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Environmental Noise in Residential Environments: The Case for Quality of Life in Minna, Nigeria

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Abstract
Environmental noise pollution lowers the quality of life and is a public health concern in residential areas. In Minna, Nigeria, the effects of exposure to noise pollution on inhabitants' health and well-being were examined in this study. The indicated maximum limits for tolerable noise levels for quality of life in a home context were exceeded by the noise data measured using a sound level meter, a hand-held geographic positioning system, and a structured questionnaire (N = 880). The study recommended the design of noise-absorbing buildings, improved urban and infrastructure planning, and noise-regulating measures
for a considerable increase in the quality of life of people.

Keywords: Environmental noise; Public health; Quality life; Residential environment

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1.0 Introduction

Environmental noise continues to be a serious environmental issue that hurts millions of people's health and well-being worldwide. Noise pollution is defined as undesirable noise brought on by human activity (Jamalizadeh *et al.,* 2018), recognised as a serious public health concern and ranked as the third most dangerous form of pollution, after air and water pollution (WHO, 2005). Noise's physiological impact ultimately accounts for a sizable portion of the burden of disease that claims millions of lives each year. In Europe, 20% of the population—or more than 100 million people—are subjected to long-term noise levels hazardous to their health (Peris, 2020). Hegewald *et al.* (2018) opined that noise is responsible for 41,033 DALYs (disability-adjusted life years) in Sweden and 26,501 DALYs in Germany (Eriksson *et al.,* 2017). In Nigeria, most people are exposed to environmental noise levels from electricity generating plants, vehicle traffic noise, pressure and engine horns, construction and industrial noise, machinery noise, noise from religious services, institutions, and household noise which are the main indications of noise pollution that exceeds national and international standards. One of the capital cities of Nigeria (Minna) has experienced rapid growth leading to an increase in noise-generating activities. There are studies on noise pollution in Nigeria,

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but little is known about the effects of noise on residents' quality of life. This study aimed to investigate the effects of noise pollution exposure on residents' health and well-being in Minna, Nigeria. The objectives are i. to determine the noise pollution levels within the residential neighbourhoods and their encompassing implications for the residents; ii. to identify mitigating measures suitable for a significant decrease in residential buildings exposed to harmful noise levels.

2.0 Literature Review

Noise is an annoyance and a stressor on the environment, but it can also disrupt a conducive environment, which can be harmful to human health (Olamijulo *et al.,* 2016). There are several detrimental effects of noise pollution on human health and society. Although there are articles on how factories, train stations, and airports cause noise pollution that affects city people. However, the majority of the publications primarily focus on key locations in metropolitan areas, work/marketplaces, and noise exposure and its related impact on job performance (Sirajus *et al.,* 2014; Yesufu *et al.,* 2012). (Ogunseye *et al.,* 2018).

The health implications of environmental noise have been established in the literature. Every day, the welfare of millions of individuals is affected by noise pollution. It most frequently results in noise-induced hearing loss (NIHL). Exposure to loud noise can lead to stress, high blood pressure, heart disease, and trouble sleeping. These health problems can affect children in particular, but people of all ages can suffer from them. According to Dendup *et al.* (2018), greater concentrations of NO_2, $PM_{2.5}$ (particulate matter with a diameter of 2.5 m) and noise are associated with a higher chance of developing Diabetes Mellitus (DM) type 2. The limitation of their findings is that they lacked sufficient data to conclude causality. In Stockholm County, Sweden, Pyko (2018) investigated the effects of long-term exposure to traffic noise on metabolic and cardiovascular outcomes. The results suggest that prolonged exposure to transportation noise affected a few metabolic and cardiovascular outcomes.

Carmona *et al*. (2018) studied the correlation between chemical and acoustic contamination and daily emergency department hospital admissions due to multiple sclerosis (MS). Although their findings did not identify any links between chemical pollutants brought on by traffic and MS admissions; however, such a link was present in the case of Leqd and there is a level greater than 67 dBA where this effect is stronger. This correlation is linear without a threshold. Negahdari *et al.* (2018) examined the danger of noise pollution caused by central traffic in Shiraz and found that the sound pressure levels above the Iranian environmental regulations and the values of the pressure levels were higher than the international limits.

A study conducted in Sweden by Eriksson *et al.* (2017) discovered that noise from both road traffic and trains increased the burden of disease, including the occurrence of approximately 1,000 myocardial infections annually. Numerous studies, like Cole-Hunter *et al.* (2018), demonstrate a connection between cardiovascular problems, noise pollution, and both. These studies show a link between long-term exposure to noise and air pollution and circulatory or cardiac problems. By increasing public knowledge of the social costs related to these risk factors, the demand for effective regulation that reduces noise and air pollution can be strengthened. Based on data from questionnaires and biomarkers, similar research by Eze *et al.* (2017) on 2631 individuals who were clear of diabetes in 2002 and did not migrate between that year and 2011 revealed cases of diabetes in 2011. The authors concluded that because of the disruptions to sleep caused by noise, transport noise requires more attention than air pollution (AP) in the development of diabetes. Diabetes is one of the health issues associated with noise's impacts that have attracted the attention of other authors like Dzhambov (2015), who investigated the link between long-term noise exposure and the risk of type 2 diabetes. The author observed that those exposed to loud household noise (Lden > 60 dB vs. Lden 60-64 dB) may be at an increased risk of 19 - 22% of having the disease.

Weinhold (2015) investigated the health impacts of home noise using a longitudinal survey of more than 5000 persons in the Netherlands. The findings indicated that the effects of neighbourhood noise on perceived health outcomes included headaches, joint and bone illness, and cardiovascular symptoms, which impacted a range of health conditions. Meanwhile, a study carried out in Nigeria by Olamijulo *et al.* (2016) found that people who live with noise from portable generators are more likely to have health problems like ear pain, headaches, fatigue, and tinnitus. Another study by Awosusi and Akindutire (2014) in Nigeria evaluated the perceived health knowledge related to noise pollution and found that residents had a good understanding of the extent of the health impacts of noise pollution. It was discovered that there was a direct correlation between location and those effects. From the above reviews, there is a paucity of studies on the effects of noise pollution in the residential environment as the majority of the studies only concentrated on sources and few areas where noise pollution is a huge problem.

3.0 Methodology

This study employed the quantitative research approach described in the following sections to obtain suitable and relevant data

3.1 Study location

Minna lies between latitudes 9°37' North and Longitude 6°33' East with an area of about 884 hectares (Figure 1) and is the capital of Niger state (Figure 2). The distance from Abuja, the federal capital of Nigeria, is roughly 145 kilometers. Its progressively more diverse population and urbanization over time made Minna City the preferred location for this type of study. The NPC (2006) determined that Minna had 304,113 residents in 2006.

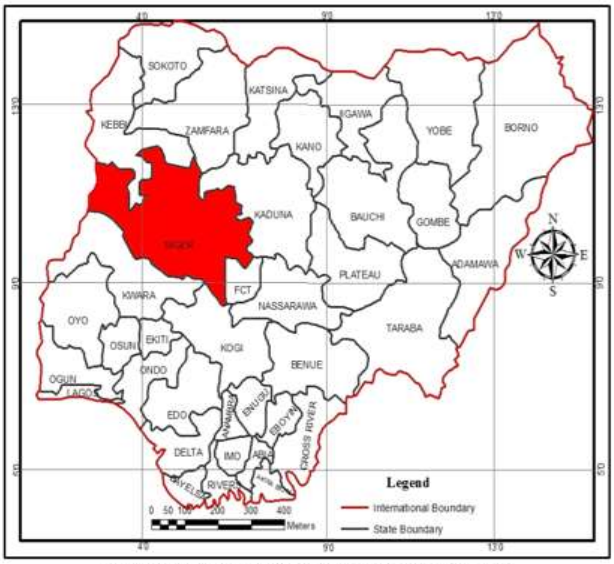

Figure 1: Map of Nigeria showing Niger state

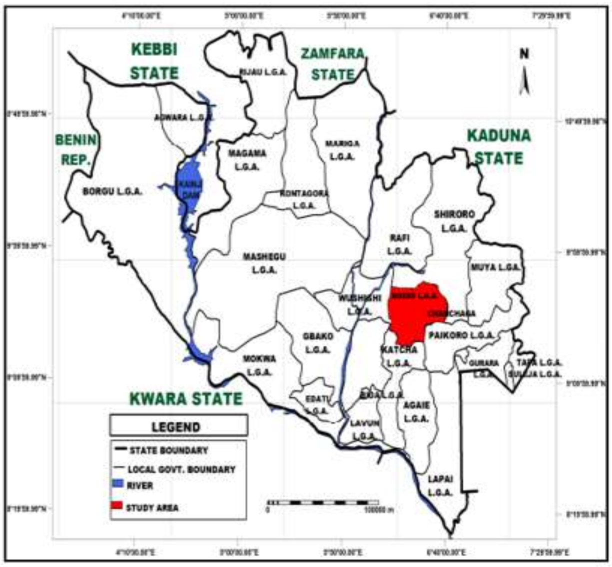

Figure 2: Map of Niger state showing Minna

Source: Ministry of Lands and Housing, Minna, Nigeria. (2013).

3.2 Data collection and instruments

A sound level meter (SLM) was used to take all noise measurements and to obtain noise values over chosen random spots. Comparable noise experiments have utilised this technique (Abbaspour *et al.,* 2015). The SLM was set up to take measurements of noise levels every 30 minutes for fourteen (14) days of recordings at each location. For safety reasons, the recordings were carried out from 8:00 to 18:15. In addition to the use of SLM, a hand-held Geographic Positioning System (GPS) was used as it was necessary to get the coordinates of the locations where the noise level was quantified. The neighbourhoods were divided into segments to conduct stratified random sampling. The map of Minna was stratified using a fishnet to generate 20 spots for the noise reading (Figure 4), and the points were afterward uploaded to a Google map to be identified. The noise level reading required a total of thirty (30) sample points.

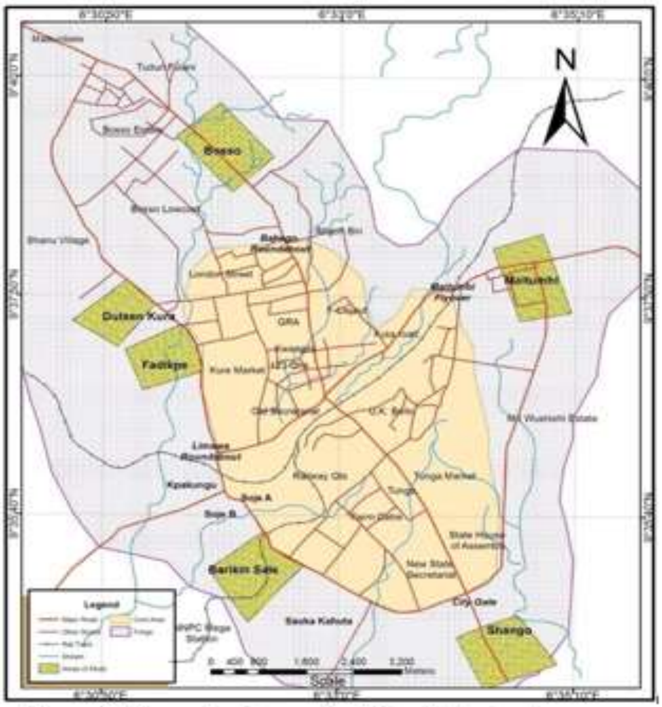

Figure 3: Minna showing residential neighborhoods

Source: Ministry of Lands and Housing, Minna, Nigeria (2013)

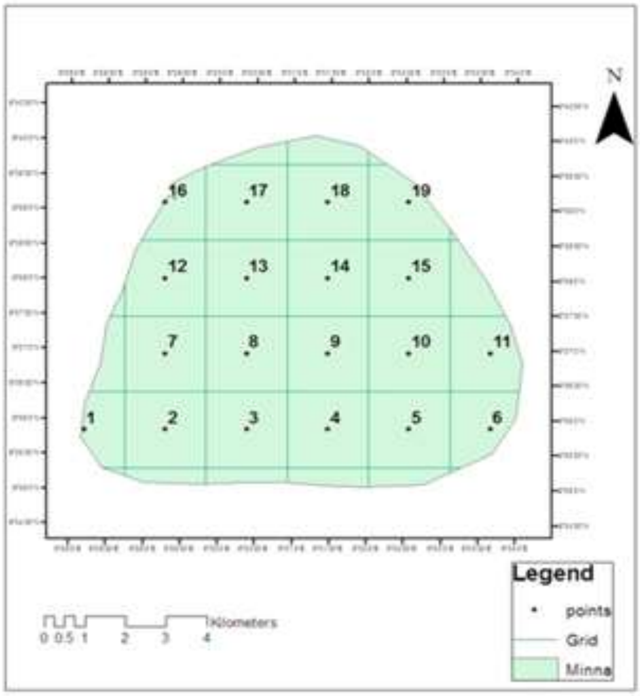

Figure 4: Noise reading using fishnet ArcGIS 10.1

Source: Author's Fieldwork

Following the selection of 20 sampling locations for noise reading, 20 points were chosen in ArcGIS 10.1 using the fishnet approach. Over the reference period, when the noise reading was taken, strong wind, heavy rain, and noises were not characteristics of the region being studied and were avoided as these conditions might increase measurement errors.

3.3 Neighborhood selection, sample size and survey administration

In Minna, there are 25 different neighbourhoods (Figure 3). Using a cluster sampling technique, the study's sample locations were selected. The residential neighbourhoods were divided into three zones: each zone denoted a cluster. To ensure equitable representation from each zone, five (5) neighbourhoods were chosen at random from each cluster. The chosen neighbourhoods served as the study's sample sites, they included: Barikin-Sale and Shango, Fadikpe and Dutsen-Kura (Gwari), and Bosso and Maitumbi. 880 households were sampled and surveyed using Adams *et al.* (2007)'s simplified formula ($n_0 = Z^2 a/x P (1 - P)/d^2$) to determine the sample size. There are 18,387 households in the sampled neighbourhoods. Using a 95% confidence interval, an estimated rate of 50% (p=.50), and a precision range of 4% (d=0.04) were established. A systematic random sampling procedure was used to spread the sample size proportionately throughout the chosen neighbourhoods and to administer the surveys. In every third house on every street, a household was chosen to complete the questionnaire.

3.4 Data analysis

Data from SLM were analysed using descriptive statistics and the results were summarised using straight-line graphs. The noise level data was utilised to produce a map that displays the research area's noise intensity and temporal distribution. For the study of temporal data, an interpolation technique known as inverse distance weighting (IDW) was employed. A weighted average of the values available at the known points was used to generate the values allocated to the unknown points. The focus area for noise management was determined using the reclassified noise map. This was compared with NESREA's (National Environmental Standards and Regulations Enforcement Agency) (2009) permissible noise level for various land uses using the reclassifying tool in ArcGIS. Statistical analysis was performed on the noise perception data using the SPSS 23 programme. The Chi-square test was used to assess the potential effects of noise exposure in the residential setting and identify any associations between exposure and source perception. The Cronbach alpha score for the questionnaire was 0.5 after the reliability data for the questionnaire's items were conducted. This indicates that the finding is reliable because it is within the permitted range.

4.0 Result and discussion

The result and the discussion of findings obtained in this study are presented below in the following sections

4.1 Demography background

Findings show that 65% of respondents are men and 35% are women. The ages of the respondents were between 16 and 54. According to the survey's findings, 88% of the respondents had formal education with only 12% without formal education which implies that the majority of the respondents were literate.

4.2 Noise pollution levels within the residential neighbourhoods

To determine the noise pollution levels within the residential neighbourhoods, the residential neighbourhood that was most susceptible to noise pollution was identified using the spatiotemporal distribution of noise map (Figures 5 to 8). The morning noise distribution is shown in Figure 5 with red colour denoted by the loudest noise level at 94 dBA. While the yellow colour tone indicated the lowest noise level (52 dBA) recorded. Similarly, the scattered contour line illustrates the noise spreading, the compacted contours describe locations with significant noise. Comparable contour values signify areas with comparable noise. The rush hour which causes daily activities to congregate during the morning hours could be the cause of the loud morning noise. The highest noise level at noon was 92 dBA, and the lowest was 58 dBA, according to Figure 6, locations with a lot of noise are indicated by a hot red tone, whereas areas with very little noise are indicated by a yellow colour. The contour lines also resemble this; the thick contours represent high-noise areas, whereas the loose contours represent low-noise areas.

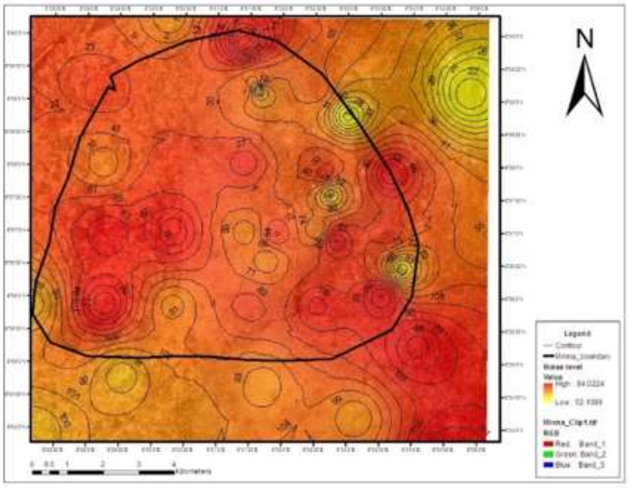

Figure 5: Noise map for morning time (8:00am)

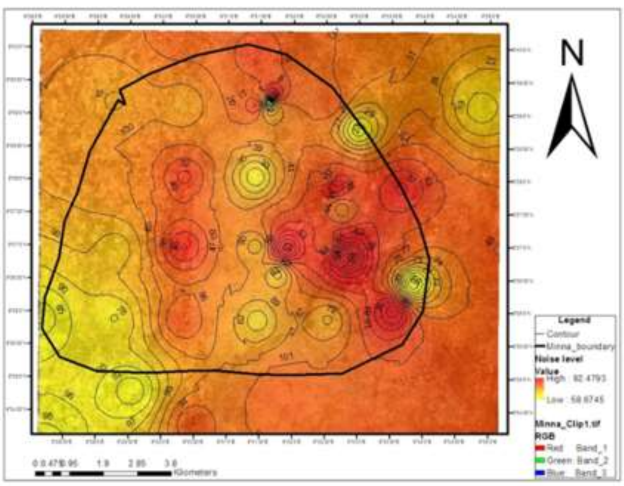

Figure 6: Noise map for midday (12:00 noon)

The noise pollution has now moved to the centre, as can be seen from the noise levels recorded throughout the city at noon. These locations show where the majority of human activity is most intense. The outcome of comparing the two maps in Figures 5 and 6 (i.e., for morning and noon) shows that noise pollution has decreased in some places with greater noise levels. The outcome of the noise that was recorded at that time is depicted in the noise map in Figure 7. The results demonstrate that the red-colored areas, which registered up to 96 dBA, are subject to a higher level of noise pollution than the yellow-colored areas, which registered up to 56 dBA. The 6:00 pm graphic shows how the noise has spread across the city. This resembles the 8:00 am noise map in terms of how noise has permeated the city. This might be because people are starting to use different spaces again.

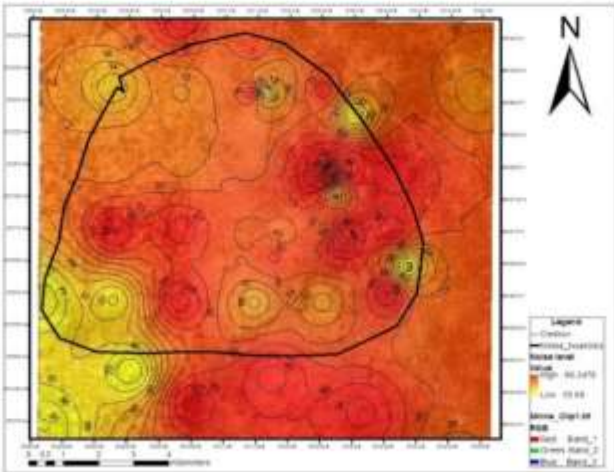

Figure 7: Noise map for evening time (6:00 pm)

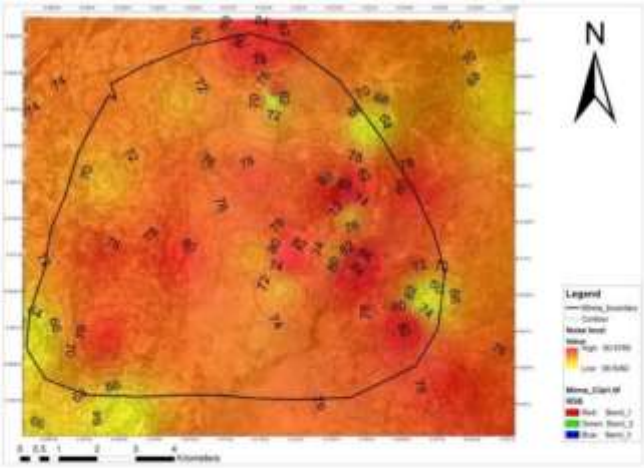

Figure 8: Noise map for overall mean noise level

The average noise level within the city is shown in Figure 8, with the greatest noise level (90 dBA) shown in red and the lowest noise level (58 dBA) shown in yellow. The results show that areas with a red tint and dense contour lines are those that are subject to very high noise levels, whereas areas with a yellow tint and sparse contour lines are those that are less noisy. The National Environmental Standards and Regulations Enforcement Agency (NESREA) recommended noise level for various land uses is shown in Table 1 as the maximum permissible noise level for the general environment from daylight to nighttime and vice versa. The permissible noise level for land uses that were observed in the city was determined using the values in Table 1.

Table 1: Maximum Permissible Noise Level for General Environment

Facility	Noise limits B (A)	
	Day (6:00a.m-10:00p.m)	Night (10:00p.m-6.00a.m)
Institutes for learning, offices etc.	45	35
Residential areas	50	35
Mixed residential (with some commercial and entertainment)	55	45
Residential + industry	60	50
Industrial	70	60

Source: NESREA (2009)

4.3 Implications of noise pollution levels for the residents

To determine the implications of noise pollution levels as it affects the residents, the values for the recorded noise level were computed and compared to the permissible noise limit indicated in Table 1. Figure 9 displays the outcome and the various noise levels in the residential neighbourhood. The results include the mean, lowest, and maximum noise levels for the entire neighbourhood. The reference parameters of 50 dB (A) (Table 1), according to NESREA (2009), were contrasted with the WHO's recommendation of 55 dB (A) for residential settings. This comparison demonstrated that the noise levels in the residential areas were unbearable for acoustic comfort. Figure 9 shows that every result was higher than the typical noise limit for residential areas. This demonstrates that residential environments are subjected to extremely high noise levels that may be hazardous to health. Responses from the survey revealed that noise from the road and places of worship were the most noticeable and rated higher than other types of noise. This result agrees with those of Abbaspour *et al.* (2015), who used a hierarchical approach to analyse noise pollution in Tehran Metropolitan City's metropolitan regions. They showed that, although not to the same amount as traffic noise, other factors such as land use and population density contributed to noise pollution in metropolitan areas. Surprisingly, this hasn't gotten as much attention in studies that assess noise pollution.

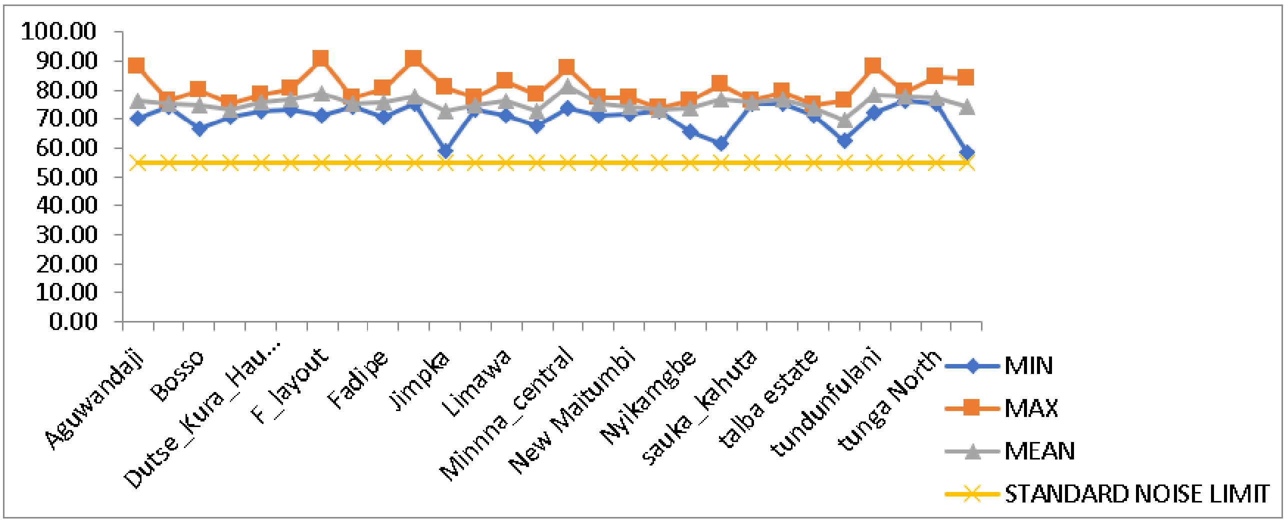

Figure 9: Minna residential neighborhoods and their noise level

4.4 Potential effects of noise pollution on the residents' wellbeing

In addition to the aforementioned findings, the residents of the high-level noisy area depicted in Figure 9 were asked to identify from a list of potential effects of noise pollution on their well-being. 79% of the respondents indicated that noise pollution affected their well-being, as seen in Table 2. One-third (31.1%) of the people indicated that noise pollution generally disturbs (irritates) them. 24.4% acknowledged that noise gives them headaches. For others (10.1%) it caused insomnia or sleep loss and stress (7.5%). This finding aligns with those of Paneto *et al.* (2017), whose study focused on the relationship between urban noise and the health of users of public areas." Their findings showed that discomfort (58%) and headaches (20%) were the most frequent reactions to noise exposure.

Table 2: Implication of noise pollution on the respondents' wellbeing

	Frequency	Percent	Valid Percent	Cumulative Percent
No disturbance (can tolerate)	184	20.9	20.9	20.9
General Disturbance (irritation)	272	30.9	30.9	51.8
Headache	218	24.8	24.8	76.6
Hypertension	24	2.7	2.7	79.3
Loss of Sleep/Insomnia	89	10.1	10.1	89.4
Stress	66	7.5	7.5	96.9
Hearing loss due to continuous noise	10	1.1	1.1	98.1
Physically and mentally affected	17	1.9	1.9	100.0
Total	880	100.0	100.0	

To determine the degree of the effect of noise pollution on the residents who indicated that noise pollution impairs their well-being the respondents were asked how long they had resided in the neighbourhood and a cross-tabulation was conducted. According to Table 3's findings, 79% indicated they were aware of the harmful effects of noise exposure. Their response could be a result of their level of literacy as 88% of the respondents were learned, people. Meanwhile, the outcome of the cross-tabulation demonstrates how the duration of residence affects the respondents' well-being.

Table 3: Length of stay in the environment and the effect of noise pollution on the respondents' health

		How long have you lived in your current neighborhood (in Years)					
		1-5	6-10	11-15	16-20	20 +	Total
How would you describe the effect of noise pollution on your wellbeing	No disturbance (can tolerate)	82	51	20	14	17	184
	General Disturbance (irritation)	131	68	25	17	31	272
	Headache	82	51	37	19	29	218
	Hypertension	2	10	6	5	1	24
	Loss of Sleep/Insomnia	46	20	10	10	3	89
	Stress	9	29	9	12	7	66
	Hearing loss due to continuous noise	3	1	0	3	3	10
	Physically and mentally affected	7	3	0	0	7	17
Total		362	233	107	80	98	880

Findings from Table 3 showed that a greater number (41%) of respondents who had been in the environment for one to five years had headaches, hypertension, sleep loss, stress, and hearing loss, while 11% of those who had been in the environment for more than 20 years had similar symptoms including annoyance, headache, hypertension, sleep loss, stress, and hearing loss. As their stays in the environment lengthen, each respondent has encountered one or more effects of noise pollution. This finding is compared to the outcome of research by Dzhambov (2015) on the association between long-term noise exposure and the risk of type 2 diabetes. The findings indicated that those who are exposed to loud household noise (Lden > 60 dB vs. Lden 60-64 dB) may be at an increased risk (19–22% of having the disease). The association was further explored through Chi-Square tests that were run to determine whether the association is significant as displayed in Table 4. Since the significant value is smaller than 0.05, there is a substantial and positive relationship between the length of stay in the environment and the impact of noise pollution on the respondent's well-being. Therefore, the impact of noise pollution on the respondents' health increases as the length of their stay does.

Table 4: Chi Square test to know the relationship between the length of stay in the environment and the effect on the respondents' wellbeing

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	95.255[a]	28	.000
Likelihood Ratio	96.532	28	.000
Linear-by-Linear Association	10.916	1	.001
N of Valid Cases	880		

a. 12 cells (30.0%) have expected count less than 5. The minimum expected count is .91.

4.5 Residential environments for a decrease in exposure to harmful noise levels

The analysis's findings as shown in Figure 10 indicated the residential areas that have points higher than the calculated standard deviation for the noise level fall under the category of noisy environments. The regions with below-average points did not go beyond the standard deviation. Residential areas that have noise levels below the standard deviation can therefore be regarded as having ideal and acoustically controlled settings. The areas over the standard deviation are classified as acoustically contaminated areas and thereby are priority locations for noise management. To manage and mitigate the high level of noise in these residential neighbourhoods, there is a need to consider the design of noise-absorbing buildings, improved urban and infrastructure planning, and noise regulating measures are necessary.

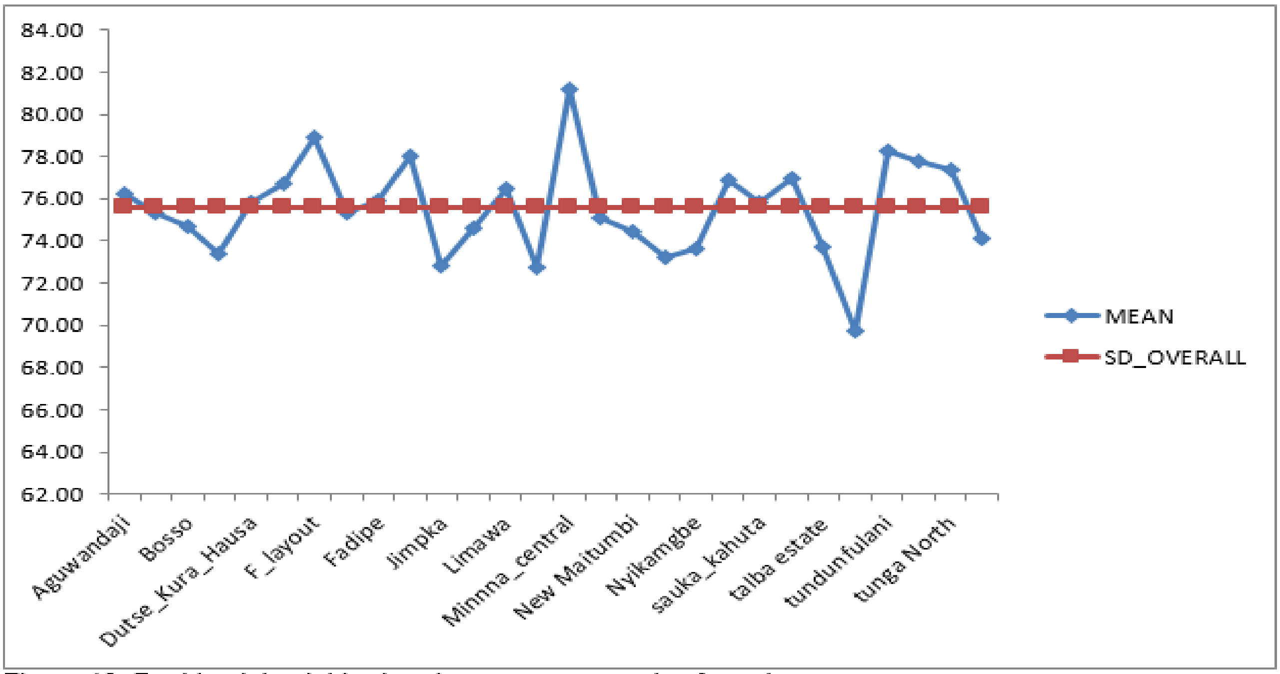

Figure 10: Residential neighborhood most prone to noise for noise management

5.0 Conclusions and Recommendations

The impact of environmental noise on people's quality of life in residential settings was explored in the study. Its goals were to increase public awareness of noise pollution and the effects it has on the health and quality of life of those who are exposed to loud noises. Most road traffic noise occurs in emerging countries as a result of urbanisation, business, and mobility. A significant improvement in the quality of people's lives would require noise-regulating measures, which were made possible by the creation of noise-absorbing buildings that enhanced urban and infrastructure planning. These steps would decrease the long- and short-term effects of noise pollution in residential areas. Green space inclusion in residential areas may also reduce mortality risk independently of other environmental exposures. Where residential green areas currently exist, public environmental health programmes should preserve and enlarge them. The consequences of environmental noise could be considerably minimised by integrating green infrastructure. The right placement of rooms in residential building designs would be beneficial. Bedrooms located farthest from traffic can result in a 1020 dB reduction when compared to bedrooms on the side of the building that is closest to a road, for example. Both the location of the bedroom and how often windows are opened significantly affect the association between noise and heart disease. The consequences of environmental noise could be considerably minimised by integrating green infrastructure. The right placement of rooms in residential building designs would be beneficial. Bedrooms located farthest from traffic can result in a 1020 dB reduction when compared to bedrooms on the side of the building that is closest to a road, for example. Both the location of the bedroom and how often windows are opened significantly affect the association between noise and heart disease.

6.0 Contributions and limitations of the study

The body of knowledge in architecture regarding how neighbourhood noise impacts local residents' well-being is expanded by this study. As far as the authors are aware, this study is one of the first to offer measurable information to raise public awareness of the dangers of exposure to excessive noise in a home setting in Minna, Nigeria. The results of this study's findings could serve as a starting point for other studies. The fact that the noise measurements were only gathered for a little time is one of the study's weaknesses. However, additional study is needed to quantify the noise levels in various household contexts in order to raise awareness and enforce noise restrictions in domestic areas. The study's failure to use the Pollution Standard Index (PSI), a state-of-the-art pollution modelling tool that would have helped to quantify noise levels at the selected sites, provide a better understanding of the city's environmental noise position, and emphasise the seriousness of the risks associated with residents' exposure to noise, is another limitation.

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