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Assessment of Observed Building Structure Setback of Shops along an Arterial Road and Noise Intrusion Level

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ABSTRACT

Roads irrespective of the type have specific standard horizontal distance measured at 90 degrees from a lot boundary to a development known as a setback. Non-observance of the recommended setbacks accommodated in any urban center's master plan creates noise hazard to the public health and safety as the movement of vehicular traffic is not without the attendant noise. This study assessed noise intrusion level in shops along a section of Ibadan-Abeokuta road with due consideration to compliance with the recommended building structure setback. Analysis of noise descriptors evaluated in this study gave A-weighted equivalent sound pressure level average of 91.3 dBA, the daytime average sound level (L_D) 92.27 dBA, traffic noise index (TNI) 41.63 dBA, the noise pollution level (L_{NP}) 85.91 dBA and noise climate (NC) 5.38 dBA. Correlation analysis between the observed setbacks and the noise levels gave an "r" value of -.496 significant at $p < .05$. The paired t-test analysis showed a mean ± SD difference of 15.90 ± 7.08, and t-value of 32.99, corresponding to a two-tailed $p < .05$ with 215 degrees of freedom. This implies that there was a significant statistical difference between the noise levels measured at the observed and recommended setbacks

Keywords: setback, recommended, noise intrusion, traffic noise level.

1. INTRODUCTION

A comprehensive or master plan of any urban center or city covers areas such as land use, transportation routes, housing, conservation, and safety **, Izueke and Eme, 2013**. Studies have shown that transportation systems and land use are interdependent **, Ewing and Cervero, 2001; Polzin, 2004**. Each distinctively and significantly depicts the growth and development pattern of a particular locality noticeable in the increased presence of services and facilities like shops, schools, offices, banks, and leisure activities. The concentration of these activities attracts consumers and ancillary service providers. This, on its part, contributes to the commercial space demand along arterial roads **, Oni, 2009**. Violation of the urban planning concern, which is a creation of a conducive environment for different activities of man towards having a pleasant livelihood creates a hazard to the public health and safety such as noise.

The movement of vehicular traffic is not in the absence of the attendant noise, thus making urban settlements noise prone zones, especially places with major road networks **, Golmohammadi, 2007**. Roads could be classified as intra-city, inter-city, or international. While international and inter-city roads designed for traffic between neighborhoods, carrying large volumes of traffic between areas in urban centers with moderate or high-capacity that are below highway level of service are usually categorized as major or arterial roads, the routes within a city (intra-city roads) are classified as minor **, Oni, 2009**. Both the minor and major roads intersect and share contributory traffic and similar roadside activities from the local streets and commercial areas such as shopping centers, petrol stations, and other businesses. Besides, the major (arterial) roads connect the freeways and expressways with interchanges. Each type of road has a specific standard horizontal distance measured at 90 degrees from a lot boundary to a development known as a setback. The setbacks, mostly regarded as roadsides, among other features, often serve as utility corridors for underground and overhead wires and conduits. Also, they play a significant role in the road traffic noise intrusion reduction to the adjacent and parallel structures. Typically, non-strict adherence to the land use setback pathways or lack of proper setbacks causes traffic congestion with associated increased road traffic nuisance **, Serageldine, 1993; Joshua et al., 2016**.

The essential qualities of noise in the exposure areas include frequency, time distribution, sound pressure, and power. Expression of noise as being hazardous deals with a combination of frequency, noise intensity, and duration capable of causing permanent hearing loss. Noise-induced hearing loss typically involves the frequency range (pitch) from a noise source, e.g. human voice and thus interferes with spoken communications **, Nelson et al., 2005**. Globally, vehicular traffic noise has long been recognized as one of the primary sources of environmental noise pollution. Traffic noise is normally created by vehicle exhaust systems, engines, road-tyre contact, and aerodynamic effects of moving vehicles. Additional factors in the level of traffic noise are the number of traffic lanes, traffic flow, size or capacity of the vehicle, traffic volume, roadworthiness, and topography. In some way, pedestrian crossing, indiscriminate parking along the roadside, stopping and picking of passengers contribute to the traffic gridlock and as such increased vehicular traffic noise level. Road traffic noise has been recorded as a nuisance to residents and pedestrians near the major highways **, Nwaogazie and Ofem, 2014**.

The concern for noise effect is their interference with communication, concentration problems, fatigued stress, safety hazard, productivity and profitability, acoustic shock, and ototoxic chemicals. The adverse impact of traffic noise on human health as well as the environment is a critical issue facing city transport management services **, Gozalo et al., 2016; Tomić et al., 2016**. Series of research and development of traffic noise covers the intensity and exposure durations, the effects of noise on human health and comfort **,Ali and Tamura, 2003, Marius et al. 2005 and Georgiadou et al. 2004**. According to **, Oyedepo, 2013.** noise along main arteries in the cities reaches up to disturbing levels. In their study, **Anomohanran et al. 2008**revealed that the peak traffic noise level at a road junction could be as high as 100 dBA, which is capable of permanent hearing impairment. **Obisung et al. 2016.** considered residences sited along a busy road in Calabar City, Nigeria, and found daytime A-weighted equivalent sound pressure level (L_{Aeq}) to be over 93 dBA. Noise pollution from road traffic on residents in the Ikeja community,

Lagos, Nigeria revealed noise levels within the ranges of L_{Aeq} 69.5 – 87.3 dBA **, Oluwasegun et al., 2015**. Road traffic noise range assessed in a Bengaluru city was found to be 71.2 to 91 decibel **,Venkatappa and Shankar, 2012**. In a study, **Singhal, 2018.** considered the sound level from unmanned railway observed that noise level varies inversely in relation to distance. A significant noise level lessening pattern was detected by **, Moshtaghie, et al. 2018.** as a factor decreasing distance for the relationship between the amount of noise pollution and traffic rates in Khojir national park considered for installing the national park fence. Most of these traffic noise levels studies focused on intrusion to the residential areas where the commercials areas were considered, all the sources of noise were factored in the assessment with no specific consideration to the recommended setback compliance effect. This study assessed the various setbacks observed by the shop buildings along a section of Ibadan-Abeokuta road and noise intrusion level.

2. MATERIALS AND METHODS
2.1 Site Selection and Study Area

This research was carried out along a section of Ibadan-Abeokuta road. Nine different locations along the road were selected as the study sites viz; Camp, Eleweran, Aregbe, Alogi, Fajol, MFM, Aladesanmi, Carwash, and Adatan, **Fig. 1**. The total distance covered in the study area (Camp junction – Adatan round-about) was 8.36 km. At each of these sites, eight shops were randomly selected. The shop owners/operators were contacted for permission to take their shops as the measurement points. The considered section of the road has a total of a number of 45 currently operational minor roads adjoining to the arterial road between the starting (Camp junction) and the endpoint (Adatan round-about). This necessitated a preliminary survey at each of 9 site locations along the arterial road. This helped to choose a measurement interval that accommodated a good representation of each type of vehicles (motorcycle, tricycle, cars, minibus, bus, and truck) in the traffic flow volume.

2.2 Inclusion/Exclusion Criteria

The inclusion criterion was all the shops along the arterial road with exceptions to shops where the nature of the job functions is noise prone, e.g. radio player, television, electric generator noise, etc. This was to avoid an aggregate of shop operators' induced noise and traffic noise intrusion. Deliberate turn down of the shop owners or operators to the request to consider their shop as a measurement point was also part of the exclusion criteria.

2.3 Instrumentation

The instrumentation for this study was a sound level meter (Benetech GM1352) with an accuracy of ±1.5 dB, frequency response and measuring level ranges of 31.5 Hz – 8 kHz and 30 – 130 dBA respectively. The sound level meter was by making internal sound level calibrated. Digital professional handheld LCD stopwatch was used for timing of the measurement intervals. The observed and recommended road setbacks of the shops along the arterial road at the considered site locations were measured using 50 feet tape.
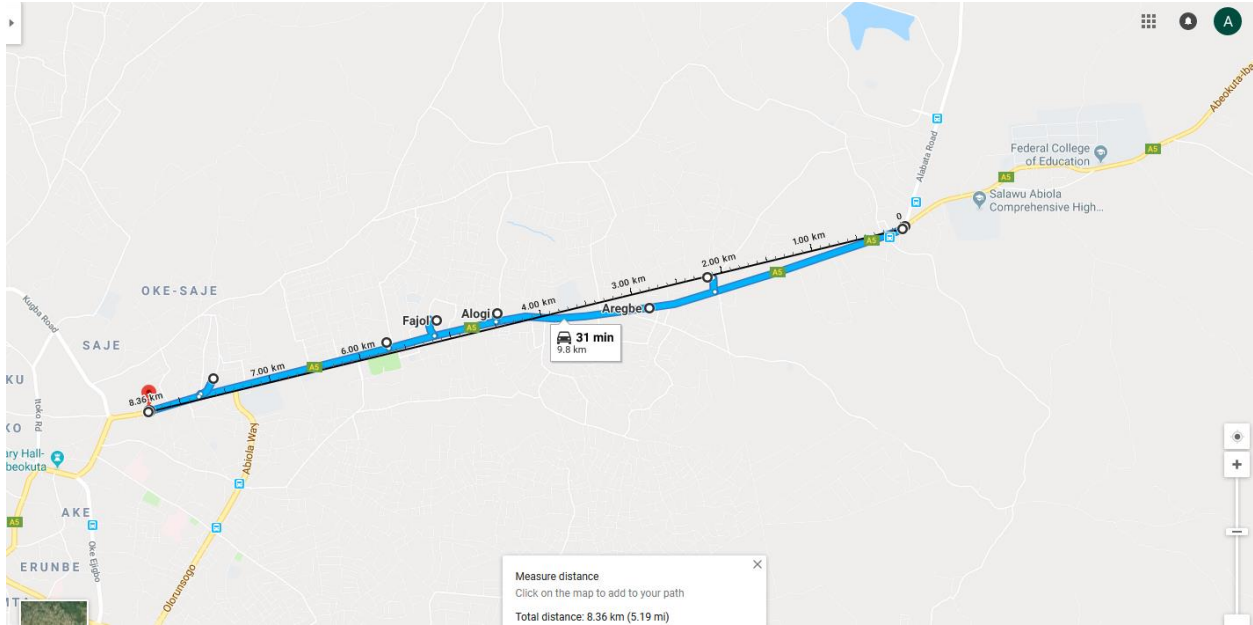
Figure 1. Site locations in the study area.

2.4 Data Collection

The noise level was taken at the observed road-shops setbacks at an average height of about 1.5 meters corresponding to the average ear level of a seated adult **,Obisung et al., 2016**. The measurements were taken and recorded five times at the intervals of 2 minutes at each of the eight selected shops in the site locations in the study area with the use of a stopwatch giving 10 minutes reading per study point (shop). The measurements were recorded at three-time intervals 7:00 – 8:45 am, 1:00 – 2:45 pm, and 7:00 – 8:45 pm. This same process was repeated at three different points for each of them for the recommended building structure setback of 30 m **EKSG, 2011 cited in Ojo-Fajuru and Adebayo, 2018**.

2.5 Analysis of Data

The noise descriptors were evaluated in the form of A-weighted equivalent sound pressure level (L_{Aeq}), the daytime average sound level (L_D), traffic noise index (TNI), the noise pollution level (L_{NP}), the noise level exceeded 10% of the time (L_{10}) the noise level exceeded 50% of the time (L_{50}), and the noise level exceeded 90% of the time (L_{90}). The relations for the computation were computed using the following expressions

$$L_{Aeq} = L_{50} + \frac{\left[\left(L_{10} - L_{90}\right)^2\right]}{60} \tag{1}$$

$$L_{NP} = L_{50} + \left[\frac{\left(L_{10} - L_{90}\right)^2}{60}\right] + \left(L_{10} - L_{90}\right) \tag{2}$$

$$NC = \left(L_{10} - L_{90}\right) \tag{3}$$

$$L_D = 10 Log\left[\frac{1}{2}\left(\frac{antilog\ L_{AeqM}}{10} + \frac{antilog\ L_{AeqA}}{10}\right)\right] \tag{4}$$

$$TNI = 4(L_{10} - L_{90}) + (L_{90} - 30) \qquad (5)$$

The descriptive statistical analysis was performed on the obtained data using the SPSS 16.0 statistical package. Pearson correlation was used to determine a relationship between setback and intrusion noise level at the shops along the arterial road at alpha level 0.05 or 95% confidence level. The paired samples t-test in the package was used to test the differences between noise levels at the observed and recommended setback points at the nine site locations. Tables were used to illustrate the result.

3. RESULTS AND DISCUSSIONS

The descriptive statistics of the noise descriptors from the survey showed that the traffic noise intrusion level to the shops along the major road was apparently high with A-weighted equivalent sound pressure level (L_{Aeq}) average of 91.3 dBA, the daytime average sound level (L_D) 92.27 dBA, traffic noise index (TNI) 41.63 dBA, the noise pollution level (L_{NP}) 85.91 dBA and noise climate (NC) 6.52 dBA. **, Kerketta et al 2011.** which recognized noise intrusion characteristics of road traffic, found that the noise levels at the commercial areas ranged from 58.33 - 78.65 dBA. In the present work, the noise levels at the assessed shops varied between 79.70 - 106.00 dBA. The obtained A-weighted equivalent sound pressure level range in this study is higher than the recommended 60 dBA for commercial areas. As well the L_{Aeq} range was beyond the commercial and traffic areas sound Level for critical health hearing impairment effect recommendation by WHO guideline for community noise. A similar observation was made by **, Onuu and Menkiti, 1993.** but with noise level ranges between 86–106 dBA in Aba and Uyo, Nigeria. In a study of **, Oyedepo and Saadu, 2010.** they also found high equivalent noise level at road junctions/busy roads to be 86 dBA, **Obisung et al., 2016.** also observed high road traffic noise pollution in Calabar City, Nigeria, with a value over 93 dBA daytime and a range between 87.0 and 100.0 dBA. This study characteristically confirmed **, Saadu et al., 1998.** and **, Garcia and Garrigues, 1998.** observations on high daytime noise levels exposure emanating from vehicular traffic at road junctions and major roads in the urban cities. The mean upper limit of the fluctuating noise (L_{10}) value obtained in this study (87.79 dBA) with a range of 74.60 - 100.30 dBA was found to be much higher when compared to the recommended noise level value (75 dBA) for land use description categories for developed areas by US Federal Highway Administration (FHWA), **Mansouri et al., 2006**. The background noise level (L_{90}) obtained in this showed a range of 80.80 - 109.70 dBA with a mean value of 93.17 dBA. The background noise level (L_{90}) obtained in this study is much higher than the background noise level (L_{90}) in commercial areas as a result of traffic noise by **, Oyedepo, 2012.** who observed 64 dBA. Contrarily to the high background noise obtained in this study, **Obisung et al., 2016** also observed 54.5 - 63.4 dBA background noise level.

Table 1. Descriptive statistics of the noise descriptors variables in the study area.

Evaluated noise descriptors	N	Minimum	Maximum	Mean	Std. Deviation
Observed setback	72	2.70	22.30	8.92	3.35
L_{Aeq}	216	79.70	106.00	91.3	5.59
L_{10}	216	80.80	109.70	93.17	4.74
L_{50}	216	78.60	102.90	90.50	5.09
L_{90}	216	74.60	100.30	87.79	6.23
L_{NP}	216	71.70	100.20	85.91	4.92

NC	216	0.00	20.00	5.38	4.32
TNI	216	5.30	70.20	41.63	14.07
L_D	216	82.40	104.70	92.27	5.07

The summary of the noise descriptors presented with respect to the measurement intervals (Morning, Afternoon and Evening) across the nine site locations showed that for all the measurement intervals the maximum noise descriptor recorded were at Alogi site location. As well it has the lowest observed setbacks among the site locations, **Table 2**. The high noise variation witnessed could be attributed to the traffic congestion and abuse of vehicle horns due to the relatively narrow setback in the location. The A-weighted maximum noise levels obtained in the 72 shops assessed in the nine study area exceeded the noise level standard of 60 and 55 dBA prescribed limits for the daytime by US EPA and WHO, **Chauhan et al., 2010**.

Table 2. Summary of results of the observed setbacks and noise descriptors of the study site locations.

Site locations	Measurement intervals	Distance (m)	L_{Aeq}	L_{10}	L_{50}	L_{90}	L_{NP}	NC	TNI	L_D
		Mean± SD	dBA	dBA	dBA	dBA	dBA	dBA	dBA	dBA
Camp	Morning	8.55 ± 1.04	92.55	94.25	92.13	89.96	88.26	4.29	47.10	93.01
	Afternoon	8.55 ± 1.04	92.41	94.33	91.66	88.96	87.05	5.36	42.88	93.01
	Evening	8.55 ± 1.04	91.59	93.00	91.29	89.53	88.11	3.48	49.10	93.01
Eleweran	Morning	9.61 ± 2.07	91.49	93.35	90.89	88.39	86.53	4.96	43.50	91.68
	Afternoon	9.61 ± 2.07	90.48	92.16	89.75	87.31	85.63	4.85	42.76	91.68
	Evening	9.61 ± 2.07	88.74	90.56	88.15	85.70	83.88	4.86	41.11	91.68
Aregbe	Morning	10.61 ± 2.67	88.51	90.19	87.85	85.45	83.78	4.74	41.24	90.94
	Afternoon	10.61 ± 2.67	85.30	83.40	91.44	88.39	-6.14	36.89	90.94	89.54
	Evening	10.61 ± 2.67	87.95	89.35	86.99	84.59	83.19	4.76	40.30	90.94
Alogi	Morning	4.36 ± 0.79	97.16	99.05	96.06	93.05	91.16	6.00	45.05	98.18
	Afternoon	4.36 ± 0.79	98.84	100.84	98.06	95.29	93.29	5.55	48.64	98.18
	Evening	4.36 ± 0.79	98.15	100.19	97.41	94.60	92.56	5.59	47.84	98.18
Fajol	Morning	11.88 ± 5.33	90.14	92.61	88.04	83.43	80.95	9.19	25.86	89.13
	Afternoon	11.88 ± 5.33	87.88	90.38	86.69	82.94	80.44	7.44	30.63	89.13
	Evening	11.88 ± 5.33	86.40	88.30	85.55	82.75	80.85	5.55	36.10	89.13
MFM	Morning	9.70 ± 4.70	89.95	91.29	89.61	87.86	86.53	3.43	47.59	90.75
	Afternoon	9.70 ± 4.70	90.41	92.46	89.59	86.68	84.63	5.79	39.31	90.75
	Evening	9.70 ± 4.70	91.60	93.63	90.66	87.66	85.64	5.96	39.78	90.75
Aledesanmi	Morning	9.88 ± 1.56	90.73	92.68	90.15	87.60	85.65	5.08	42.38	91.84
	Afternoon	9.88 ± 1.56	89.41	91.60	88.1	84.58	82.39	7.03	33.50	91.84
	Evening	9.88 ± 1.56	88.09	90.03	87.48	84.88	82.94	5.15	39.43	91.84
Carwash	Morning	8.16 ± 0.74	93.26	95.78	92.04	88.24	85.73	7.54	35.63	93.80
	Afternoon	8.16 ± 0.74	91.91	93.61	91.28	88.86	87.16	4.75	44.61	93.80
	Evening	8.16 ± 0.74	94.85	96.81	94.05	91.25	89.29	5.56	44.56	93.80
Adatan	Morning	7.56 ± 2.41	92.14	93.91	91.71	89.46	87.69	4.45	46.11	91.08
	Afternoon	7.56 ± 2.41	89.73	91.26	89.41	87.55	86.01	3.71	46.41	91.08
	Evening	7.56 ± 2.41	91.10	92.65	90.58	88.45	86.90	4.20	45.85	91.08

The relationship between the evaluated A-weighted traffic noise level and the numerically measured setback (distance) from which the noise level was measured using Pearson's correlation analysis between the observed setbacks and the noise levels gave an "*r*" value of -.496 which was a negative correlation significant at p < .05 (Table 3). This implies that the shorter the setback observed the higher the level of noise intrusion in the shops and vice versa. A similar observation was recorded in **,Singhal, 2018.** and **,Moshtaghie, et al., 2018**. This means that distance is significant importance in traffic noise attenuation when the source-receptor distance of considered. The paired sample *t*-test statistical procedure used to determine whether there is a mean difference between the two categories of noise level measurements at the observed and recommended setback distances showed that the mean difference of the noise intrusion levels between the two categories was 15.90, and the standard deviation (SD) was 7.08. The *t*-value was 32.99, corresponding to a two-tailed *p*-value of less than 0.00 based on a t-distribution with 215 degrees of freedom as in **Table 4**. Since the *p*-value is less than 0.05, the finding implied that there was a significant statistical difference between the noise levels measured at the observed and recommended setbacks in Nigeria. This result depicts that compliance with the recommended setbacks for the erection of building structures such as shops has a good effect on the noise intrusion level from the traffic and as such safe health of the shop operators.

Table 3.Correlations Analysis between the Land Surface and Ambient Temperatures.

			Observed setback	Noise levels
Observed setback	Pearson Correlation		1	-.496**
	Sig. (2-tailed)			.000
	N		192	192
Noise levels	Pearson Correlation		-.496**	1
	Sig. (2-tailed)		.000	
	N		192	192

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4. Paired samples t-test for noise level between observed and the recommended setback

Setbacks	N	Mean	Std. Deviation	Std. Error Mean	Mean difference ± SD	t	df	P-value (Sig. (2-tailed))
Observed setback	216	90.50	5.089	.35	15.90 ± 7.08	32.99	215	.00
Recommended setback	216	74.60	5.50	.37				

4. CONCLUSIONS

This study investigated road traffic noise intrusion level in shops along an arterial road in Nigeria as a function of adherence to the recommended building structure setback. Analysis of the noise descriptors apparently gave a high traffic noise intrusion level in the assessed shops. The implication of the observed shop structure setback distances on the noise intrusion level analyzed

using correlation analysis to measure of the strength and direction of the association that exists between two measured variables showed that noise level increased with the decreased setback. The paired-samples t-test used to compare the means between observed and recommended setback showed that there is a significant difference in both cases which warrant attention. This study, therefore, proposed public enlightenment to the health implication challenges of exposure to noise. As well it is recommended that government should see to the implementation of recommended road-building structure setback since it is a working traffic noise mitigation approach for the healthy commercial environment.

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