Effect of Factory Process and Location on Residential Area Noise Level

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Abstract-
Tranquility is one of the healthy environment factors on the residential areas which elevate the standard of living of the people and their psychological well-being. On the contrary, when there is a high level of noise intrusion at home, it might deprive one of these benefits. This study measured the industrial noise intrusion level in the residential area with respect to distance. A total of 40 residences, with 8 each around 5 food and drug processing factory sites in three local government areas (Idemili North, Onitsha North, and South) of Anambra state, Nigeria were selected as study site locations. Benetech Model GM 1352 digital sound level meter was used for the measurement of environmental outdoor noise levels at a height of 1.5 m and 3 m from any reflecting surfaces. The distance between the factory sites and the residences assessed was calculated using the coordinates of the study site points obtained with A Garmin GPS 72H on the CDXzipdistance2WP function on Microsoft Office Excel. All measurements were carried out during the daytime between 6:00 am – 10:00 pm. Three categories of environmental outdoor samples of noise levels were obtained; off work-hour, and work hour which comprises of generator usage and the national grid connection hours. The computed $L_{Aeq}$ noise intensity level obtained at the residences assessed showed that 12(30.0) and 28(70.0) of the residences assessed were quiet and moderately loud during national grid connection hours which was; quiet 32(80) and moderately loud 8(20) during off work-hours. It, however, translated to moderately loud 24(60.0) and very loud 16(40.0) during the engagement of the services of electricity generator. The Pearson correlation analysis showed that there was a strong negative correlation between the distances of the residences assessed from the factory sites and the noise level which were significant at $p < 0.01$ for values of $r = -0.976$ during generator use and 0.981 when compared with the national grid. This implies that the closer factory sites are on the residential area the higher the noise intrusion level which is not healthy.

Key words: Noise, factory sites, residences, distance, $L_{Aeq}$

1. Introduction

The primary sources of data for the development planning of any city cover areas such as land use, housing, transportation, conservation and safety [1]. This is presumably skewed towards land use development planning to avoid issues of clustered and intermix development of the residential area and actual, or potential, sources of unpleasant sound such as airports and
factories in the same area [2]. Land irrespective of means of ownership or acquisition is necessarily subject to the local jurisdiction for any kind of development for a conducive environment that will accommodate and control different activities of man as well as towards effective urban growth and settlement pattern. The distinct feature which the urban development plan safety scheme addresses are issues on the public health and safety protection from natural or artificial hazards like noise, flood, fire, etc. [1].

Most urban areas of underdeveloped or developing countries of the world are besotted with enormous amounts of noise pollution from electricity generating plants, industrial equipment/tools, and on-road vehicles [3]. With advances in technology innovations, industrial growth and urban development, more and more acoustic problem evidence is being recorded [3 – 5]. Unpleasant or unwanted outdoor noise in the environment disrupts human life activity [6]. The range of outdoor noise levels is extremely large, ranging from the tranquil quiet of the wilderness to the noisy urban environment [7]. Mohd [5] put forward that most people are affected by noise exposure more than any other environmental stimulus. Noise from the electricity generating plant according studies is a significant contributor to the environmental noise pollution wherever they are used [8, 9]. Aaberg [10] noted that unaddressed noise levels from electricity generator set can approach 100 dBA or more. Current estimates on the electricity generating plants population made by Ibidapo-Obe and Ajibola [11] showed that more than ninety percent and thirty percent of businesses and homes have diesel-powered generators. This witnessed generator population in the nation is as a result of Nigeria’s persistent electricity crisis and the growing gap between power production and consumption. Evidently diesel-powered generators function as a supplement, emergency backup, or as the only means of electricity supply in many areas and locations where the electricity supply from the national grid is either the unreliable or non-existent. These include hospitals, banking sectors, learning institution and telecommunication networks [12, 13]. However, this is not only in Nigeria but around the globe and this has grossly undermined the industrialization process which culminate into production hitches, high cost of operation, and significantly compromising the efforts of government towards achieving sustainable economic growth and development thus, compelling the consumers to look for standby energy sources [13 – 15].

Generators being among the available options are predominantly relied on as a source for the power generation [13, 16 – 17]. Homeowners, businesspersons, and industrialists utilize generators as an off-grid source of the power generator. Industrial plant managers often engage the service of generators for almost all time electric power availability and operation efficiency of electric power dependent utility system for profit maximization, retention in business, target actualization and favorable competitiveness. Evidence in medical researches has shown that direct implication of ambient sound levels above 60 – 70 dB is significant health problems among many are depression, loss of hearing and hypertension [18 – 19]. Oyedepo [20] citing the World Health Organization stated that 60 dBA sounds for a period of 16 hours per day can affect hearing temporarily and when the sound level gets to 100 dBA it can cause permanent impairment. Mbamali et al. [21] found that noise levels beyond the World Health Organization’s (WHO) limit of 70 to 75 dB were associated with high blood pressure, abnormal fetal development, extreme emotions, and behavior. Considering that tranquility is a healthy environment factor on the residential area which elevates the standard of living of the people and their psychological well-being. High noise level intrusion might deprive one of these
benefits. Hence, this study measures the industrial noise intrusion level in the residential area with respect to distance.

2. Methodology
The study site locations in this study were residential areas around food and drug processing factory sites in three different local government areas (Idemili North, Onitsha North, and South) of Anambra state, Nigeria. A total of 40 residences were assessed 8 each in the vicinity of 5 factory sites. The characteristics of the study site locations within the Anambra state and the map are presented in the table 1 and figure 1 respectively. The geographical coordinates of Anambra state is 6° 16’ 33’’ North, 7° 0’ 25’’ East.

Table 1. Characteristics of the study site locations

| Study area characteristics | Anambra state | Idemili North | Onitsha North | Onitsha South |
|----------------------------|----------------|---------------|---------------|---------------|
| Area                       | 4,844 km²      | 115 km²       | 42.0 km²      | 10.0 km²      |
| Population                 | 4,177,828      | 431,005       | 125,918       | 137,191       |
| Population density         | 1,141/km²      | 4,959/km²     | 3,967/km²     | 18,150/km²    |
| Growth rate                | +2.84 % per year | +2.84 % per year | +2.84 % per year | +2.84 % per year |

Source: [22]

Figure 1. Map of Anambra state showing the study site locations
The environmental outdoor noise levels in the residences selected for this study were measured using a Benetech Model GM 1352 digital sound level meter calibrated by Benetech with slow response mode and A-weighting (dBA) setting (Shenzhen Jumaoyuan Science And Technology Co., Ltd., China), (Figure 3). Measurements were obtained at the outdoor of the residences at a height of 1.5 m and 3 m from any reflecting surfaces using 5 m tape rule (Figure 4). Three categories of samplings were adopted for the environmental outdoor noise levels; off work-hour, and work hour which comprises of generator and national grid power supply hours. All measurements were carried out during the day from 6:00 am – 10:00 pm. The official work hour of the factories were 8:00 am – 5 pm with break periods between 1:00 - 1:30 pm Mondays – Fridays but on Saturdays, the work hour is 8:00 am – 2:00 pm. The noise level measurements were obtained following the operation of the factories, Noise levels during the work hours were measured from 8:30 am – 1:00 pm and 1:30 – 5:00 pm while that of off work-hour measurements were obtained 7:00 – 8:00 and 1:00 – 1:30 pm. Interference of noise generated by the residences which were assessed such as the use of personal generating plants, sound system, human speeches, and animal cries was avoided. Distances between the factory sites and the residences were determined by first obtaining the coordinates of the measurement sites and the factory locations using a Garmin GPS 72H high-sensitivity handheld floatable global positioning system (Garmin Ltd. Kansas, United States) (Figure 2) then, followed by the distance was calculated using the CDXzipdistance2WP function on Microsoft Office Excel.

\[ L_{Aeq} = 10 \log_{10} \left[ \frac{1}{N} \sum_{i=1}^{N} \left( \text{anti} \log \frac{L_{Ai}}{10} \right) \right] \]  

(1)

Where

- \( L_{Aeq} \) = A-weighted equivalent sound pressure level
- \( L_{Ai} \) = A-weighted sound pressure level in dB
- \( i = 1, 2, 3 \ldots N \)
N = total number of measurements

The A-weighted equivalent sound pressure level (L_{Aeq}) computed at each of the residences assessed were analyzed on the typical noise level scale for the noise intrusion intensity from factory sites. The categories of L_{Aeq} used for the noise intensity interpretation is presented in table 2

| L_{Aeq} range          | The noise intensity interpretation |
|------------------------|-----------------------------------|
| L_{Aeq} < 30 dBA       | Very quiet                        |
| 30 < L_{Aeq} ≤ 50 dBA  | Quiet                             |
| 50 < L_{Aeq} ≤ 75 dBA  | Moderately loud                   |
| 75 < L_{Aeq} ≤ 100 dBA | Very loud                         |
| L_{Aeq} > 100 dBA      | Uncomfortably loud                |

Source [10], [24].

Statistical Package for the Social Sciences (SPSS) version 16.0 and the Microsoft Office Excel version 2007 was used to analyze the data collected. A statistical measure of the strength of the relationship and the relative movements between the distances of the residences assessed from the factory sites and the noise level was determined using Pearson Product-Moment Correlation computed at the confidence level of 0.01 for significance. The interpretation of the linear relationship of the distance of the residences assessed from the factory sites and the noise level, Pearson’s Correlation Coefficient strength is constrained within the bounds of -1 < r < 1 which is further clarified in the table 3 below

Table 3. Interpretation of Pearson’s Correlation Coefficient

| Pearson’s Correlation Coefficient (r) | Interpretation |
|--------------------------------------|---------------|
| 0 < |r| < 0.3                             | Weak correlation |
| 0.3 < |r| < 0.7                             | Moderate correlation |
| |r| > 0.7                              | Strong correlation |

Source: [25]

The interpretation of the linear relationship of the distance of the residences assessed from the factory sites and the noise level Pearson’s Correlation Coefficient strength is constrained within the bounds of -1 < r < 1 with three “extreme” correlation values of -1, 0 and 1 which is further clarified in the table 4 below. The closer the value is to 1 or −1, the stronger the linear correlation.

Table 4. Reliability of the Product Moment Correlation coefficients and Interpretation

| Sign for Pearson’s Correlation Coefficient (r) | Interpretation                     |
|-----------------------------------------------|-----------------------------------|
| Positive (+)                                 | Positive linear correlation        |
| Zero (0)                                     | No linear correlation              |
| Negative (-)                                 | Negative linear correlation        |

Source: [26]

3. **Result and discussions**
A summary of the descriptive statistics of obtained data in the survey is presented in table 5. This includes the minimum, maximum, mean and std. deviation of the calculated distances, the computed $L_{Aeq}$ at the off work-hour and the work hour (noise during generating plant use and national grid connection). The highest average $L_{Aeq}$ was obtained in residence around factory site 5 with a value of 73.49 dBA. During the national grid connection and usage by the factories’ residence around factory site 2 recorded the highest average $L_{Aeq}$ of 62.9 dBA. The highest $L_{Aeq}$ recorded during the off work-hour is 59.7 dBA in residence around factory site 5.

Table 5. Descriptive statistics of the calculated distances and the computed $L_{Aeq}$ of the study site location

| Characteristics | Variables | Factory 1 | Factory 2 | Factory 3 | Factory 4 | Factory 5 |
|-----------------|-----------|-----------|-----------|-----------|-----------|-----------|
| Distance        | Minimum   | 17.37     | 18.83     | 10.81     | 12.46     | 10.81     |
|                 | Maximum   | 73.02     | 75.03     | 64.58     | 64.72     | 56.29     |
|                 | Mean      | 39.08     | 41.4      | 37.52     | 37.22     | 36.39     |
|                 | Std. Deviation | 19.22  | 18.66     | 18.91     | 18.31     | 16.26     |
| Noise level from generator | Minimum | 63.8      | 65.6      | 63.2      | 63.4      | 65        |
|                 | Maximum   | 72.5      | 77.4      | 77.8      | 78.7      | 78.3      |
|                 | Mean      | 68.18     | 73.08     | 70.45     | 73.49     | 73.03     |
|                 | Std. Deviation | 3.15  | 4.04      | 6.54      | 5.61      | 5.06      |
| Noise level from Grid | Minimum | 46.3      | 46.3      | 44.5      | 46.7      | 53.9      |
|                 | Maximum   | 55.7      | 62.9      | 55.6      | 56.6      | 59.1      |
|                 | Mean      | 55.7      | 62.9      | 55.6      | 56.6      | 59.1      |
|                 | Std. Deviation | 55.7  | 62.9      | 55.6      | 56.6      | 59.1      |
| Off work noise level | Minimum | 45.6      | 42.5      | 41.1      | 42.1      | 41.9      |
|                 | Maximum   | 59.4      | 57.4      | 59.7      | 58.5      | 55.5      |
|                 | Mean      | 59.4      | 57.4      | 59.7      | 58.5      | 55.5      |
|                 | Std. Deviation | 59.4  | 57.4      | 59.7      | 58.5      | 55.5      |

Interpretation of the $L_{Aeq}$ computed at each of the residences on the typical noise level scale for the noise intrusion intensity from the factory sites showed that during the off work-hours the environmental outdoor noise level of the assessed residence were quiet 32(80) and moderately loud 8(20). The $L_{Aeq}$ environmental outdoor noise level the assessed residence the shifted to 12(30.0) quiet and 28(70.0) moderately loud. The noise intensity level increase as the factory sites engaged the services of a generator for power supply to moderately loud 24(60.0) and very loud 16(40.0) (Table 6).

Table 6 Analysis of the residential environment outdoor $L_{Aeq}$ on the typical noise level scale (See Table 2)

| Noise intensity interpretation | Off work-hour | Work hour |
|-------------------------------|---------------|-----------|
| Very quiet                    | 0(0.0)        | 0(0.0)    | 0(0.0)    |
Pearson correlation coefficient between the distances of the residences assessed from the factory sites and the noise level caused by generator use gave “r” value of -0.976 at the confidence level of 0.000 which is less than 0.01 (Table 7). This shows a strong negative linear correlation between the distances of the residences assessed from the factory sites and noise level emanating from the generator. It means that as the distance increases the noise level decreases. With the Pearson correlation coefficient value of -0.981 obtained between the distances of the residences assessed from the factory sites and noise level during national grid connection at \( p = 0.000 \) (Table 8), there is strong negative correlation between the distances and the noise level. This implies that the closer the factory sites are on the residential areas the high the noise intrusion level. The outcome obtained in this study similar to the findings in Larkin et al. [27] and Koper et al. [28]. The distance of the residences assessed from the factory sites and the noise level during the off work-hours of the factories’ correlation analysis for strength of linear relationship using Pearson correlation coefficient, \( r = 0.055 \) and \( p = 0.735 \) hence a weak positive correlation which is not significant since \( p > 0.01 \) (Table 9). This means that during the off work-hours there was no noise interference at the residence.

Table 7. The correlation between the distances of the residences assessed from the factory sites and the generator noise

| Distance       | Pearson Correlation | Sig. (2-tailed) | N  | Effect of the generator noise |
|----------------|---------------------|-----------------|----|-------------------------------|
| Quiet          | 32(80)              | 12(30.0)        | 0(0.0) |                              |
| Moderately loud| 8(20)               | 28(70.0)        | 24(60.0) |                              |
| Very loud      | 0(0.0)              | 0(0.0)          | 16(40.0) |                              |
| Uncomfortably loud | 0(0.0)       | 0(0.0)          | 0(0.0)   |                              |

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

Table 8. The correlation between the distances of the residences assessed from the factory sites and factory noise during the national grid connection

| Distance       | Pearson Correlation | Sig. (2-tailed) | N  | Effect of the generator noise |
|----------------|---------------------|-----------------|----|-------------------------------|
| Distance       |                     |                 |    |                               |
| Sig. (2-tailed)|                     |                 |    |                               |
| N              |                     |                 |    |                               |
| Effect of the generator noise | Pearson Correlation | -0.976** | 1 |                               |
| Sig. (2-tailed)|                     | 0.000           |    |                               |
| N              |                     | 40              | 40 |                               |
Distance

| Effect of the national grid noise | Distance | Pearson Correlation | Sig. (2-tailed) | N |
|----------------------------------|----------|---------------------|----------------|---|
|                                  |          | -0.981**            | .000           | 40 |

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

Table 9. Correlation between residences distances from the factory sites and noise at off work-hour.

| Effect of the off work-hour noise | Distance | Pearson Correlation | Sig. (2-tailed) | N |
|----------------------------------|----------|---------------------|----------------|---|
|                                  |          | 0.055               | 0.735          | 40 |

4. Conclusion

This study which measured the industrial noise intrusion level in the residential area with respect to distance under categories of samples; off work-hour, and work hour which comprises of the generator and the national grid power supply hours observed that the intensity of the noise intrusion level in the environmental outdoor of the residential areas has a strong negative correlation with the distance which implies that the closer the factory sites are on the residential areas the higher the intrusion noise levels from the factories. This deprives the residents’ tranquility which is a healthy environment factor on the residential area.

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