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Noise Pollution in Urban Residential Environments: Evidence from Students' Hostels in Awka, Nigeria

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ABSTRACT

Noise pollution and its concomitant effects on humans and environment has reached dangerous levels in many urban areas across the world. However, very little is known about the sources and effects of noise pollution within students' hostels in a developing country like Nigeria. This study investigated urban noise pollution in residential neighbourhoods, using the Nnamdi Azikiwe University students' off-campus accommodation in Awka, southeast Nigeria as the study area. Data were obtained through measurements of noise levels using sound level meter and by conducting a survey to gather feedback from 260 students in the study area. Descriptive statistics and Chi-Square tests were used to analyse the data; the results revealed mean noise levels of 89.8 dB(A) and 46.9 dB(A) during noisy and quiet periods, respectively. The main sources of noise were portable electricity generators, vehicular traffic and loudspeakers used by students and business operators; they were found to have deleterious effects such as low tolerance, headache, anger, lack of concentration and low productivity on the students. The study concludes by noting that to effectively minimize the effects of noise pollution within urban residential neighbourhoods in the study area and beyond, architects and urban planners should engage in proper land use zoning and the application of sound absorbing materials on walls and locating balconies of residential buildings away from noise sources. In addition, vegetation belts and sound barriers of earth mounds or wood, metal or concrete could also be constructed between the sources of noise and residential buildings, especially in the case of roadside communities.

1. INTRODUCTION

Contemporary urban areas are confronted with several challenges that affect public health and wellbeing as well as the productivity of residents across the different socio-economic groups. Noise pollution is one of these challenges that appears to be receiving increasing research attention across the globe. It is known that various activities in urban areas or cities generate high levels of noise, usually beyond the permitted limit. In fact, the study by Bowling and Edelmann (1987) indicates that sound is a common feature in human settlements, but it translates to noise when it becomes irritating and causes physiological or psychological harm to the human body. Consequently, noise pollution has been defined as any unwanted sound that has deleterious effects on human health and environmental quality (Onuu and Iyang, 2004; Darbyshire et al., 2019; Encyclopaedia Britannica, 2020).

The World Health Organization (2018) has described noise pollution as one of the most dangerous environmental threats to mental health. Studies have specifically shown that noise pollution has become a serious environmental issue and that it is even more dangerous than water and air pollution (Gunnarsson and Evy, 2007; Oviasogie and Ikudayisi, 2019). Hence, as noted by Sordello et al. (2019), increased research attention has been paid to the effects of noise pollution and to the strategies for preventing and minimizing these effects. Previous studies have focused on the various aspects of noise pollution, including its sources (Piccolo et al., 2005), effects (Bowling and Edelmann, 1987; Taylor et al., 2001; Schapkin et al., 2006; Don Pedro 2009; Jakovljevic et al., 2009; Sordello et al. 2019), and remedies (Watts et al., 1999; Tokairin and Kitada, 2005; Lee et al, 2007; Gunnarsson et al., 2007; WHO, 2018). Aggregate findings of these studies indicate that the key sources of noise pollution are the anthropogenic activities associated with production (industrial), commercial and consumption activities, including vehicles, trains and aircrafts, construction sites and neighbourhood activities. These studies have also shown that noise pollution affects humans physically, psychologically and physiologically.

In a developing and rapidly urbanizing country like Nigeria, despite the measures put in place to check the growing incidence of noise pollution, some authors have noted that noise pollution was on the increase unabated in the major towns and cities in this country (Olayinka, 2012 and 2013; Ogunseye et al., 2018; Oviasogie and Ikudayisi, 2019). In bid to find a lasting solution to this challenge, researchers have investigated some aspects of urban noise pollution in Nigeria. Examples are the studies on the sources and effects of environmental noise in Port Harcourt (Abumere et al., 1999), level of environmental noise pollution in University of Calabar, Calabar in Cross River State (Onuu and Inyang, 2004), the noise level in Kolo Creek Gas Turbine in Bayelsa State (Avwiri, Enyinna and Agbalagba, 2007), the health implications of exposure to noise in Ibadan metropolis (Oloruntoba, et al., 2012; Ogunseye, Jibiri and Akanni, 2018) and the sources of noise in two residential neighbourhoods in Benin city (Oviasogie and Ikudayisi, 2019).

A close examination of these studies reveals that they were carried out in the south-south and south-west geo-political zones of Nigeria. Apart from the study by Onuu and Menkiti (2003), which investigated road traffic noise in south-east Nigeria, very little research effort has gone into the exploration of noise pollution in this part of Nigeria, where there is rapid spatial and demographic growth and visible proliferation of unplanned urban centres. Moreover, the existing studies on urban noise pollution at the global level seem to have neglected a critical segment of the urban population - students in higher education institutions. In view of the foregoing, this research sought to investigate urban noise pollution in residential neighbourhoods using the Nnamdi Azikiwe University Students' off-campus hostels in Awka, south-east Nigeria as the study area. The specific research objectives pursued were: 1) to determine the levels of ambient noise in the students' hostels in the study area, 2) to identify the main sources of noise pollution within and around the hostels, and 3) to examine the effects of noise pollution on the students living in the study area. In addition, the following two research hypotheses stated in both alternate forms were tested in this study.

$H1_a$: There is a significant variation in the respondents' perception of the major sources of noise pollution in the study area.

$H2_a$: The perceived effects of noise pollution on people's wellbeing in the study area are statistically significant.

This research is considered valuable to the ongoing discourse on how to improve public health and environmental quality of urban areas in the Global South by revealing the levels of noise, the main sources of noise pollution in urban neighbourhood where students reside and suggesting possible control measures for urban noise pollution. Therefore, the findings of this research are expected to inform architects, urban planners and managers on how to tackle the growing levels of noise pollution in urban residential neighbourhoods through effective planning of settlements and adoption of measures to effectively mitigate the effects of noise on the urban population in Nigeria and beyond.

2. REVIEW OF RELATED LITERATURE

2.1. Noise pollution and permissible noise level

The word 'noise' comes from the Latin word 'nausea' and it is measured by scientists in 'decibels', which is a measure of sound waves intensity that strike the ear drums. Air is the medium of transmission of sound energy in the form of pressure wave. Sound is defined according to a person's response or perception as any sensation perceived by the sense of hearing by the affected persons not only by loudness, pitch and duration but also by the hearer's own physical and mental state (Avwiri et al., 2007). Thus, sound can be enjoyable or stimulating depending on how the hearer is tuned in. The interrelationship of sound and noise is that all noise comes from sound but when sound becomes "unwanted" or "uncomfortable" it is referred to as noise (Darbyshire et al., 2019). Noise is also dependent on human perception because while one individual enjoys 'loud noise, for example young people in a music hall, another individual can be hypertensive to even the slightest noise (Preethi et al., 2016). Peoples' irritability or annoyance is therefore felt whenever they are exposed to an environment where an acceptable level of sound is exceeded.

Research has shown that noise pollution is, among other things, a function of the location of the source and the type of environment where the receiver is. For example, Piccolo et al. (2005) revealed that on the main roads of Messina, Italy, with heavy road traffic, noise levels exceeded the environmental standards by about 10 dB in the residential areas due to the proximity to the road. Another study by Bangjun et al. (2003) also concluded that when the sources of the noise were visible, the annoyance was higher compared to when the sources were not visible although at the same intensity. Mehdi et al. (2011) studied the spatial and temporal patterns of noise exposure due to road traffic in the city of Karachi in Pakistan, and reported an average value of noise levels of over 66 dB with a maximum of 101 dB.

In an attempt to control noise pollution, the World Health Organization WHO (2018) has set a standard for the permissible level of noise at 90 dB, which is the highest allowable level of noise humans can be exposed to. However, many countries, including Brazil, Japan, Spain, Sweden, Switzerland, Denmark and India, have adopted higher standards of permissible noise levels, such as 55 dB(A) for daytime, and 45 dB(A) for night-time, while Ireland (Dublin) has set 55 dB(A) for daytime and 35-45 dB(A) for night-time, Australia set her standard at 45 dB(A), the Netherland has different threshold values, namely 75 dB - 70 dB(A) for the industrial area, 65 dB- 55 dB(A) for the commercial area, 55 dB - 45 dB(A) for the residential area and 50 dB – 42 dB or 46 dB(A) for the silent zone for day and night time. The noise standards for low density areas in Malaysia are of 50 dB(A) and 40 dB(A) and for high density mixed-use areas, the noise standards are higher than 60 dB(A) and 50 dB(A) for daytime and night-time.

In Nigeria, the National Environmental (Noise Standards and Control) Regulations 2009, set the maximum noise level permitted in residential buildings for daytime (6:00 am-10:00 pm) to be of 43 dB and for night (10:00 pm-6:00 am) of 35 dB, whereas for higher education institutions to be 60 dB for day and 50 dB for night (Federal Republic of Nigeria, 2009). These standards are comparable to what are obtained in other countries. Based on these, a combination of the WHO's 16-hour day and night limit standard of 55 dB and National the Environmental (Noise Standards and Control) Regulations 2009 for residential areas of 50 dB was adopted for this study.

2.2. Sources of noise pollution in urban areas

The sources of urban noise pollution have been subject of several scientific inquiries in the different countries. For examples, the following studies investigated the different sources of noise in many cities of the world (Singh and Davar, 2004; Lam et al., 2009; Weinhold, 2015; Olayinka, 2012; Oloruntoba et al., 2012; Preethi et al., 2016). They have shown that noise pollution in urban areas comes from different sources that are mainly related to the institutional, industrial and commercial activities. Some authors specifically identified the common sources of noise in urban centres to include - blasting of microphones and loudspeakers (Don Pedro, 2009), honking of vehicles, while other authors identified train and vehicles (Morihara et al., 2004), aircrafts (Van Praag and Baarsma, 2005) and road transport (Babisch, 2014) as the principal sources of urban noise pollution.

In Nigeria, a number of studies have attempted to identify the sources of urban noise pollution. For instance, the study by Abumere et al. (1999) identified industrial plants as sources of noise pollution, while Onuu and Menkiti (2003) reported that vehicular traffic on highways and major roads were the key sources of noise in parts of Southeast Nigeria. A similar study by Onuu and Inyang (2004) also revealed that about 92% of the environmental noise pollution within the University of Calabar in Cross River State was from vehicular traffic, which is similar to the findings of another study by Babisch (2014) as previously highlighted. Anomoharan and Osemeikhian (2005) compared noise pollution in some major urban areas in Delta State in the south-south geopolitical zone, and observed that the daytime equivalent noise level in Warri was more than 90 dB, which was recommended by the World Health Organisation (WHO), while the other towns studied had an equivalent noise level of between 75 dBA and 85 dBA. They also observed that the highest level of daytime noise for other towns except Abraka, which was 76.2 dB, was also beyond the WHO permissible limit. In this case, the high values of noise in some of the towns were attributed to vehicular traffic, portable electricity generators, loudspeakers used by music recording houses and salesmen. Similarly, in the neighbouring Benin City, Oviasogie and Ikudayis (2019) revealed that the prominent sources of noise pollution in two residential neighbourhoods were portable electricity generators and commercial activities.

Oloruntoba et al. (2012) also investigated the level of noise pollution and its possible impacts in some selected residential areas in Ibadan metropolis, southwest Nigeria, and reported the mean noise values for the low density area to be 53.10±2.80 dB, for the medium density area (68.45±2.10 dB) and for the high density area (68.36±1.92 dB) of which the medium density neighbourhoods had the highest mean value. Similar to the findings of previous studies (Anomoharan and Osemeikhian, 2005; Oviasogie and Ikudayis, 2019) the authors noted that the main sources of noise pollution were the loudspeakers used by churches and mosques, highly amplified music from record shops, bells used by peddlers, hawkers, and salesmen as items to advertise their wares and grinding machines; Olamijulo et al. (2016) identified private electricity-generating plants as another source of noise in urban residential neighbourhoods in Nigeria. In addition, Izeogu (1989) reported that in Port Harcourt southern Nigeria, noise pollution has increased as a result of increasing commercial and industrial activities, rapid population growth, expansion of highways and growing number of automobiles. This was corroborated by Olayinka (2012) who also noted that noise pollution in urban areas in Nigeria has been on the increase due to rapid population growth, industrial and commercial activities and that the key sources of noise pollution were vehicular traffic, industrial and home generating plants.

From the studies reviewed here, it can be inferred that noise pollution in contemporary urban areas, especially, in a developing country like Nigeria, is mainly caused by automobiles, aircrafts, loudspeakers from worship centres, music shops, salesmen, portable electricity generating sets of different sizes, shrill horns of motorists, piercing sirens of escorts and ambulances, train whistles, roaring of motorcycles and noise from construction sites.

2.3. Effects of urban noise pollution

The review of published literature also revealed that noise pollution has several negative effects on humans and the environment. Taylor (2001) specifically noted that the effects of short exposure to levels of noise of between 100 dB and 125 dB can lead to temporary deafness, and beyond 150 dB the inner ear can be permanently damaged. Ouis (2001) identified the negative effects on the wellbeing of people due to the exposure to road traffic noise, among various other kinds of discomfort. Some of these discomforts, as identified in previous research, include physiological or psychological harm to the human body (Bowling and Edelmann, 1987), psycho-social stress, rise in blood pressure and increase in cholesterol level (Noweir, 1984), increased body tension, allergies and stomach ulcers and other psycho-social stress and low productivity at work (Smith and Stansfield, 1986), inhibitory brain processes due to sleep disturbances (Schapkin et al., 2006) and annoyance (Jakovljevic et al., 2009), which may lead to violent acts (Don Pedro, 2009).

Other studies have shown that exposure to high levels of road traffic noise can have adverse effects on sleep (Öhrström et al., 2006), health implication for children (Ising et al., 2004), increases in episodic memory (Stansfeld et al., 2005) and hearing loss (Ingle et al., 2005). Further, in Hong Kong, annoyance triggered by noise was found to be largely due to noise disturbances caused by automobiles (Lam et al., 2009). Beyond human health and wellbeing, research has also shown that noise pollution can affect the environmental quality (Onuu and Inyang, 2004; WHO, 2018) and engender the loss of biodiversity (Sordello et al. 2019). There is also evidence in the literature (Mehdi et al., 2011; Abbaspour et al., 2015) showing that there is a relationship between the land use and noise, others (Gidlöf-Gunnarsson and Öhrström, 2007; Islam et al., 2012; Oviasogie, 2020) have shown that land use type and pattern and physical distance from a given source, play an important role in determining the level of noise felt within residential neighbourhoods. This suggests that urban land use and spatial planning can play a significant role on the levels of noise pollution and its effects on the population.

The foregoing review indicates that noise pollution has a wide range of deleterious effects on humans including annoyance, lack of concentration on tasks, leading to low productivity, interference with speech communication and may result in hearing loss by causing damage to the hair-cells in the cochlea in the inner ear. Although the existing studies are very insightful in improving our understanding of the effects of urban noise pollution on humans and environment, they fail to provide information on the level of noise pollution and its sources where students live. This is the gap the current study attempted to fill in.

3. METHODOLOGY

Geographically, the study area is located within the Awka Capital Territory of Anambra State, in the southeast geopolitical zone of Nigeria (Fig. 1).

Fig. 1. Map of Awka Area *(source: Geographical Map of Nigeria, 2020).*

Awka is the capital city of Anambra State and lies between latitudes 6°10' N and 6°15' N and longitudes 7°2'30" E and 7°7'30" E on the South-East geopolitical zone of Nigeria. According to the 2006 Nigerian census, the town had a population of 301,657 and currently estimated to have a population of over 2.5

million people. The study area is located off Enugu-Onitsha expressway and bounded to the southern axis by Enugu-Onitsha highway - a Trunk A road, to the west by a local market, off a busy commercial road, and to the east by a mixed residential/commercial neighbourhood. The area under study covers the noisy Arthur Eze Avenue Business District; Nnedioramma Off-Campus Students' Hostels at the Nnamdi Azikiwe University Temporary site, Awka.

The research design adopted for this study was a combination of quasi-experimental and survey, as the noise pollution within the students' hostels were assessed using field measurements and the students' perception. A similar approach has been adopted by previous authors (Alani et al. 2020) in the geospatial analysis of environmental noise levels in a residential area in Lagos, Nigeria. The research population consisted of students of Nnamdi Azikiwe University, Awka living in Nnedioramma Off-Campus Hostel at the university's temporary site and the rented apartments in Nudu Okpono, which is an adjoining housing estate. These two locations house a total of 1040 university students. To ensure that an adequate sample size was used in the survey aspect of the research, Yamane's (1967) formula for finite population stated in equation 1 was used to determine the sample size.

$$n = \frac{N}{1 + N(0.05)^2} \quad \text{(Eq. 1)}$$

where:

n – the calculated sample size;

N – the research population;

e – the allowable error in statistical estimation, which for this research is ±5% margin of error at 95% confidence level. Substituting these parameters in the equation, 289 students were obtained as the sample size.

$$n = \frac{1040}{1 + 1040(0.05)^2} = 289 \text{ participants} \quad \text{(Eq. 2)}$$

The data collection instrument used in the survey was a structured questionnaire designed by the researchers specifically for this study. The questions included in the questionnaire were based on variables identified from the review of literature. The questions were organised into different sections based on the research objectives. The first section included questions on the respondents' awareness of the occurrence of noise pollution in the study area. The second section consisted of questions on the sources of noise and the period noise pollution occurs within and around the hostels, while the last section comprised questions on the self-perceived effects of noise.

The data collection process was carried out in two stages. The first stage involved the physical measurements of the noise level in the hostel environments in the aforementioned two locations using the CEL 254 Digital Impulse Sound Level Meter made by CASELLA USA. This particular instrument was used because it has the capacity to pick up many types of noise sources and provides an accurate measurement of the source level. In addition, its measurements range for instantaneous sound level is from 30 dB(A) to 135 dB(A) at a measurement accuracy of ±1 dB, while its operating temperature ranges between -10°C and +50°C, while the effective relative humidity for <0.5 dB is from 30% to 90%. The sound level meter was positioned with its microphone placed in the direction of the sound sources: the bustling commercial Arthur Eze Avenue by Enugu-Onitsha highway. The microphone was positioned 1.0m away from the hostel building facades, both inside and outside the hostel buildings, and at 1.2 m above the ground and floor levels taken as average distance for a human ear. This procedure is in line with that adopted in previous research (Onuu and Iyang, 2004). Measurements were taken from 72 locations for the time periods divided into: First Noise period (8:00 am-12:00 pm), Second Noise period (3:00 pm-6:00 pm), (daytime) and Quiet Period (8:00 pm-12:00 am) (night-time). However, the sources of the noise were not stable at a particular point, as the sounds fluctuated when loudspeakers from nearby shops went up and down, and the noise from motorcycles sounded at different intervals or came from honking of commercial vehicles. The meter provided digital readings and three readings were taken at a point and average values were calculated.

Table 1. Statistics of questionnaire distribution and response rate.

Location	No. of questionnaires administered	Successfully filled out	Incomplete	Response rate (%)
Unizik Temp Site off-Campus Hostel	156	144	12	92.30
Students in rented Estates in Nudu Okpono	124	116	8	93.50
Total	280	260	20	92.90

The survey was conducted to gather information from the students living in hostels, and this represented the second stage of data collection. Random sampling technique was used to select the students who took part in the survey. This was to eliminate as much as possible the sampling bias and to ensure that every student in the research population had equal opportunity of being selected to participate in the survey. Totally, some 280 students in the Nnedioramma Hostel and rented accommodations in the nearby housing estates were selected and they answered the questions of the survey face to face. Table 1 shows the number of questionnaires distributed, retrieved, completely filled as well as the response rate (around 92.9%), which was considerably good and acceptable.

The data collected using the sound level meter type CEL 254 were analysed by computing the noise levels using the equation developed by Foreman (1990), as follows:

$$Lw = Lp + 20\log d + 11 \quad \text{(Eq. 3)}$$

where:

Lp – represents the mean average sound pressure levels;

d – the distance from the noise source, taken as 20m constant because the noise source was not fixed, at a particular location.

The readings obtained and computed for Lw in dBA are represented in Table 2.

Table 2. Measurement of noise periods.

Recorded noise periods between 8:00 am (day) – 12:00 am (night)								
First Noise Period 8:00 am – 2:00 pm								
	Windows facing East		**Windows facing West**		**Windows facing North**		**Windows facing South**	
	Lp in dB(A)		Lp in dB(A)		Lp in dB(A)		Lp in dB(A)	
	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor
RM 1	60.6	68.4	71.8	78.9	68.8	76.8	76.8	86.9
RM 2	61.4	69.2	71.8	80.1	72.4	76.8	76.8	87.2
RM 3	63.2	75.4	72.6	80.2	78.4	78.2	78.2	88.2
RM 4	68.8	76.8	72.8	81.2	76.8	78.6	78.8	88.9
RM 5	68.9	77.1	74.6	82.4	78.8	79.1	79.1	89.1
RM 6	71.2	**78.4**	74.8	86.8	78.9	78.8	78.2	**89.2**
Second noise period 3:00 pm – 6:00 pm								
	Windows facing East		**Windows facing West**		**Windows facing North**		**Windows facing South**	
	Lp in dB(A)		Lp in dB(A)		Lp in dB(A)		Lp in dB(A)	
	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor
RM 1	57.4	68.4	70.5	78.0	68.8	70.3	72.8	80.5
RM 2	57.4	71.2	72.5	78.2	68.9	72.6	74.5	81.2
RM 3	58.2	73.6	72.8	82.6	67.9	76.6	72.8	85.6
RM 4	66.0	75.2	74.2	84.6	68.0	76.8	75.9	86.6
RM 5	66.4	76.5	76.8	85.5	68.9	76.4	**76.9**	87.8
RM 6	67.8	77.6	77.6	87.8	70.2	78.8	75.7	88.2
Quiet period 8:00 pm – 12:00 am								
	Windows facing East		**Windows facing West**		**Windows facing North**		**Windows facing South**	
	Lp in dB(A)		Lp in dB(A)		Lp in dB(A)		Lp in dB(A)	
	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor
RM 1	40.3	41.4	44.4	44.8	43.4	43.9	44.9	45.9
RM 2	40.6	41.6	44.8	45.2	43.6	43.9	45.0	45.8
RM 3	42.8	43.6	44.8	45.4	43.8	43.9	45.2	45.9
RM 4	43.1	43.8	44.4	45.3	43.9	44.0	45.8	46.8
RM 5	43.2	43.8	44.9	45.8	43.9	44.2	45.9	46.8
RM 6	43.6	44.1	44.9	45.8	43.9	44.6	45.4	46.9

Lp = Mean average sound pressure level taken at intervals.
RM 1, RM 2, RM 3, RM 4, RM 5, and RM 6 = Rooms from which windows the experiment was carried out.

The data obtained from the questionnaire survey were analysed using descriptive statistics (i.e. frequencies and percentages), while the hypotheses were tested using the Chi-Square tests. The results are presented using tables and charts.

4. RESULTS AND DISCUSSION

Results of the measurements of the sound level at various locations in the study area presented in Table 2 show that the highest outdoor mean level of noise pollution in the First Noise Period, was 89.2 dB(A) on the South façade, while the lowest was 78.4 dB(A) on the East Façade. The highest outdoor mean level of noise pollution in the Second Noise Period was 89.8 dB(A) on the West Façade, while the lowest was 77.6 dB(A) on the East Façade (see Table 2). Notably, these noise levels are more than 53.10±2.80 dB, 68.45±2.10 dB and 68.36±1.92 dB reported for low, medium and high-density residential areas in Ibadan metropolis by Oloruntoba et al. (2012) as previously highlighted, but appear to be similar to those reported by Anomoharan and Osemeikhian (2005) in some major urban areas in Delta State, south-south Nigeria.

However, the highest outdoor mean level of noise pollution in the *quiet period*, was 46.9 dB(A) on the South Façade, while the lowest was 43.8 dB(A) on the East Façade (Table 2). Going by the WHO permissible noise level of 55 dB and that of the National Environmental (Noise Standards and Control) Regulations 2009 for the residential areas of 50 dB, it can be inferred from the results that the West and South Façades are the noisiest parts of the hostel environment, especially, during the hours of 8:00 am and 6:00 pm. This result was to be expected because the West Façade faces the noisy business district with busy mass transportation bus stands, several retail shops, music shops, motor cycle and tricycle riders' parks, barbing saloons, fast food centres and a local market.

In the same vein, the South Façade faces the ever busy Enugu-Onitsha Trunk A road with a high volume of vehicular traffic, and two busy motor parks for Enugu and Lagos bound passenger vehicles and also a highbrow commercial area. The noise levels at the East Façade and North Façade were below the standards of the WHO and the National the Environmental (Noise Standards and Control) Regulations 2009 because while the East Façade faces a residential estate, the North Façade faces a mixed-use area (residential/commercial) area, which are areas that produce less noise compared to the other adjourning developments that are key sources of noise pollution in the study area.

4.1. Knowledge of noise pollution and its occurrence in the study area

The descriptive analysis revealed that all respondents (100%) indicated that they were aware of the noise pollution, with the majority of them (76.9%) indicating that indeed noise pollution occurred in the area, while 23.0% either disagreed or were indifferent to this issue. In addition, around 30.8% of the respondents felt that the level of noise in the area was bearable, 34.6 % said it was unbearable, while 34.6 % declared they do not know whether the noise level in the areas was bearable or not. These results showed a divergent opinion among the respondents on whether the level of noise in their locality was within the bearable level. In any case, it can be inferred that all the participants and a high majority of them acknowledged the noise pollution and were aware that it occurs in their living environment. However, just about one-third of them claimed that the level of noise in the study area was unbearable, while the rest did not share this view. The differences in opinion among the participants on whether the noise level was bearable or not as reported here may be due to individual differences and other factors, which were not investigated in this research.

The results of the period during which the highest level of noise was experienced in the study area are shown in Figure 2.

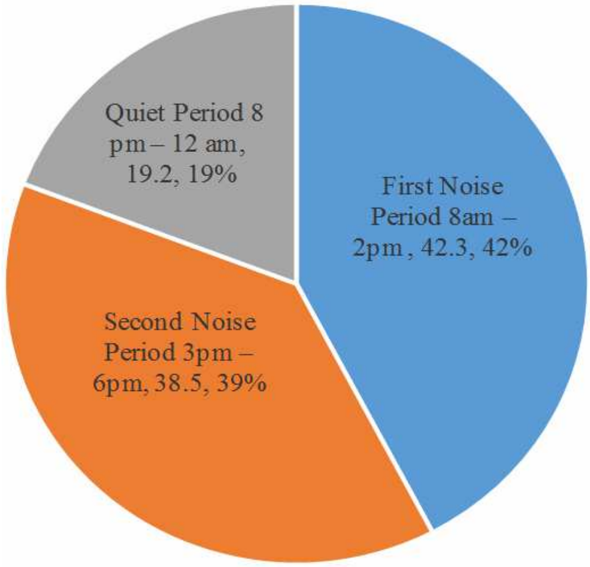

Fig. 2. The level of noise, by the periods of the day.

Around 42.3% of the participants indicated that the time of the day when they experienced the highest level of noise was usually between 8:00 am and 2:00 pm; this was followed by 38.5% who indicated that it was between 3:00 pm and 6:00 pm, and 19.2% who claimed that it was from 8:00 pm to 12:00 am (Fig. 2). These results show that the total period of time when noise pollution was mostly experienced in the study area as reported by the highest majority of the respondents (80.8%) in the survey was between 8:00 am and 6:00 pm, which is about 10 hours.

The results showing the period participants experienced the highest level of noise did not come as a surprise because from 8:00 am to 6:00 pm is associated with the working hours, when commercial and business activities take place, and these busy activities are potential sources of noise. Moreover, the study area is bounded to the Southern axis by the ever busy Enugu-Onitsha highway - a Trunk A road, to the west by a local market of a busy commercial road, and to the east by a mixed residential/commercial neighbourhood; and these are real sources of noise pollution due to the chaotic nature of activities that take place there. Firstly, these results further provide support to the earlier study of the major towns of Delta State, Nigeria, by Anomoharan and Osemeikhian (2005) indicating that the peak of the noise pollution was in the daytime; and secondly, they also confirm the data in Table 2 showing that the highest level of noise of 89.2 dB recorded in the study area was between 8:00 am and 2:00 pm, followed by the value of 88.2 dB recorded between 3:00 pm and 6:00 pm and the lowest value, of 40.3 dB, recorded between 8:00 pm and 12:00 am. Therefore, the participants' perception of the period when the highest level of noise pollution was experienced in this neighbourhood is indeed consistent with the measurements obtained using the sound level meter as presented in Table 2.

4.2. Sources of noise pollution in the study area

The descriptive analysis also revealed that the major sources of noise pollution in the study area were the portable electricity/power generators identified by all of the respondents in the survey (100%), followed by the traffic chaos (85.0%), horns blowing (80.0%), the use of loudspeakers (75.0%) and the use of loudspeakers by salesmen (75.0%) (Fig. 3). The results on the major sources of noise pollution in the study area (Fig. 3) seem to align with the findings of previous studies (Singh and Davar, 2004; Lam et al., 2009; Olayinka, 2012; Oloruntoba et al., 2012; Weinhold, 2015; Preethi et al., 2016) who identified different sources of urban noise pollution. Specifically, the results provide support to the early study in residential neighbourhoods of Benin City by Oviasogie and Ikudayis (2019) which reported that portable electricity generators and commercial activities were the main sources of noise pollution in the residential neighbourhoods. In addition, the results also appear to be consistent with the previous studies indicating that the common sources of noise in our urban centres are the vehicular traffic (Onuu and Menkiti, 2003; Babisch, 2014), the blasting of microphones and loudspeakers, and the honking of vehicles (Pedro, 2009).

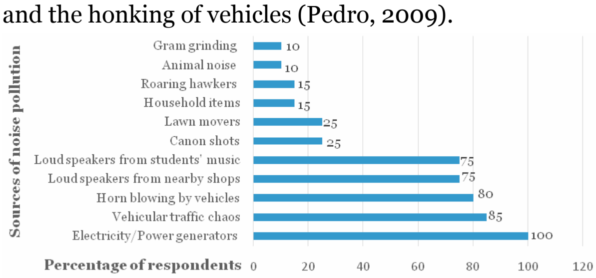

Fig. 3. Sources of noise pollution in the study area.

The result of the Chi-Square test for hypothesis 1 indicates that significant variation exists in the respondents' perception regarding the major sources of noise pollution in the study area ($X^2 = 7.627$; alpha-significance =0 .006, at $P < 0.01$) (Table 3). This means that the alternate hypothesis is accepted while the null hypothesis is rejected. This implies that the results on the various sources of noise pollution in the study area did not come by chance; on the contrary, these are the major sources of noise pollution in the area.

Table 3. Chi-Square Tests of the 1st hypothesis.

	Value	df	Asymptotic significance (2-sided)
Pearson Chi-Square	7.627	1	0.006
Likelihood ratio	11.293	1	0.001
Linear-by-Linear association	7.597	1	0.006
Number of valid cases	260		

4.3. Effects of noise pollution on the respondents

The major effects of noise pollution on the respondents' wellbeing were also investigated. These were classified into three categories: general effects, effects on body physiology, and effects on emotional intelligence (Table 4).

Table 4. Effects of noise pollution on the respondents.

General effects	Frequency (n=260)	Percentage (%)
Low tolerance	199	76.5
Irritation or anger	180	69.2
Headache	130	50.0
Low productivity	117	45.0
Stress	110	42.3
Fatigue or tiredness	100	38.5
Hypertension	97	37.3
Temporary hearing loss	50	19.2
Anxiety	50	19.2
General distraction	41	15.8
Effects on body physiology		
Lack of concentration	140	53.8
Unwillingness to read	20	7.7
Not applicable	10	3.8
Effects on emotional intelligence		
Inefficiency in studies	170	65.4
Annoyance and irritation	50	19.2
Not applicable	30	11.5
Anxiety	10	3.8

The descriptive analysis revealed that the highest share (76.5%) of the respondents reported that noise pollution in the area resulted in low tolerance, 69.2% said it caused irritation or anger, headache (50.0%), low working output (45.0%) and stress (42.3%).

These results tend to be in agreement with the findings of other authors previously showing that the effects of noise pollution include low productivity (Smith and Stansfield, 1986) and annoyance (Jakovljevic et al., 2009; Lam et al., 2009) and hearing loss (Ingle et al., 2005). In support of the previous study on the effect of noise pollution on the physiology of human body (Bowling and Edelmann, 1987), about 53.8% of the respondents reported that noise pollution results in lack of concentration, while many (65.4%) of them also indicated that noise pollution affects their emotional intelligence by reducing efficiency in their work.

The results of the Chi-Square tests for hypothesis 2 revealed that the respondents' perception of the effects of noise pollution in the study area is statistically significant (X^2 = 34.667; alpha-significance =0.000 at P < 0.01) (Table 5).

Table 5. Chi-Square test of the 2nd hypothesis.

	Value	df	Asymptotic significance (2-sided)
Pearson Chi-Square	34.667[a]	2	0.000
Likelihood ratio	30.705	2	0.000
Linear-by-Linear association	25.353	1	0.000
Number of valid cases	260		

This means that alternate hypothesis is accepted, while the null hypothesis is rejected. Therefore, the effects of noise pollution on the respondents in the survey are generally high and significant.

5. CONCLUSIONS AND RECOMMENDATIONS

This research investigated urban noise pollution in residential neighbourhoods, having as a case study the Nnamdi Azikiwe University Students' off-campus hostels in Awka, Southeast Nigeria.

The study specifically examined the noise levels, sources and effects of noise pollution in the study area. The findings revealed that firstly, the noise levels between the hours of 8:00 am and 6:00 pm at the west and east façades of the hostels were far above the permissible noise limits for residential neighbourhoods set by the World Health Organization and the Federal Government of Nigeria.

Secondly, it was also found that the major sources of noise pollution in the study area were the portable electricity/power generators, traffic chaos, horns blowing and loudspeakers form music shops and salesmen. Thirdly, the study indicates that the effects of noise from these sources on the respondents were the low tolerance level, irritation or anger, headaches as well as the lack of concentration and inefficiency in studying.

The findings of this research have some key implications for building design and construction as well as settlements planning, which deserve further elaboration. First, is that the study implies that students residing in the hostel accommodations in the neighbourhood investigated are being subjected to the levels of noise beyond the recommended limits for good health, wellbeing and productivity. This means that noise pollution constitutes an impediment to good health and academic performance of the students who live in this part of Awka, the capital city of Anambra State Southeast Nigeria.

Therefore, some remedial measures are required to address the current situation from further degeneration. In view of the observation that the west and east façades of the hostels face the directions of the sources of noise from traffic on the highway and the local market and motor parks have balconies facing the directions of the sources of noise, it is therefore recommended that the interiors and exterior walls of the west and east ends of hostel buildings be retrofitted with sound absorbing materials to dampen the sound incident on them or to prevent entering the interiors of the buildings through the windows and other openings on the façades. Similarly, in future developments, balconies, which are currently facing the sources of sources of noise in the buildings investigated, should be located opposite to the sources of noise to reduce the level of noise that enters the interior spaces via the balconies. These recommendations are in line with the view of Lee et al. (2007) and Adhikari and Thapa (2020) on noise control measures in buildings. In addition, vegetation belts could be used as effective barriers for traffic noise control along the roadsides, while green areas with facilities for rest and relaxation can be created between the buildings and the sources of noise. These will help ensure that the sound levels from road traffic, market and motor parks are reduced to the barest minimum before getting to the buildings, and that such facilities can offer the students the relief from stress and the discomfort associated with the high level of noise in the area. This in line with the opinion of previous authors (Tyagi et al., 2006) on the role of vegetation belts, courtyards and open spaces (Adhikari and Thapa, 2020) in the reduction of traffic noise.

Furthermore, the epileptic power supply situation responsible for the massive use of portable electricity (power) generating sets has been consistently identified as a major source of noise pollution in residential neighbourhoods in the urban areas in Nigeria. To this end, it is recommended that more emphasis should be given to the development and usage of alternative and sustainable sources of power supply such as solar and wind in students' hostel accommodation in the study areas and beyond. This will reduce the overdependence on fossil fuel electricity generating sets that contribute to both air and noise pollution in most of Nigeria's towns and cities.

Beyond these measures outlined above, there is also the need for the strict enforcement of the existing laws prohibiting noise pollution in urban areas in Nigeria with offenders made to face the full weight of the law. Prior to this, it is recommended that public enlightenment campaigns in electronic and print media, as well as in worship centres, markets, schools and community halls as well as seminars should be organized to enlighten and educate the people on the provisions of the laws against noise pollution and the consequences associated with violation of such laws. For urban planners, designers and managers, consideration should be given to the provision of underground transportation network to reduce traffic noise, where the location of such vital infrastructure is envisaged to conflict with the residential neighbourhoods.

In addition to this and in line with the investigation made by Olayinka (2013) on the use of earth mounds or walls of wood, metal, or concrete as solid obstacles between the road and roadside communities, it is suggested that highway noise can also be reduced by constructing sound absorption walls or screens along the edges of highways, especially, where they are close to residential neighbourhoods. Also, the findings by Watts et al. (1999) confirm that the use of porous asphalt surfacing and spatial planning and structural barriers to check traffic noise can be implemented in the case of facilities developed close to busy roads. Again, in line with the recommendations of Oviasogie (2020) on proper land use planning and zoning as mitigating strategies for the effects of noise in residential neighbourhoods, it is suggested that in future development of students hostels, architects and urban planners should ensure that such buildings are located away from markets and motor parks, where high levels of noise are generated. This is to ensure that students and indeed other urban residents are not subjected to unnecessary levels of noise that have deleterious effects on their physical and mental health and wellbeing as well as decreasing productivity in their various tasks.

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