	Road Traffic Volume per hour (VPH) Day time: Truck/Lories	Buses	Cars	Motorcycles	Total Traffic Volume (V)	Road Traffic Volume night time (VPH): Truck/Lories	Buses	Cars	Motorcycles	Total Traffic Volume (V)	Grand Total Traffic Volume Daytime+night
CA1	48.0	90.0	86.0	90.4	84.2	80.5	78.6	85.7	86.1	327	289	417	38	1101	286	193	317	415	1211	2312
CA2	48.0	96.0	89.0	93.8	83.7	80.0	78.8	84.0	85.6	481	507	815	49	1852	150	275	283	361	1069	2921
CA3	41.0	87.0	82.0	93.2	82.9	79.4	78.8	89.2	84.9	416	503	613	32	1564	109	182	314	307	912	2476
CA4	45.0	94.0	90.0	93.5	83.1	79.7	78.1	86.8	85.4	249	476	588	59	1427	87	219	496	211	1013	2440
CA5	50.0	49.0	92.0	93.7	83.8	79.9	75.0	86.6	86.6313		393	601	56	1364	205	337	504	315	1361	2725
CA6	51.0	100.0	78.0	94.0	83.4	80.2	78.4	89.2	85.6489		610	829	41	1969	189	223	461	209	1082	3051
CA7	43.0	87.0	75.0	94.6	83.7	80.8	78.4	87.3	87.4391		533	565	102	1591	273	486	514	356	1629	3220
CA8	40.0	92.0	78.0	94.7	83.9	80.9	79.0	89.5	86.4	503	642	471	59	1675	197	318	472	291	1278	2953
CA9	41.0	97.0	81.0	93.7	83.9	79.7	76.8	86.4	87.0	367	470	386	73	1296	265	401	519	306	1491	2787
CA10	43.0	100.0	79.0	94.7	834.8	80.9	76.3	88.7	86.4	412	593	617	108	1730	214	396	502	197	1291	3021
									Total	3993	5017	5932	4727	19669	1975	3030	4382	2950	12337	27906
									%	20.3	255	30.2	34.0	100.0	16.0	24.6	35.5	23.9	100.0	100.0

Table 5a: Statistics of road traffic noise on television watching/radio listening disturbances at Calabar urban city, Nigeria

Sites	Noise rating (x) ESD (6)	VSD (5)	SD (4)	MD (3)	LD (2)	ND (1)	Respo-nse (n)	Weighted ratings (nx)	Mean weighted ratings $\left(\frac{nx}{n}\right)$
C1	19	15	8	4	2	0	48	237	4.94
C2	31	8	5	3	2	1	5047	260	5.20
C3	16	20	5	5	1	0	48	233	4.96
C4	21	16	6	4	1	0	50	244	5,08
C5	25	12	6	4	3	0	47	252	5.04
C6	25	1	5	3	2	1	48	239	5.09
C7	9	28	7	3	1	0	48	233	4.85
TOTAL	231	142	57	33	18	5	486	2464	50.68
%	47.53	29.22	11.73	6.79	3.71	1.02	100.00		

Table 5b: Correlation between acoustical data (x) and social reaction data (y) on television watching radio listening disturbances

Sites	X	Y	XY	X2	Y2	r
C1	90	4.94	444.60	9100	24.40	
C2	96	5.20	499.20	9216	27.04	
C3	87	4.96	431.52	7569	24.60	
C4	94	5.08	477.52	8836	25.81	
C5	99	5.04	498.96	9801	25.40	
C6	100	5.09	509.00	10,000	25.91	
C7	89	4.85	431.65	7921	23.52	+0.73
C8	92	5.08	467.36	8464	25.81	
C9	97	5.22	506.34	9409	27.25	
C10	100	5.22	522.00	10000	27.25	
TOTAL	944	50.68	4788.15	89316	256.99	

Table 6a: Statistics road transportation noise pollution telephone/GSM conversation disturbances at Calabar urban city, Nigeria

Sites	Noise rating (x)						Respons	Weighte ratings	Mean weighted ratings
	ESD (6)	VSD (5)	SD (4)	MD (3)	LD (2)	ND 0)	(n)	(nx)	$(^{nx}/_n)$
C1	22	15	6	4	1	0	48	245	5.10
C2	31	8	8	2	1	0	50	266	5.32
C3	22	18	4	3	0	0	47	247	5.26
C4	30	16	6	4	1	1	48	249	5.19
C5	25	12	8	3	2	0	50	255	5.10
C6	36	6	3	2	0	0	47	264	5.62
C7	21	16	5	4	1	1	48	241	5.02
C8	26	10	6	4	1	1	48	245	5.10
C9	38	4	4	2	2	0	50	274	5.48
C10	41	4	3	2	0	0	50	284	5.68
TOTA	292	99	53	30	9	3	486	2570	52.87
%	60.08	20.37	10.91	6.17	1.85	0.62	100.00		

Table 6b: Correlation between acoustical data (x) and social reaction data (y) on television /GSM conversation disturbances

Sites	X	Y	XY	X2	Y2	r
C1	90	5.10	459.00	8100	26.01	
C2	96	5.32	510.72	9216	28.30	
C3	87	5.26	457.62	7569	27.67	
C4	94	5.19	487.86	8836	26.94	
C5	99	5.10	504.90	9801	26.01	+0.67
C6	100	5.62	562.00	10000	31.56	
C7	89	5.02	446.78	7921	25.20	
C8	92	5.10	469.20	8464	26.01	
C9	97	5.48	531.56	9409	30.03	
C10	100	5.68	568.00	10,000	32.26	
TOTAL	944	52.87	4977.90	89316	280.02	

Table 7a: Statistics road transportation noise on face-to-face verbal communication disturbances at Calabar urban city, Nigeria.

Sites	Noise rating (x)						Response	Weighted ratings	Mean Weighted Ratings
	ESD (6)	VSD (5)	SD (4)	MD (3)	LD (2)	ND 0)	(n)	(nx)	$(^{nx}/_n)$
C1	18	16	10	3	1	0	48	239	4.98
C2	29	10	6	3	1	1	50	260	5.20
C3	20	18	5	3	1	0	47	241	5.13
C4	22	14	6	4	2	0	48	242	
C5	25	13	6	4	2	0	50	255	5.04
C6	27	13	4	2	1	0	47	251	5.38
C7	11	26	6	2	2	1	48	231	4.81
C8	23	16	5	2	1	1	48	247	5.15
C9	29	10	6	4	1	0	50	272	5.44
C10	32	8	5	3	1	1	50	264	5.28
TOTAL	236	144	59	30	13	4	486	2402	51.47
%	48.56	29.63	12.14	6.17	2.68	0.82	100.00		

Table 7b: Correlation between acoustical data (x) and social reaction data (y) on face-to-face conversation disturbances at Calabar urban city, Nigeria

SITES	X	Y	XY	X^2	Y^2	r
C1	90	4.98	448.20	8100	24.80	
C2	96	5.20	499.20	9216	27.04	
C3	87	5.13	446.31	7569	26.32	
C4	94	5.04	473.76	8836	25.40	
C5	99	5.10	504.90	9801	26.01	+0.66
C6	100	5.38	534.00	10,000	28.52	
C7	89	4.81	428.09	7921	23.14	
C8	92	5.15	473.80	8464	26.52	
C9	97	5.44	527.68	9409	29.59	
C10	100	5.28	528.00	10,000	27.88	
TOTAL	944	51.47	4863.94	89316	265.22	

Table 8a: Statistics road transportation noise on speechcommunication disturbances at Calabar urban city, Nigeria

Sites	Noise rating (x)						Response	Weighted ratings	Mean weighted ratings
	BSD (6)	VSD (5)	SD (4)	MD (3)	LD (2)	ND 0)	(n)	(nx)	$(^{nx}/_n)$ V /n>
C1	14	18	9	5	1	1	48	228	4.75
C2	34	6	4	3	2	1	50	264	5.23
C3	5	35	4	2	1	0	47	229	4.87
C4	27	12	6	3	0	0	48	255	5.31
C5	22	14	6	5	2	1	50	246	4.92
C6	28	9	4	3	2	1	47	243	5.17
C7	13	23	6	3	2	1	48	231	4.81
C8	22	18	5	2	1	0	48	250	5.21
C9	35	6	4	3	2	0	50	267	5.34
C10	37	4	3	3	2	1	50	268	5.36
TOTAL	237	145	51	32	15	6	486		51.02
%	48.77	29.84	10.49	6.58	3.09	1.23	100.00		

Table **8b: Correlation between acoustical data (x) and social reaction data (y) on speech communication disturbances at Calabar urban city, Nigeria**

Sites	X	Y	XY	X^2	Y^2	r
C1	90	4.75	427.50	8100	22.56	
C2	96	5.28	506.88	9216	27.88	
C3	87	4.87	423.69	7569	23.72	
C4	94	5.31	499.14	8836	28.20	
C5	99	4.92	487.08	9801	24.11	+0.69
C6	100	5.17	517.00	10000	26.73	
C7	89	4.81	428.09	7921	23.14	
C8	92	5.21	479.32	8464	27.14	
C9	97	5.34	517.98	9409	28.52	
C10	100	5.36	536.00	10000	28.73	
TOTAL 944		51.02	4822.68	89316	260.73	

Table 9: Questionnaire distribution patterns

	No. of questionnaire distributed	No. of valid questionnaires collected	Valid percentage return rate
C1	50	48	96.00
C2	50	50	100.00
C3	50	47	94.00
C4	50	48	96.00
C5	50	50	100.00
C6	50	47	94.00
C7	50	48	96.00
C8	50	48	96.00
C9	50	50	100.00
C10	50	50	100.00
TOTAL	500	486	
%	100.00	97.20	97.20

Table 10: Respondent distribution by socio-economic/demographic variables for Calabar high sound sites (HCA)

(a) Respondents' distribution by sex

Site	Male	Female	Total
HCA	27	21	48
HCA2	25	25	50
HCA3	24	23	47
HCA4	27	21	48
HCA5	22	28	50
HCA6	24	23	47
HCA7	21	22	48
HCA8	26	22	48
HCA9	26	24	50
HCA10	28	22	50
Total	250	236	468
%	51.4	48.6	100.0

(b) respondent' distribution by age

Site	A 15-19		B 20-29		C 30-39		D 40-49		E 50 & above		Total					Grand total
	M	F	M	F	M	F	M	F	M	F	15-19	20-29	30-39	40-49	50 +	
HCA1	7	5	6	5	6	8	5	2	3	1	12	11	14	7	4	48
HCA	8	5	8	8	5	6	3	4	1	2	13	16	11	7	3	50
HCA3	5	6	5	7	8	6	4	2	2	2	11	12	14	6	4	47
HCA4	4	6	10	6	8	4	3	2	2	3	10	16	12	5	5	48
HCA5	8	5	4	9	5	11	3	2	2	1	13	13	16	5	3	50
HCA6	4	4	6	8	7	7	4	2	3	2	8	14	14	6	5	47
HCA7	5	3	6	10	6	8	4	4	0	2	8	16	14	8	2	48
HCA8	5	6	8	6	9	5	1	3	3	2	11	14	14	4	5	48
HCA9	3	3	11	9	8	10	2	1	2	1	6	20	18	3	3	50
HCA10	4	3	9	6	12	8	2	2	1	3	7	15	20	4	4	50
Total	53	46	73	74	74	73	31	24	19	19	99	147	147	55	38	486
%	10.9	9.5	15.0	15.2	15.2	15.0	6.4	4.9	3.9	3.9	20.4	30.3	30.3	11.2	7.8	100.0

(c) Respondents'' distribution by marital status for Calabar High Sound Sites (HCA)

Sites	Single (SG)		Married (MA)		Divorced/ Separated (DS)		Totals			Grand Total
	M	F	M	F	M	F	SG	MA	SD	
HCA1	10	12	13	6	4	3	22	19	7	48
HCA2	13	20	12	4	0	1	33	16	1	50
HCA3	11	16	12	7	1	0	27	19	1	47
HCA4	16	8	10	10	1	3	24	20	4	48
HCA5	8	17	11	6	3	5	25	17	8	50
HCA6	12	6	12	13	0	4	18	25	4	47
HCA7	14	17	6	10	1	0	31	16	1	48
HCA8	10	9	16	10	0	3	19	26	3	48
HCA9	13	13	11	9	2	2	26	20	4	50
HCA10	12	9	15	10	1	3	21	25	4	50
Total	119	127	118	85	13	24	246	203	37	486
%	24.5	26.1	24.3	17.5	2.7	4.9	50.6	41.8	7.6	100.0

(d) Respondents distribution by educational level

SITES	Primary school (PS)		Secondary school (SS)		Tertiary school (TS)		Total			Grand total
	M	F	M	F	M	F	PS	SS	TS	
HCA1	6	5	9	7	12	9	11	16	21	48
HCA2	10	10	8	10	7	5	20	18	12	50
HCA3	6	7	10	9	8	7	13	19	15	47
HCA4	6	4	14	10	7	7	10	24	14	48
HCA5	10	12	9	11	3	5	22	20	8	50
HCA6	8	6	5	5	11	12	14	10	23	47
HCA7	6	12	12	13	3	2	18	25	5	48
HCA8	7	5	10	9	9	8	12	19	17	48
HCA9	10	6	6	8	10	10	16	14	20	50
HCA10	3	2	4	3	21	17	5	7	38	50
TOTAL	72	69	87	85	91	82	141	172	173	486
%	14.8	14.2	17.9	17.5	18.7	16.9	29.0	35.4	35.6	100.0

(e) Respondents distribution by income level

Site	High income (HI)		Medium income (MI)		Low income (LI)		Total			Grand total
	M	F	M	F	M	F	HI	MI	LI	
HCA1	9	7	5	3	13	11	16	8	24	48
HCA2	5	4	9	10	11	11	9	19	22	50
HCA3	10	8	7	6	7	9	18	13	16	47
HCA4	16	10	6	4	5	7	26	10	12	48
HCA5	6	8	12	13	4	7	14	25	11	50
HCA6	8	9	8	6	8	8	17	14	16	47
HCA7	5	8	3	5	13	14	13	8	27	48
HCA8	4	3	10	11	12	8	7	21	20	48
HCA9	6	5	9	7	11	12	11	16	23	50
HCA10	11	8	7	10	10	4	19	17	14	50
	80	70	76	75	94	91	150	151	185	486
Total	16.5	14.4	15.6	15.4	19.3	18.7	30.8	31.1	38.1	100.00

(f.) Respondents' distribution by motor vehicle ownership

Site	Motor Vehicle		Non motor vehicle		Total		Grand Total
	M	F	M	F	Owners	Non-Owners	
HCA1	18	12	9	9	30	18	48
HCA2	15	18	10	7	33	17	50
HCA3	16	13	8	10	29	18	47
HCA4	17	10	10	11	27	21	48
HCA5	14	22	8	6	36	14	50
HCA6	18	10	6	13	28	19	47
HCA7	15	10	6	17	25	23	48
HCA8	19	16	7	6	35	13	48
HCA9	20	14	6	10	34	16	50
HCA10	21	16	7	6	37	13	60
Total	173	141	77	95	314	172	486
%	35.6	29.0	15.8	19.6	64.6	354	100.00

(g)**Respondents' distribution by house ownership**

Site	Motor vehicle owners		Non motor vehicle owners		Total		Grand total
	M	F	M	F	Owners	Non-owners	
HCA1	4	6	23	15	10	38	48
HCA2	8	5	17	20	13	37	50
HCA3	3	5	21	18	8	39	47
HCA4	10	9	17	12	19	29	48
HCA5	6	8	16	20	14	36	50
HCA6	12	12	12	11	24	23	47
HCA7	7	10	14	17	17	31	48
HCA8	6	4	20	18	10	38	48
HCA9	9	11	17	13	20	30	50
HCA10	3	2	25	20	5	45	50
Total	68	72	182	164	140	346	486
%	14.0	14.8	37.4	33.8	28.8	71.2	100.0

(h) **Respondents distribution by occupational status**

	Junior worker (JW)		Senior worker (SW)		Top executive (TE)		Total			Grand total
	M	F	M	F	M	F	JW	SW	TE	
HCA1	11	8	9	6	7	7	19	15	14	48
HCA2	10	10	19	13	6	2	20	22	8	50
HCA3	16	12	6	5	2	3	18	14	5	47
HCA4	12	6	8	11	6	5	18	19	11	48
HCA5	11	14	7	9	4	5	25	16	9	50
HCA6	9	12	15	6	5	5	21	16	10	47
HCA7	7	5	10	17	4	5	12	27	9	48
HCA8	10	12	14	6	2	4	22	20	6	48
HCA9	14	9	11	8	1	7	23	19	8	50
HCA10	15	14	8	4	5	4	29	12	9	50
Total	115	102	92	88	42	47	210	180	89	486
%	23.7	21.0	18.9	18.1	8.6	9.7	44.7	37.0	78.3	100.0

(i) **Respondens' distribution by occupation**

12	A Civil servant		B Trader/business		C Artisan		D Student		E Jobless		Total					Grand total
	M	F	M	F	M	F	M	F	M	F	A	B	C	D	E	
HCA1	10	6	7	5	4	1	5	3	7	6	16	12	5	8	7	48
HCA	6	8	3	5	9	3	5	9	2	0	14	8	12	14	2	50
HCA3	4	6	8	5	5	2	3	6	4	6	10	13	7	9	8	47
HCA4	12	5	6	7	3	6	4	2	2	1	17	13	9	6	3	48
HCA5	3	10	4	6	7	1	5	6	3	5	13	10	8	11	8	50
HCA6	4	12	10	4	3	2	2	2	5	3	16	14	5	4	8	47
HCA7	6	9	7	4	2	3	4	3	2	3	15	16	5	7.	5	48
HCA8	5	6	11	4	3	1	3	6	4	5	11	15	4	9	9	48
HCA9	7	6	6	2	5	2	2	5	6	3	13	8	7	13	9	50
HCA10	12	5	4	6	3	2	6	8	3	1	17	10	5	14	4	50
Total	69	63	66	53	54	23	45	50	32	31	142	119	67	95	63	486
%	14.2	13.0	13.6	10.0	11.1	4.7	9.3	10.3	6.6	6.4	29.2	24.5	13.8	19.5	13.0	100.0

(j) **Respondents distribution by duration of residence at present location (in years)**

	A 3-9		B 10-15		C 16-19		D 20-		E 30-		F 40-		G 50+		Total							Grand Total
Site	M	F	M	F	M	F	M	F	M	F	M	F	M	F	A	B	C	D	E	F	G	
HCA1	10	6	6	6	4	2	4	2	2	1	1	2	0	2	16	12	6	6	3	3	2	48
HCA2	8	7	7	10	5	2	2	2	1	3	1	1	1	0	15	17	7	4	4	2	1	50
HCA3	6	4	5	7	3	5	4	3	3	2	2	0	1	2	10	12	8	7	5	2	7	47
HCA4	5	4	9	5	6	4	1	5	3	0	2	2	1	1	9	14	10	6	3	4	2	48
HCA5	4	7	5	5	6	10	6	2	0	2	0	2	1	0	11	10	16	8	2	2	1	50
HCA6	6	10	6	2	3	5	2	3	4	2	1	0	2	1	16	8	8	5	6	1	3	47
HCA7	3	6	8	5	4	7	4	6	1	1	1	1	0	1	9	13	11	10	2	2	1	48
HCA8	5	2	9	5	6	6	5	4	1	2	0	1	0	2	7	14	12	9	3	1	2	48
HCA9	8	6	6	4	4	5	3	5	2	1	1	1	2	2	14	10	9	8	3	2	4	50
HCA10	6	2	7	4	4	6	4	5	4	2	2	1	1	2	8	11	10	9	6	3	3	50
Total	61	54	68	53	45	52	35	37	21	16	10	11	10	13	115	121	97	72	37	22	22	486
%	12.6	11.1	14.0	10.9	9.3	10.7	7.2	7.6	4.3	3.3	2.1	2.3	2.1	2.7	23.7	24.9	20.0	14.8	7.6	4.5	4.5	100.0

Table 11: Noise Risk Area (NRA) criteria used for this study

Noise Levels dB(A) L_{eq}	L_{dn}	Respondents" Reactions Ratings description	Rating Codes Rating Code
≥95	≥ 85	Extremely sever	(ESD)
86-95	76-85	Very severe disturbance	(VSD)
76-85	66-75	Sever disturbance	(SD)
66-75	56-65	Moderately severe disturbance	(MSD)
56-65	45-55	Little disturbance	(LD)
≤ 55	≤ 45	No disturbance	(ND)

Table 12: Statistics of noise pollution disturbance to the communication activities and their corresponding sound pollution levels (in decibels, dB(A)) based on the sound pollution risk area criteria developed for this study

	Noisepollution disturbance of respondents' communication activities (in percentage, %)				Noise Levels (dB(A))		
	TV/radio disturbances reactions (%)	TV/GSM disturbance reactions	Verbal Communication disturbance reactions (%)	Speech Communication disturbance reactions (%)	L_{Aeq}	L_{dn}	Ratings Coded
	47.53	60.08	48.56	48.77	>95	> 85	ESD
	29.22	20.37	29.63	29.84	86-95	76-85	VSD
	11.73	10.91	12.14	10.49	76-85	66-75	SD
	6.79	6.17	6.17	6.58	66-85	56-65	MSD
	3.71	1.85	2.68	3.09	56-65	46-55	LD
	1.02	0.62	0.82	1.23	≤55	≤45	ND
Total	100.00	100.00	100.00	100.00			

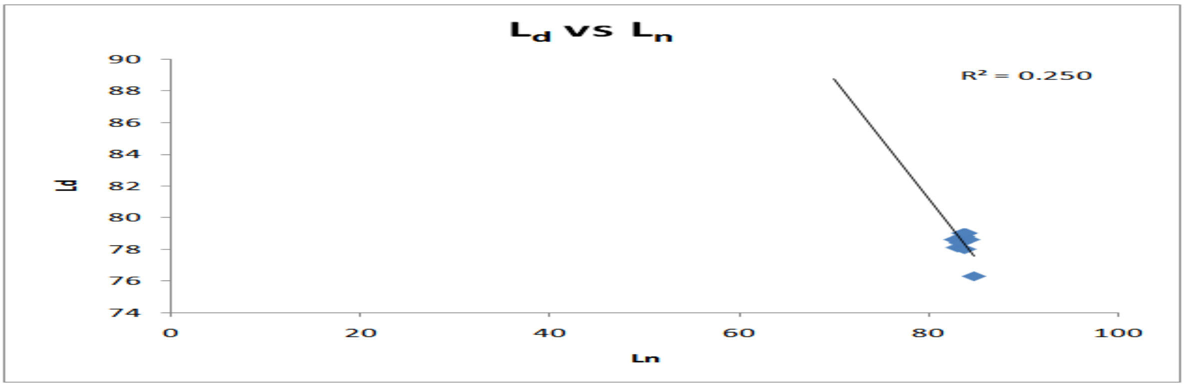

Fig.1: A graph of L_{Aeq}15hrs vs. $L_A$eq, 9hrs

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