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https://dx.doi.org/10.4314/wojast.v15i2.9

ISSN: 2141 – 3290
www.wojast.com

DETERMINATION OF UNSAFE DISTANCE OF SOUND LEVELS FROM A 65 kVA NON-SOUND PROOF ELECTRIC POWER GENERATOR

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ABSTRACT

No matter the power rating of a non-sound-proof electric power generator, it can generate sound that adversely affects residents if proper control measures are not implemented. This work presents the determination of unsafe distance of sound levels from a 65 kVA non-sound proof electric power generator for a better environment. All sound levels were measured using a sound level meter while, a distance, x of 5m interval from the generator was maintained using a measuring tape. The background sound levels, L_{Bs} were taken when the generator was switched off while, the average sound levels, L_{Avs} were measured when the generator was switched on. The generator sound levels, L_{Gs} were calculated from the average and background sound levels. Finally, the data obtained were compared with the World Health Organization, (WHO) safety standards. The results showed that L_{Av} and L_G were not strongly correlated with L_B. Here, a linear regression model of a plot of L_{Av} against L_B had a coefficient of determination, $R^2 = 0.069$ while that of a plot of L_G against L_B had a coefficient of determination, $R^2 = 0.068$. The results revealed that the adverse effects of the generator were beyond a distance of 65 m from it. This is because at x = 65 m, the generator sound level L_G = 56.9 dBA which was greater than 55 dBA (WHO standard). It is recommended that a 65 kVA power generator of this type be installed from a distance of 70 m in residential areas.

KEYWORDS: Sound level, unsafe distance, electric power, non-sound proof, 65 kVA generator.

INTRODUCTION

Electric power generators are among the major sources of sound that can cause environmental noise pollution in our cities. This noise pollution is one of the major environmental pollutants that are encountered in daily life and has direct effects on human performance. Noise pollution in Nigerian cities is relatively high when compared to recommended levels by the World Health Organization, WHO (Oyedepo, 2012; Ekott and Menkiti, 2015). Population explosion and increasing human activities are also attributed to noise pollution in many urban areas and cities of the world. Environmental noise is often referred to as unwanted sound (Menkiti and Ekott, 2014). When an object vibrates in the open air and the process emits pressure waves into the air, sound is generated (Amos *et al.*, 2018). In most urban areas, noise pollution is a result of unplanned settlements and is perceived as the least containment among all environmental pollutants (Mansouri, 2006). Noise is a growing health threat, and if left unchecked, could result to hazardous conditions (Adejobi, 2012). Researchers have shown that constant noise above 55 dBA causes serious annoyance and above 50 dBA moderate annoyance at home (WHO, 2009). In a non-workplace and for health and safety purposes, 55 dBA is set as a safety noise level for outside and 45 dBA inside. WHO (2011) recommended community noise levels of less than 30 dBA in bedrooms, during the night for sleep of good quality and less than 35 dB(A) in classrooms for good teaching and learning conditions. Noise beyond harmless levels leads to numerous health impacts which include high blood pressure, annoyance, sleep loss, stress, hearing impairment, loss of productivity and the ability to concentrate, among others (Akpan *et al.*, 2019). Increasing noise pollution in the world has affected human beings, animals, plants and even inert objects like buildings and bridges; noise has been used to signify the hazard of sound which consequences in modern-day development is immeasurable (Mohammed, 2008). Noise exposure is not a new phenomenon as records show that even in medieval times, carriages and horseback riding were banned during the night in some cities in Europe, to prevent sleep disturbance (WHO, 2000). Hearing losses are the most common effects of noise pollution. An investigation shows that markets with very high noise levels have a high risk of adverse health effects on humans if the duration of exposure is not properly managed (Ekott *et al.*, 2022). The survival and healthy existence of man depend largely on the enabling environment where he resides, as disruption in the environment may lead to dysfunction in his health status (Passchier-Vermeer and Passchier, 2000). Traffic noise on the other hand is probably the most rigorous and pervasive type of noise pollution (Ohrstrom and Skanberg, 2004). A recent study to evaluate the health risk levels associated with types of residential noise indicated that people in the areas were exposed to many sources of noise, where cars and lorries top the list. It was maintained that planting of trees along streets, roads and highways can be adopted to reduce the levels of health risk associated with residential noise (Ekott *et al.*, 2023). Traffic noise is not usually a serious problem for people who live more than 160 m from heavily travelled free-ways (Chepesiuk, 2005). Blasts and other intense or explosive sounds can rupture the eardrum or cause immediate damage to the structures of the middle and inner ear, while, hearing loss due to prolonged noise exposure is generally associated with the destruction of the hair cells of the inner ear (Olaosun *et al.*, 2009).

Community noise is a growing issue at a global level and abnormal social behaviour is well-known as a sign of excessive community noise; and (Clark and Sörqvist, 2012). The evaluation of noise pollution from a welding workshop with a maximum noise level of (96.91±0.83) dBA indicated that the noise levels emitted during the hours of arc welding workshop had adverse health effects on the people beyond a distance, x of 55 m because at x = 55 m, the noise level was 59.37 dBA instead of 55 dBA safe level by WHO. It was therefore recommended that the safe distance for locating this type of workshop should be beyond a distance of 55 m from the residential areas (Ekott *et al.*, 2021). High noise level was discovered to cause stress and high blood pressure which is the leading cause of health problems (Mead, 2007). Findings on the determination of safe acoustic distances for installation of a 635 kVA soundproof power generator at residential area revealed that the maximum noise level of the generator was (76.88± 0.37) dBA. It was discovered that the adverse effect of this kind of generator covered distances beyond 70 m. Therefore, this kind of generator should be installed beyond a distance of 80 m from residential areas (Ekott *et al.*, 2020). Children from noisy areas have been found to have heightened sympathetic arousal indicated by increased levels of stress-related hormones, likewise, those working in noisy office environments have also been found to be less cognitively motivated, and to have higher stress levels (Holmes, 1995). In generators, investigation revealed specific noise sources as Alternator, mechanical/combustion in the engine, cooling fan, structural/mechanical system, induction, and exhaust (Jack *et al.*, 2009; Amos *et al.*, 2018). In an environmental noise impact assessment, people were exposed to many sources of noise like aircraft, tricycles/motorcycles, cars, churches, children, animals, workshops/factories, lorries, compact disk sellers, traders and ships/engine boats, power generators and night clubs (Ekott *et al.*, 2020).

Findings involving the evaluation of noise levels and distances from a business centre with a maximum noise level of (83.35±0.91) dBA showed that its noise affected the area beyond a distance of 50 m. The findings revealed that at a distance of 50 m, the total noise level was 56.3 dBA instead of the WHO-tolerant noise level of 55 dBA for a non-workplace. Hence, it was recommended that this kind of business centre should be situated beyond a distance of 50 m from the residential areas (Ekott *et al.*, 2019). In the workplace, noise pollution is generally a problem once the noise level is greater than 55 dB (A). Sources of generator noise include engine noise, Cooling fan noise, alternator noise and induction noise. Others are engine exhaust and structural/mechanical noise (Tandon and Nakra, 1999). For the betterment of our environment, this study presents the determination of unsafe distance of sound levels from a 65 kVA non-sound proof power generator.

MATERIALS AND METHOD

Sound Level Meter

A sound level meter (SLM), model WensnWS1361 with ½ inch Electret condenser microphone was used to measure all the sound levels. This model has both A and C weightings and 0.1dB resolution with fast/slow response. It has a measuring range, 30 to 130 dBA or 35 to 130 dBC. Also, it is equipped with a built-in calibration check (94.0 dB) and tripod moving. It has an accuracy of ± 1.5 dB. It has AC and DC outputs for frequency analyser level recorder, Fast Fourier Transform (FFT) analyser, graphic recorder and others. It also has an electronic circuit and readout display and a weight of 308 g. The microphone senses the small air pressure variations related to sound and converts them into electrical forms. These signals are then passed to the electronic circuitry of the instrument for processing. The readout displays the processed sound levels in dB. The sound level meter picks the sound pressure level at one instance in a certain location. Measurements were taken by adjusting the sound level meter to A-weighting network in all the sampling locations.

Noise Level with Distance Measurements

In this case, a 65 kVA non-soundproof power generator was identified. Measurements of noise levels from it as they vary with distances were taken. All noise level measurements were carried out using the sound level meter stated above, while distance measurements were made using a measuring tape. Lastly, Generator Sound Levels were calculated.

Calculating Generator Sound Level (L_G) (dBA)

The generator sound levels were calculated using Equation (1) (Cunniff, 1977; Ekott *et al.*, 2019):

$$(L_G)(\text{dBA}) = 10\log\{10^{0.1L_{av}} - 10^{0.1L_B}\} \quad 1$$

RESULTS AND DISCUSSION

Results

The results of the study showing the distance from the generator (x), background sound level (L_B), average sound level (L_{Av}) and generator sound Level (L_G) are presented on Table 1 and Figures 1 -6.

Table 1: Values of x, L_B, L_{Av} and L_G

x (m)	L_B (dBA)	L_{Av} (dBA)	L_G (dBA)
5	41.0	84.0	83.9
10	46.0	77.0	76.6
15	36.0	73.0	72.8
25	39.0	71.0	70.7
30	43.0	72.0	71.2
35	33.0	69.0	68.5
40	34.0	67.0	66.9
45	33.0	66.0	65.3
50	40.0	64.0	62.8
55	37.0	63.0	62.1
60	42.0	58.0	57.8
65	34.0	57.0	56.9
70	36.0	55.0	54.9
75	44.0	54.0	53.8
80	32.0	50.0	49.6
85	41.0	49.0	48.3
90	38.0	46.0	45.8
95	35.0	42.0	41.7
100	37.0	43.0	42.8

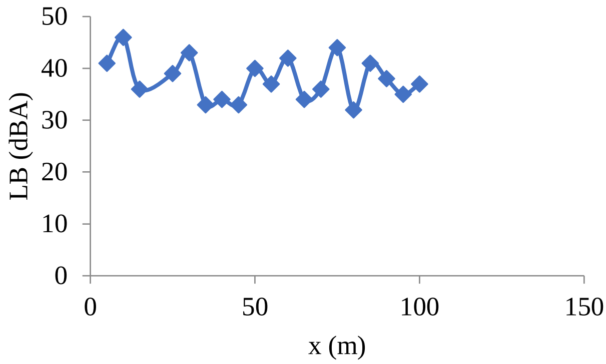

Figure 1: A plot of L_B against x

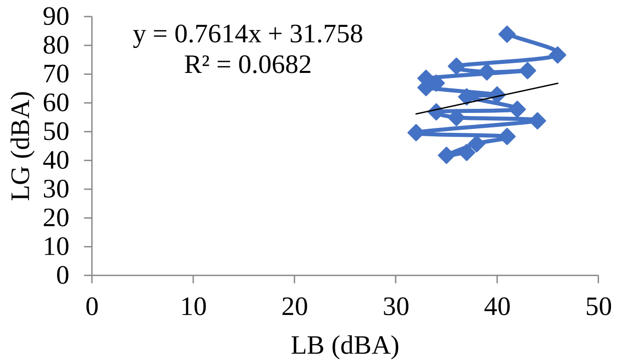

Figure 5: A plot of L_G against L_B

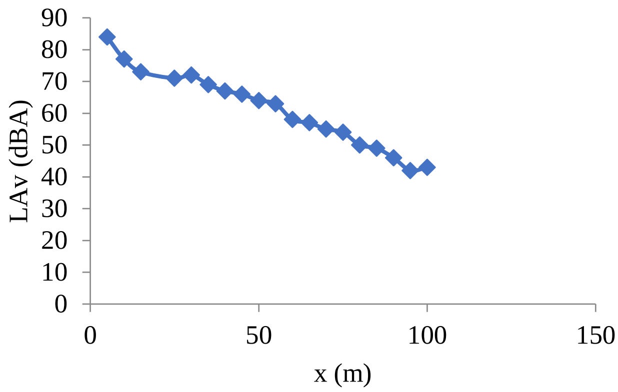

Figure 2: A plot of L_{Av} against x

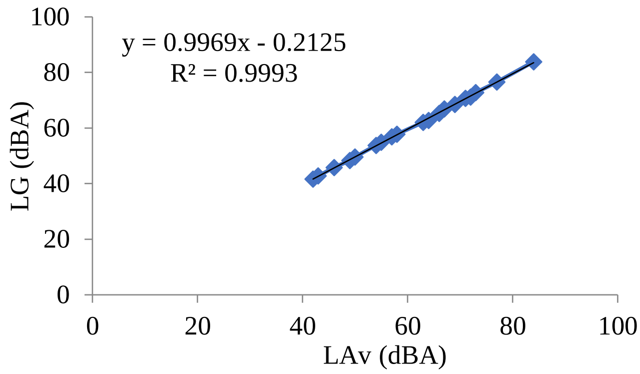

Figure 6: A plot of L_G against L_{Av}

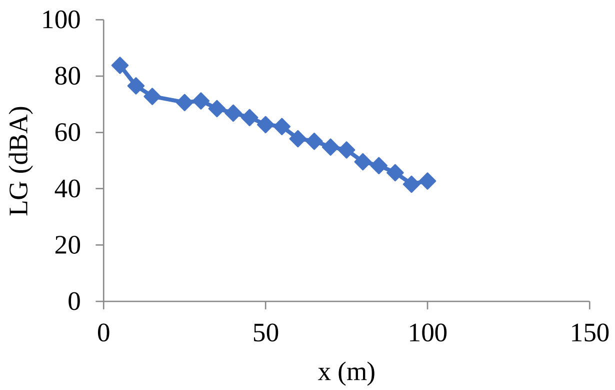

Figure 3: A plot of L_G against x

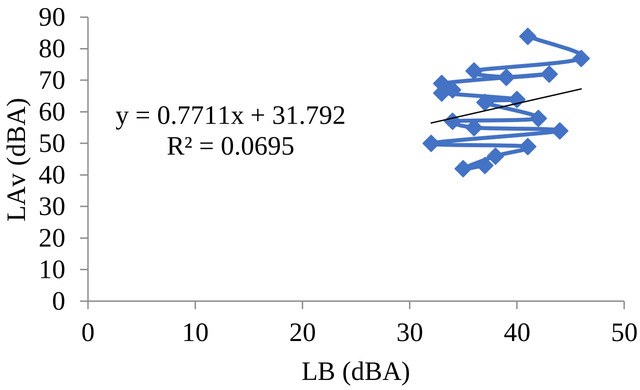

Figure 4: A plot of L_{Av} against L_B

DISCUSSION

A plot of L_B against x (Figure 1) shows that the background sound level (L_B) did not depend on the distance from the generator (x). For instance, at x= 15 m, L_B=36.0 dBA; at x= 75 m, L_B=44.0 dBA and at x= 100 m, L_B=37.0 dBA. This is because the generator (the source of sound under investigation) was switched off during L_B measurements. Figures (2 - 3) show that L_{Av} and L_G decreased with x. Here, at x=15 m, L_{Av}= 73.0 dBA, while L_G=72.8 dBA; at x=75 m, L_{Av}= 54.0 dBA while L_G=53.8 dBA and at x=100 m, L_{Av}= 43.0 dBA while L_G=42.8 dBA. This decrease in L_{Av} and L_G as x increases means that the adverse effect of the sound from the generator decreased as the distance from it increased. Linear regression models in Figures (4-5) presented as Equations 2 and 3 with their respective coefficients of determination, $R^2 = 0.069$ and $R^2 = 0.068$ show that L_{Av} and L_G are not strongly correlated with L_B.

$$y = 0.771x + 31.79; \quad R^2 = 0.069 \qquad 2$$

In Equation 2, $L_{Av} = y \; while \; L_B = x$

$$y = 0.761x + 31.75; \quad R^2 = 0.068 \qquad 3$$

In Equation 3, $L_G = y \; while \; L_B = x$

Figure 6 shows that there is no significant difference between L_G and L_{Av}. Here, a plot of L_G against L_{Av} gives a linear regression model presented as Equation 4 with coefficient of determination, $R^2 = 0.999$. This means that the generator was the main source of elevated sound in the area.

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Table 1 and Figures (1 – 6) showed that when the generator was switched off, the environment was conducive as the background noise level at any distance (x) was less than the WHO safety noise level of 55 dBA for a non-work environment. When the generator was turned on, its adverse effects covered beyond a distance of 65 m. This is because at this distance (x = 65 m) from the generator, the generator sound level was 56.9 dBA which is greater than the WHO standard for a non-work place. This type of generator should be installed from a distance of 70 m at residential areas (Ekott *et al.*, 2020).

CONCLUSION

It is concluded that L_{Av} and L_G were not strongly correlated with L_B. A linear regression model of a plot of L_{Av} against L_B had a coefficient of determination, $R^2 = 0.069$ while that of a plot of L_G against L_B had a coefficient of determination, $R^2 = 0.068$. It was shown that L_B did not depend on x. It was also revealed that the adverse effects of the generator covered beyond a distance of 65 m from it. This is because at x = 65 m, the generator sound level, L_G = 56.9 dBA which was greater than 55 dBA (WHO standard).

RECOMMENDATIONS

i. It is recommended that a 65 kVA power generator of this type should be installed from a distance of 70 m at residential areas.

ii. The use of sound proof on such an electric power generator is highly recommended, as this will help to reduce the noise emanating from it.

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