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# Assessment of Noise Pollution from Power Generating Sets: A Case Study of Nnewi-North L.G.A, Nigeria

**S. U. Onwuka[1], C. M. Ezigbo[1] and P. S. U. Eneche[2*]**

*[1]Department of Environmental Management, Nnamdi Azikiwe University, Awka, Nigeria.*
*[2]Department of Geography and Environmental Studies, Kogi State University, Anyigba, Nigeria.*

***Authors' contributions***

*This work was carried out in collaboration between all authors. Author SUO designed the study and the first draft. Author PSUE performed the statistical analysis, produced the maps, and wrote the protocol of the manuscript. Author CME managed the literature searches and wrote the final manuscript. All authors read and approved the final manuscript.*

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## ABSTRACT

The assessment of noise pollution caused by emissions from power generating sets in Nnewi, a fast-growing town in Anambra State of Nigeria is presented in this paper. Some areas were randomly selected from the four quarters (i.e. Otolo, Umudim, Nnewichi and Uruagu) of Nnewi North Local Government Area. Noise level readings were collected for three (3) days, i.e. Monday, Friday and Saturday, during noon (11 am – 1 pm) and evening periods (7 pm – 8 pm) over a space of three months. BAFX Digital Sound Level Meter was used to collect the noise data, whereas the Statistical Package for Social Sciences (SPSS-22) was used to analyze the data obtained, using One-Sample T-Test and Analysis of Variance (ANOVA) test. Results obtained showed that there existed no significant difference between the mean noise levels of the study area and the NESREA standard. However, the mean of noise level readings for noon time (i.e. 53.31 ± 4.68 dBA) were found to be significantly different and less than the mean of noise level readings obtained during the evening period (i.e. 73.82 ± 5.83dBA). The study revealed that evening hours in the study area

**Corresponding author: E-mail: enelche.psu@ksu.edu.ng;*

are generally noisier than the standard limit for noise. In view of the rapidity of urbanization and increasing population in the area, it therefore calls for urgent steps by the government and also environmental managers, to enact policies to enlighten the populace on the need for the adoption of noise-proof (power) generating sets, retrofitted and energy-efficient building strategies such as the use of solar energy and other more environmentally friendly options that will enhance urban liveability.

*Keywords: NESREA; sound level meter; noise level and generator.*

## 1. INTRODUCTION

Unstable electric power supply in Nigeria has remained a major challenge of government. With an estimated population above 180 million people, less than 40% of Nigerians have access to electric power supply from the national grid. Less than 10% of the national electricity demand could only be met through the national grid [1]. This is one of the reasons most of the populace generate their own energy using electricity generators. Commercial electricity generation in Nigeria currently comes from 7 power stations and various independent Power Projects around the country. Current estimates indicate that over 90% of businesses and 30% of homes have diesel-powered generators, meaning that there are currently about 15 million generators in use in Africa's most populous nation, Nigeria [2]. The Energy Commission of Nigeria (ECN) [3] reported that 60 million Nigerians now own generators. In fact, noise pollution emissions from domestic generators surpass those from workplaces, trucks, and buses, and pose greater risks to human health and the environment due to proximity to homes and prolonged duration of use [4].

The Nigerian Environmental Standards and Regulation Enforcement Agency (NESREA) has identified noise as a criminal offence, punishable by imprisonment or fine or both. According to the World Health Organization (WHO), the maximum permissible noise level of 90dBA is recommended. However, in the face of all these recommendations, Nnewi North Local Government Area (LGA) have suffered for decades from the inadequate electricity service from the (government-owned) Power Holding Company of Nigeria (PHCN) and its newly privatized subsidiary, Enugu Electricity Distribution Company (EEDC), which is in charge of electricity supply to the southeastern region of Nigeria. Thus, Nnewi North residents resort to alternative supply of energy, mainly diesel and petrol fueled generators, as evidenced by preliminary field visit. With the recent increased pump price of fuel from ₦85 to ₦145 per litre (almost 100%) in 2016, the fueling of these generators may or have affected the household standard of living and businesses negatively. In fact, in a typical Nnewi household setting, electricity is used to power electronics, charge handsets, laptops and torchlights, while students use it to study at night; ironing of cloths, cooling (air-conditioning and fan), pumping of water from boreholes, microwaving food, amongst others. During the field visits, many of the small-scale business operators reported that the use of electric generators affects their businesses and profit margins negatively. In many cases, they had to either shut their businesses, or lose patronage, or hike the price of their services due to the extra cost of fueling and maintaining the electric generators. These are more of direct economic implication but other issues associated with this development are not easily traced.

Noise pollution is a major fallout of widespread generator use in the study area. As a result, there is an upsurge in the use of electricity generators in spite of the noise pollution and its consequent impact on the environment and human health (Mbamali et al. [5,6], Olayinka [7], Aderoju et al. [8], Adinife & Babatope [9], Yesufu & Ana [10] and Luqman et al. [11]). Noise pollution is serious: with noise-related damages to humans ranging from annoyance, interference or disruption of communication/ speech, distraction or loss of concentration, to difficulty in falling asleep and high blood pressure. Chronic exposure to less intense but hazardous sounds can result in a gradual seemingly unnoticed deterioration of hearing sensitivity referred to as noise-induced hearing loss (NIHL). Mbamali et al. [6] found that noise levels beyond the World Health Organization's (WHO) limit of 70 to 75dB were associated with high blood pressure, abnormal fetal development, extreme emotions and behavior. Such noise levels have also been reported to cause instantaneous hearing impairment as well as complaints and friction among neighbors. A noisy environment can be a source of heart related problems. Studies have shown that high intensity sound can cause a drastic rise in blood pressure as noise levels constrict the arteries, disrupting the blood flow. The heart rate (the number of heart beats per minute) also increases. These were evident in one study wherein the heart rate of children staying in noisy surroundings was measured and found to be more than the heart rate of children living in less noisy environment [12].

Hence, assessing the problem and programming actions for controlling noise and most importantly, its adverse impact are gradually becoming very serious issues, especially in fast urbanizing urban areas such as Nnewi in Anambra State. Although, significant numbers of research papers have been published on the subject (as shown in the preceding section of this paper) accounts for the adverse status of noise in different Nigerian cities, little or no data is available for Nnewi and environs. Therefore, the paper presents the current status/level of noise pollution in the study area vis-à-vis the permissible limit set by NESREA.

## 1.1 Literature Review

Boateng & Amedofu [13] carried out a research on noise pollution and its effects on the hearing capabilities of workers, using electricity generating plants. A highly significant correlation was found between noise exposure level, duration of exposure and the development of noise-induced hearing loss (NIHL) in corn mills and saw mills but not in the printers. Hearing impairment was also observed at the speech frequencies among some of the workers exposed to hazardous noise. These findings suggest that more specific intervention is required to protect workers exposed to such hazards at their work places.

Bisong et al. [12] studied hearing acuity loss of operators using power generators in their food grinding machines in Calabar, Nigeria. Forty food-grinding machines operators in Watt and Marian markets, Calabar, were exposed to noise for at least 6months formed the test subjects. Control subjects, however, were age and sex matched staff and students of the University of Calabar and University of Calabar Teaching Hospital, Calabar, who were exposed to low noise level. Results obtained showed that noise level in test sites (105.8±9.24dBA) was significantly higher than that in the control sites (55.5±1.78dBA; P< 0.001). At every frequency tested, the machine operators had poorer hearing acuity than control subjects. The hearing threshold of the operators positively correlated with their duration of exposure at 2000Hz and 4000Hz, and age at 2000Hz, 4000Hz and 8000Hz. The prevalence of hearing loss among the machine operators was significantly higher (62.5%), compared to control (15.79%). The incidence of symptoms such as tinnitus, insomnia and headache was also significantly higher in the test group (26.32%, 21.05% and 34.2%) than in the control (5.26%, 2.63% and 5.26% respectively). Therefore, chronic exposure to noise at 105.8±9.24dBA can impair hearing acuity and associated risk factor appears to be prolonged exposure. This should include education on the risk of noise to the ears and the enforcement of wearing ear protection devices.

Mokhtar et al. [14] researched on the effects of generators noise on industrial workers in Malaysia. Three different industries selected for the study were rubber product manufacturing, metal stamping, publication and printing. Chi-Square test was used to determine whether the effects of noise were statistically significant or not. It was found from the results of the survey, at a level of significance, α=0.05, physiological, hearing loss, auditory, and sleep disturbances were affected by the existing noise levels. The effects of noise were statistically significant. However, psychological effect of noise is found to be non-significant. Even though the minimum requirement of noise exposure is met, there are significant effects of the noise on workers in Malaysia.

Omubo-Pepple, Briggs-Kamara & Tamunobereton-ari [15] studied the sources and effects of noise pollution in Port Harcourt Metropolis. It was found that the problem of noise pollution within the Port Harcourt metropolis is endemic. A good percentage of the inhabitants reveal that the main sources of noise pollution are generators, road traffic and the use of loudspeakers mainly in religious and social activities. The potential health effects of noise pollution are numerous, pervasive, persistent, medically and socially significant. Noise produces direct and cumulative adverse effects that impair health and degrade residential, social, working, and learning environments with corresponding real (economic) and intangible (well-being) losses. They revealed that the major effects of noise included disturbance in mental health, cardiovascular disturbances, negative social behavior and annoyance reactions, interference with communication, sleeplessness, reduction in efficiency, can reduce productivity and led to impairment in teaching and learning.

Otutu [16] carried out noise pollution studies within Campus 2 of Delta State University, Abraka, to study the effects of different generators. The study made use of a digital sound level meter of type 2 model 1EC651. Noise measurements were taken from 22 locations within the campus during working hours as from 8.00am and after working hours as from 4.30 pm. The noise levels from each of these locations were taken four times each at a period (time) of ten minutes interval before the average and percentages were calculated. The result indicated that the average noise level of 87dBA in campus 2 is mostly generated by the business centers as a result of the electricity generated from different power plants, which is attributed to the frequent power failures by the Power Holdings of Nigeria. In addition, offices using small generators from a pole interval to another with voices in and out contribute a lot to the noisy environment. It was revealed that environmental noise affect sleep, conversation, academic work in terms of reading and learning, and cause annoyance as well as affects task performance. The measured noise levels when compared with the exposure limits of 90dBA as recommended by both WHO (1980) and the Federal Environmental Protection Agency (FEPA, 1991) called for urgent need in employing control strategies.

Oguntoke, Odeshi & Annegarn [17] carried out an assessment of noise emitted by vibrator-block factories and their diesel power plants (lister), and the impact on human health in Abeokuta, Nigeria. Ten vibrator concrete block (VCB) factories were randomly selected and residential areas of Odeda LGA of Abeokuta metropolis. In all, 20 workers and 20 residents were sampled. Daily noise dose (D) and the Time Weighted Average (TWA-8) exposure of the factories workers were calculated using the formulae published by the U.S. Department of Health and Human Services (24). Allowable limit of D value is 100dBA; any exceeding is unsafe. All the factories except Kammy (100dBA) were above the allowable limit; Ogo-Oluwa factory (115dBA), followed by Toluwalase (108 dBA) and Jotas (108dBA). The effects include auditory ailment such as ringing ear or tinnitus (90%), impaired hearing (70%), speech interference (90%), stress to workers and residents (100% and 90%), headache (80 and 85%), dizziness 90% and 75%).

Meanwhile, UN-Habitat [18] studied Karu, an urban slum in Abuja. After the relocation of the seat of the Government of Nigeria from Lagos to Abuja in 1991, the population of the (then) new capital city grew very rapidly. In 1991, the population of the Federal Capital Territory was 371,674. In 2006, it rose to 1.4 million, representing an average annual growth rate of 9.3 percent during the 15-year period. In 1991, Karu's population was approximately 10,000, and it grew at an astounding rate of 22.7 percent annually to reach 216,230 by 2006. The principal reason for this growth, according to UN-Habitat [18] was because Abuja failed to fully absorb the people who migrated there looking for jobs and opportunities. Electricity supply from the Power Holding Company of Nigeria was found to also be erratic, and frustrated both domestic and commercial users, hence, the incessant use of electric generators and its attendant noise and air pollution. The study found that if no action was taken to resolve the deficiencies, serious costs were to be inflicted on local, state and federal governments, as well as on the citizens themselves.

Aderoju et al. [19] carried out an assessment of the level of noise from Base transceivers' station in Abuja Municipal Area Council (AMAC), using diesel electric generators. These telecommunication providers made available diesel plants for constant electricity supply to their Base Transceivers. There are over one hundred and twenty six BTS in AMAC Abuja, which are all being serviced by diesel plant. The NESREA established a guideline of the level of noise at 65dB at daytime and 45dB at nights is required in residential environment in Nigeria. It was deduced that out of 126 diesel plant at BTS locations, 43 diesel plant at BTS location failed night-time standards but met the day-time standard while 83 diesel plants at BTS location failed both day-time and night-time NESREA standard of the level of noise respectively at a distance of 10m. At 20m distance from the BTS, the whole of the 126 diesel plants at BTS location failed for the night-time standard but passed for day-time standards. The study recommended that regulatory authorities (one of which is NESREA) should strictly enforce the penalties for violating the standard and keep these base stations away from residential areas.

Adinife & Babatope [9] studied the effects of noise pollution from generators on the residents of Obantoko, Ogun State, Nigeria. The study revealed that electrical energy occupies the top grade in energy hierarchy as it finds innumerable uses in homes. The health effects of noise among residents of Obantoko, Ogun State, Nigeria was assessed using a 43-item questionnaire. A sample size of 262 persons was randomly selected which cut across different age groups and sex. Results showed that Obantoko residents are in constant exposure of generator noise which results in adverse health effect of the habitants which includes hearing impairment, interference with spoken communication, sleep disturbances, cardiovascular disturbances, impaired task performance and negative social behavior and annoyance reactions. The negative health effects of noise noted among residents of Obantoko deserves urgent attention. The study therefore recommended that generator owner should building acoustic barrier and insulation made of rigid materials with significant mass and stiffness to reduce the noise pollution.

Yesufu & Ana [10] carried out an assessment on the knowledge and perception of noise induced health hazards associated with generator use in selected commercial areas in Ibadan, Nigeria. All 515 generator users in both communities (Agbowo: 304, Ajibode: 211) were surveyed. Information on socio-demographic characteristics, knowledge and perception were obtained with a pretested interviewer-administered questionnaire. Majority of respondents in both commercial areas, (Agbowo: 82.9% and Ajibode: 86.7%) admitted that sound from an electric generator was a noise source capable of inducing hearing impairment, but none were aware of the sound level that could cause it. The proportion of respondents with negative perception were 51.3% and 82% in Agbowo and Ajibode respectively ($p<0.05$). Few respondents perceived noise induced hearing impairment as a serious health problem as compared to other health conditions. Although more than 80% and 26% in Agbowo and Ajibode respectively perceived their workplaces to be noisy ($p<0.05$), only 11.5% and 6.6% desired to change occupation. The study recommended the need for increased awareness on the hazards associated with generator use while access to steady power supply is being advocated.

These and many other literatures show the effect of noise, especially as a result of the use of electricity generators.

## 2. METHODOLOGY

### 2.1 Study Area

Anambra State is one of the 36 states of Nigeria, and is situated on Latitudes 5° 47' N and 6° 48' N, and Longitudes 6° 38' E and 7° 21' E (See Fig. 1). There are seven urban areas recognized by the Anambra State Government, namely: Awka, Onitsha, Nnewi, Ihiala, Ekwulobia, Otuocha and Ogidi (See Fig. 2). Thus, out of the seven (7) urban areas, this study focused rather on the State's industrial nerve, Nnewi.

Nnewi is the second largest city in Anambra South Senatorial Zone of Anambra State. Nnewi comprises of two LGAs – Nnewi North and Nnewi South LGAs. It lies about 25km south of Onitsha between Latitudes 5°05' N and 6°05'N and Longitudes 6°55' E and 7°00' E, covering an area of 72.52km$^2$. Nnewi is bounded in the north by Nnobi, to the south by Utuh, east by Amichi and to the west by Ojoto. Nnewi North is commonly referred to as Nnewi Central, and comprises four autonomous quarters: Otolo, Uruagu, Umudim, and Nnewichi (See Fig. 3).

As of 2006, Nnewi had an estimated population of 391,227 according to the Nigerian census making it the second most populated town in the State. The city which spans over 1,076.9 square miles (2,789 km$^2$) in Anambra State and together with its satellite towns is a home to nearly 2.5 million residents as of 2005. However, using the 1991 and 2006 census figures and the estimations made by the Anambra State Bureau of Statistics for years 2001 – 2005 and 2009 – 2011, the population of Nnewi North and South LGAs increased also from about 260,000 in 1991 to more than 500,000 in 2016 [20].

### 2.2 Method

To effectively conduct this research, primary data were used in this study. Primary data for the study were collected from field measurement for noise levels of the immediate environment around the running generators in the area, while household heads were interviewed. Meanwhile, reconnaissance survey was carried out, before the street selection, homes with generators earmarked and generator owners interviewed.

Data were generated using experimental methods. Obviously, there are many streets in the four (4) Quarters of Nnewi Urban area in Nnewi North LGA. Four (4) streets from each of the four (4) Quarters of Nnewi North LGA were randomly chosen. However, the present study covered only sixteen (16) streets from which the household heads (respondents) were systematically chosen. The noise measurements were carried out in duplicates: in the morning (11.00 am – 1.00 pm) and evening (7.00 – 8.00pm). The BAFX Digital Sound Level Meter was used to obtain noise level from electricity generators. This was coupled with interview sessions with household heads in small groups in different streets. Meanwhile, the BAFX sound level meter ranges from 30dBA to

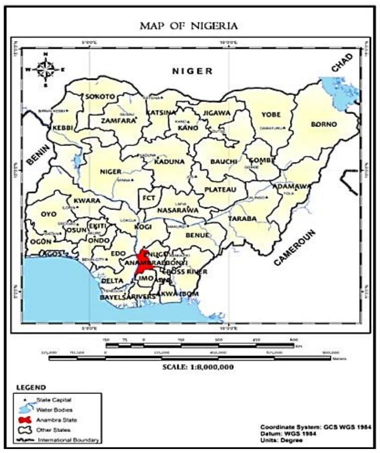


**Fig. 1. Nigeria showing Anambra State**

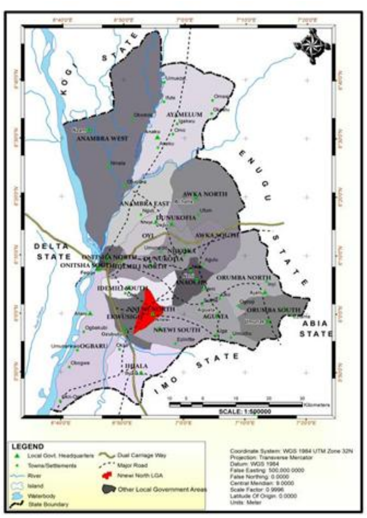

**Fig. 2. Anambra showing Nnewi north local government area**

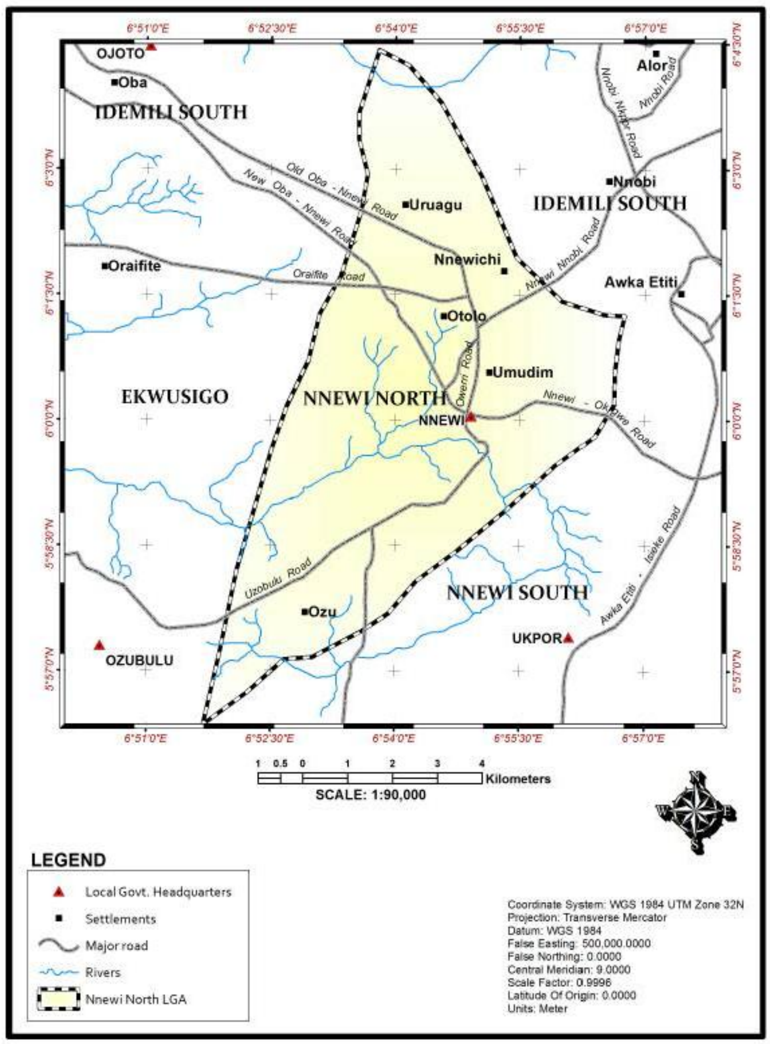


**Fig. 3. Nnewi North LGA showing the four (4) autonomous quarters**

130dBA; has an accuracy of ± 1.5dB, frequency range of 31.5Hz to 8.5KHz, digital display of 4 digits, resolution of 0.1dB, operating conditions of 0 – 50°C, 10 – 80% Relative humidity. However, to measure the noise levels emanating from the generators in the indoor environment, the sound level meter was placed at a distance of at least 1m from walls and 1.5 m above the floor. In the outdoor environment, the sound level meter was placed at 1.2 to 1.5 m above ground level and at least 3 m away from the walls, buildings, or other sound reflecting sources. During measurement, the microphone was oriented towards the points or area to be measured. This is because all intruding objects (such as the body of the sound level meter (SLM) or the operator itself) will degrade the frequency response of the microphone at high frequencies, whereas the effects of directivity appeared at much smaller frequencies. Thus, the SLM was, whenever possible, installed on a stable and sturdy tripod equipped with resilient blocks to isolate the sound level meter from vibration and consequent spurious readings. If the temperature of the instrument is significantly different from the ambient temperature where it was used, it was first warmed up before calibration and use. The calibration (done via the Standard Acoustic Calibrator) was checked at the end of each session.

Meanwhile, field investigation revealed that different electric generator sets ranging from 650 watts to 5.0 kilowatts characterized the study area. There include: ELEPAQ Generator Sv 3500 E2 2.5kw, GIO RITO Generator RT 1000 650w, JINLING Generator JL 3600 2.5kw, DUMEK DG 1000 650w, TIGER Generator 2.3kw, Sz Generator TG 1150 650w, SUMEC FRMAN SPG 3000E2 2.5kw, POWER Generator SV 2940E 2.4kw, JINLING Generator JL 2800 2.5kw, TIGER Generator TG 1000 650 watt, GASOLINE Generator LL3GF – 4A 2.8kw, G5 SUMEC Generator SPG 2500 2.0kw, TIGER Generator TG 950 650w, JINLING Generator JL 6600 5.0kw, amongst others that were not in use during the periods of noise data capture. In some instance, generator owners tend to switch usage of different electric generating sets in the morning and/or evening period, depending on the load and consumption of fuel or diesel as the case may be. The table below shows the data collected on noise level of the study area.

At the end of the data collection period, the mean for each period was computed respectively – per week and overall. This was done for three (3) days in a week (Monday, Friday and Saturday) over a period of three (3) months. However, the mean sound pressure level was logarithmically computed per street over the period based on formula given below (See Smith et al. [21]):

$$L_{AV} = 10\log_{10}\left(10^{L1/10} + 10^{L2/10} + \ldots\ldots\ldots + 10^{Ln/10}\right) - 10\log_{10} n \quad \ldots\ldots\text{(Eq. 1)}$$

Where,

n = number of different Sound Pressure Levels (SPLs) in dB
$L_{AV}$ = average of SPL in dB
L1, L2, ... Ln = first, second, to the nth SPL in dB, respectively.

Statistical analysis and data transformation was conducted using the One Sample T-Test and the analysis of variance (ANOVA) test and Microsoft Excel (2016) in the statistical package for social sciences (SPSS: version 22). ANOVA was used to test the significant difference between the noise emissions from power generating sets in the study area (at morning and evening periods) while the One Sample T-Test was used to test if a statically significant difference existed between the noise emission levels of the study area and the permissible level/standard set by the National Environmental Standards and Regulatory Agency (NESREA), i.e. 60dBA (See Aderoju, et al. [19]). The test statistics was then used to determine whether groups of data were the same or different, as it is very useful in making comparison of two or more means (statistically or significantly different) [22]. Note that with a degree of freedom $n-1$ in a T-distribution, if $T_{cal} > T_{tab}$, $H_o$, is rejected; otherwise, it is accepted.

## 3. RESULTS AND DISCUSSION

From Table 1, evening period (7:00 – 8:00 pm) recorded the highest level of sound (noise) than the morning in all the sampled points (residences); and similarly, it was noticed that the evening values were all higher than NESREA standard or permissible limits for Noise in the residential Areas. These were as a result of the use of generators mostly in the evening hours, after work and the activities of the day. The highest value for evening was got at SS16 (Agbakagu Drive, Obiofia). This is followed by SS 5 (IBBC Avenue Off Eze Ogidi Road), SS1 (St Peter's Road Odida), SS4 (Bishop Uzodike Road Odida), SS8 (Ogbufor Road) and SS6 (Eze Okalagbo Lane Akabedorji).

From Fig. 4, Evening Period (from 7 pm) readings were clearly above the morning period and the NESREA standard, implying that the use of electric generators is at its peak during evening hours. These may be because most of the residents are either at their place of work, business or workshop and hence generators

**Table 1. Mean noise levels from power generating sets in NNEWI NORTH LGA**

| S/N | Street | 11 – 1 pm Morning [dBA] | 7-8pm Evening [dBA] |
|---|---|---|---|
| 1 | St Peter Road | 51.1 | 80.1 |
| 2 | Adakwa Street | 53.2 | 71.3 |
| 3 | Agawana Street | 49.7 | 68.5 |
| 4 | Bishop Uzodike Rd | 51.8 | 78.4 |
| 5 | IBBC Avenue Off Eze Ogidi Rd | 61.3 | 82.2 |
| 6 | Eze Okalagbo Lane Akabedorji | 57.1 | 72.6 |
| 7 | Gab Onwugbewu Drive, Umuimejiaku | 49.3 | 66.4 |
| 8 | Ogbufor Road | 55.0 | 74.3 |
| 9 | Ikemba Drive Umudimkwa | 62.1 | 72.5 |
| 10 | Eme Court Rd Okpuno Egbe | 55.1 | 66.8 |
| 11 | Etiaba Road Umudim | 49.9 | 71.7 |
| 12 | Owerri Road | 46.4 | 82.1 |
| 13 | Igwe Orizu Road Okpuno | 47.5 | 70.9 |
| 14 | Ekenedili Chukwu Rd Ndimgbu | 58.9 | 67.3 |
| 15 | Agwuncha St Okofia | 53.7 | 71.8 |
| 16 | Agbakagu Drive, Obiofia | 50.8 | 84.2 |

*Note: These values are the computed mean values from power-generating sets in the streets selected above*

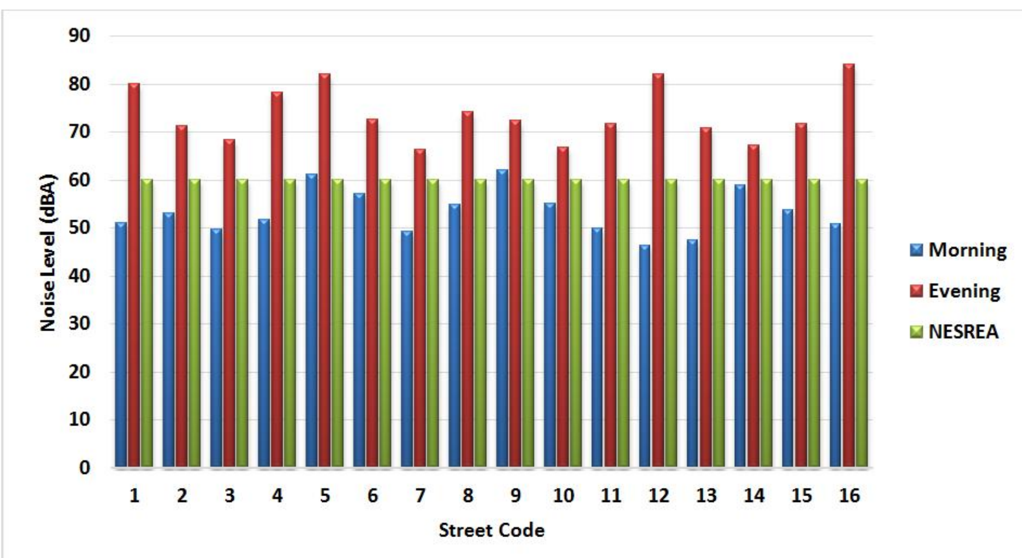


**Fig. 4. Comparison of Noise Levels [dBA] from power-generating sets in Nnewi North with NESREA permissible limit**

**Table 2. One-sample test**

| | Test value = 60 | | | | | |
|---|---|---|---|---|---|---|
| | t | df | Sig. (2-tailed) | mean difference | 95% Confidence interval of the difference | |
| | | | | | Lower | Upper |
| Noise readings | *1.731* | *31* | *.093* | *3.56250* | *-.6360* | *7.7610* |

are not needed at their homes then. Generally, the morning (11 am – 1 pm) readings were lower than NESREA Permissible Limit, except at SS5, SS9 and SS14. To check for the difference between the noise readings and the permissible limit, he result of the T-test is shown in Table 2.

In the Table 2., the top row (labelled ‘Test Value = 60’) provides the value of the known and hypothesized population mean which the data is being compared with - in this case, the NESREA standard noise level reading (60*dBA*). From the “**t**” column, we see the *t*-value of the one-sample population which is *1.731* is less than the critical value for *t*-distributions. This means the difference between the sample-estimated population mean and the comparison population mean are not statistically, significantly different. In this case, therefore, we surmise that the mean of the noon and evening noise level readings and the mean of the NESREA standard noise level are not significantly different. In this case, *p*-value for the one-sample test is greater than the chosen level of significance (0.093 > 0.05). Therefore, we must accept the null hypothesis which states "There is no significant difference between noise level in the study area, Nnewi and the permissible limit set by NESREA.

Furthermore, since no statistically significant difference between noise level and NESREA standard existed, there was need to check whether or not there exist a significant difference within and between the noise level readings collected at noon and evening times. This result is presented in the Table 3.

In the ANOVA table above, it is obvious that the significance value (Sig.) is 0.000, which is less than 0.05 indicates a statistically significant difference in the mean of noon and evening noise levels as obtained from generators from different streets in the study area, sampled. Thus, there was a significant difference between the noise level readings collected at noon and evening periods.

From Fig. 4, it is evident that evening period recorded the highest level of noise than the morning period in all the sampled points (residences) and similarly, it was noticed that the evening values were all higher than NESREA standard or permissible limits for noise in residential areas. These were as a result of the use of generators mostly in the evening hours, after work and the activities of the day. However, noise level readings acquired for SS6 (Eze Okalagbo Lane, Akabedorji), SS5 and SS9 (Ikemba Drive Umudimkwa) and SS9 (Ikemba Drive Umudimkwa) were observed to be higher than the NESREA permissible limit. The highest value for evening was obtained at SS16 (Agbakagu Drive, Obiofia). This is followed by SS 5 (IBBC Avenue Off Eze Ogidi Rd), SS1 (St Peter Road Odida), SS4 (Bishop Uzodike Rd Odida), SS8 (Ogbufor Road) and SS6 (Eze Okalagbo Lane Akabedorji), in the order.

From Table 3, the test statistic for morning and evening noise level proves that there is a significant difference between noise level [dBA] of Nnewi North and NESREA standard for noise. This may be attributed to the operation of the generators in the households of Nnewi North. According to NESREA, noise levels beyond the 60dBA for residential houses is deleterious and can lead to high blood pressure, abnormal foetal development, extreme emotions and behavior. Such noise levels have also been reported to cause instantaneous hearing impairment as well as complaints and friction among neighbors [22]. Use of electricity generators is associated with noise pollution. This is in agreement with Yesufu & Ana [10], Omubo-Pepple et al. [15], Otutu [16], Olayinka [7], Adinife & Babatope [9], Weje et al. [23], Carter et al. [24], Nwokocha & Taiwo [25] and Ofoegbu et al. [26].

Meanwhile, from the interview of generator owners in the study area, it was gathered that even though generators disturbed or served as nuisance to their immediate surrounding and/or neighbour(s), they claimed that the use of their respective electric generating sets were

**Table 3. ANOVA for noise readings**

| | Sum of squares | df | Mean square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | *3366.101* | *1* | *3366.101* | *120.555* | *.000* |
| Within Groups | *837.654* | *30* | *27.922* | | |
| Total | *4203.755* | *31* | | | |

inevitable amidst serious economic hassles they portend. Meanwhile, the study area, Nnewi (just like Onitsha [27] and Awka [28] in Anambra State is rapidly urbanizing and this will consequently translate into more people and more electric generators and hence, more noise pollution.

## 4. CONCLUSION

This study showed that both the morning and evening noise levels of the study area exceeded the NESREA Standard. The study showed heavy reliance of Nnewi North households on electricity generator for their alternative power supply, with a statistically significant difference between evening and daytime noise levels. The study also suggests that apart from the health hazard, households of the study area are likely to be affected socially and economically by this heavy reliance on generators for power supply. This is in addition to other noise effects which can be annoying and disturbing. Given the nature and rapidity of urbanization in this part of the country, Nigeria, it is expected that these ugly scenario or menace of noise pollution and its deleterious consequences will be deepened in the future. Thus, there is need for the government of Nigeria to not just expand and improve power supply from the national grid, but to also create awareness and policies to enhance retrofitted, energy-efficient building development as suggested by Nnodu, *et al.* [29], especially on the use of solar power generation options, electrical inverters and other more environmentally friendly options, to ensure and enhance urban livability.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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