Journal of Engineering Research and Reports

Volume 26, Issue 12, Page 1-10, 2024; Article no.JERR.121791
ISSN: 2582-2926

Assessment of Noise Pollution from Petrol Generators in Nigeria: An Analysis of Distance, Capacity and Age Variables

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jerr/2024/v26i121335

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/121791

Original Research Article

Received: 04/09/2024
Accepted: 08/11/2024
Published: 25/11/2024

ABSTRACT

Irregular and epileptic power supply in Nigerian, parts of Africa and some other parts of the globe has made electricity generators the primary source of power for domestic and commercial purposes in such places. These generators produce noise pollution in the environment. Noise pollution is hazardous to human hearing and health and it adversely affect plant growth and development. This study investigated the noise generated from five different capacity gasoline generators of varying ages at varying distances, representing the range of petrol generator for both domestic and

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Cite as: *Nwabueze, Onwe David, Okafor Victor Chijioke, and Nathaniel Samuel Blessed. 2024. "Assessment of Noise Pollution from Petrol Generators in Nigeria: An Analysis of Distance, Capacity and Age Variables". Journal of Engineering Research and Reports 26 (12):1-10. https://doi.org/10.9734/jerr/2024/v26i121335.*

commercial uses in Nigeria. Five petrol generators of varying capacities 2, 3, 6, 10 and 14 kilo Volt Ampere (kVA), and age 1, 2, 3, 4, 5 years respectively were used for the experiment. The sound level from the generators were measured at varying distances of 0, 5, 10, 15 and 20 m respectively using a digital sound level meter. Two-way Analysis of Variance (ANOVA) was used to test the difference between generators of different ages at the varying distances ($\alpha = 0.05$). The sound intensity decreased as distance from the generators increased. The lowest sound was recorded for the generators of age 1, and increased as the age of the generators increased. For the capacity of generators tested, weighted (A) sound level produced by 1 year old generators at distances 0-20 m from the generator ranged from 60.9-83 dB (A) for 2 kVA generator; 60.2-84.1 dB (A) for 3 kVA generator; 64.7-86 dB (A) for 6 kVA generator; 66.52-88.02 dB (A) for 10 kVA generator; 70-91.8 dB (A) for 14 kVA generator respectively. The study showed that sound levels from generators increased as they aged. The sound levels from all the generators indicate noise pollution, as they are, on average, above the World Health Organization's specified limits of 30 and 70 decibels for indoor and outdoor environments, respectively. Consequently, the sound generated by various petrol generators is a significant source of noise pollution.

Keywords: Petrol-powered electricity generators; electricity generators; sound levels; noise pollution; World Health Organization (WHO) limits.

1. INTRODUCTION

Mechanical power required in supplying most of the energy needed for global industrialization and motorization is supplied by fossil fuels (Onwe and Bamgboye, 2022). Most of the earth's secondary source of energy comes in form of mechanical or electrical energy. The socio-economic development and standard of living of any nation are influenced by its energy generation capacity and per capita power consumption. This is evident with countries such as the United States of America, Australia, Germany and Japan with high per capita power consumption and countries like Bangladesh, Cambodia, Nigeria and Myanmar with low per capita power consumption (Etukudor et al., 2015). Nigeria as a country is highly blessed with abundant natural resources required for electricity generation. These resources include crude oil, coal, tar sands, natural gas, wind, hydro, solar radiation, numerous biofuel sources, as well as other sources of energy such as hydrogen, geothermal and nuclear energy (Ibitoye and Adenikinju, 2007). According to Babatunde et al.,2020, only 45% of Nigerians have access to electricity supply. This access is both unstable and unreliable due to inadequate generation and incessant collapse of the grid (Nweke et al., 2016). Thus, to satisfy their energy needs, Nigerians have resulted to the use of gasoline and diesel generators to augment for their power needs both for domestic and commercial purposes. This, development is accompanied with both economic and environmental consequences. Noise pollution is one of the factors listed amongst the major disadvantages of internal combustion (IC) engines in addition to low power production efficiency, high heat loss and air pollution. The pressure wave that results from alternating air pressure pulses of high and low pressure is known as sound (Kakadiya et al.,2007).

Sound, according to Amos et al., 2018 is the result of an object vibrating in open air and emitting pressure waves into the air. He noted that the decibel (dB) scale defines the level of sound from 80 to 100 dB as (very loud), 100 to 125 dB (uncomfortable) and 140 dB (threshold of pain), and 70-75 dB as normal. Noise is defined as an undesirable or an unwanted sound (Willis and Scott, 2000). The recurring opening and closing of the exhaust valves of the IC engines creates a pressure pulse from high pressure of exhaust gases being transformed to low pressure. This effect creates sound waves that produces noise. Electricity generators are normally accompanied with vibrations and noise from the engines, which poses environmental, social and health challenges to man and animals (Willis and Scott, 2000). Vibration and noise from electricity generators is a global problem (Ibitoye and Adenikinju, 2007). However, the Nigerian experience is enormous as a result of irregular and epileptic power supply, making electric power generators the primary source of power for domestic and commercial purposes (Yesufu et al., 2013, Okoro,2014, there has been a steady increase in the rate of importation of electric power generators over the years. Babatunde et al.,2020 estimated the importation of about 60 million generators of varying sizes into Nigeria, used massively in offices, business premises, homes, schools, churches, and others. Shopping or commercial centres are particularly affected, where several units operate simultaneously to run businesses. Unmuffled gasoline and diesel engines produce exhaust noise in the range of 85-100 and 100-125 decibels (dB), respectively (Okoro,2014) The human ear has the ability to receive noise from 0-140 dB (Rajendra et al., 2015) Noise from 0-80 dB can be considered healthy. As the sound level exceeds 100 dB, it will become sensationally loud to the ear, and about the threshold of 140 dB the sound level will become painful noise to the ear. Prolonged exposure to high decibel levels can lead to hearing damage (Okoro, 2014).

Plant growth and development can be adversely affected by noise pollution. Photosynthetic process can be disrupted by high decibels leading to reduced plant production (Abhishek and Kuldip,2022), According to Barberousse,2018, stress from induced noise can deter seed germination and thus affect plant production processes. Some species of plants also depend on definite acoustic signals for seed pollination. Excessive noise can disrupt this process, leading to interruptions in ecological interactions and biodiversity. A wide variety of animal species are adversely affected by noise pollution. Loud noises can disrupt natural habitats and behaviours of wildlife, causing altered migration patterns, changes in feeding and breeding habits, and increased stress levels. Excessive noise can disrupt the conveyance of vital signals to animals that rely on acoustic communication for mating, territorial defence, or parental care (Mbamali et al., 2012).

According to Mbamali et al.,2012, sound levels beyond the World Health Organization's (WHO) recommended limit of 70-75 dB have been associated with ailments such as hypertension, aberrant foetal development, intense emotions, and inappropriate behaviour. Such noise levels have also been reported to cause instantaneous hearing impairment as well as complaints and friction among neighbours. Chronic exposure to sound at above 105 dB can impair hearing acuity in addition to other associated health risks when exposure is prolonged (Bisong et al., 2015).

The increase in dependency on electricity generators in Nigeria has led to spike in noise pollution both in homes and business places which has a damaging impact on the environment, human, animal and plant health (Mbamali et al.,2012). Effects of noise on humans include: irritation, interference with communication, distraction or loss of concentration, insomnia and high blood pressure. Noise-Induced Hearing Loss (NIHL), a progressive and seemingly undetectable decrease in hearing sensitivity, can be brought on by prolonged exposure to less powerful yet harmful sounds (Orikpete et al., 2024).

The range of noise level of a normal electric generator is between 80-105 dB at 6.4 m (McNamara and Buland, 2004). This noise level fall into very loud to uncomfortably loud level with respect to sensitivity of human ears. This makes electrical generators a source of noise pollution to the environment**.** In the United States, for instance, laws and regulations usually permit noise levels in residential homes to not exceed 67 dB, and in industrial locations not exceed 72 dB (McNamara and Buland, 2004). Noise pollution from generators has been mostly mitigated using mechanical silencers for active noise control, and acoustic foam or textile materials for passive control methods (Buluklu et al., 2022).

Most previous research on noise pollution from petrol generators focused on questionnaire responses from users and assessments of noise pollution from clustered generators (Azodo et al., 2018, Onwukaet al., 2017, Azodo and Adejuyigbe, 2013). This study aims to provide a more detailed analysis by investigating noise pollution at varying distances from five gasoline generators of different capacities and ages, representing both domestic and commercial uses in Nigeria.

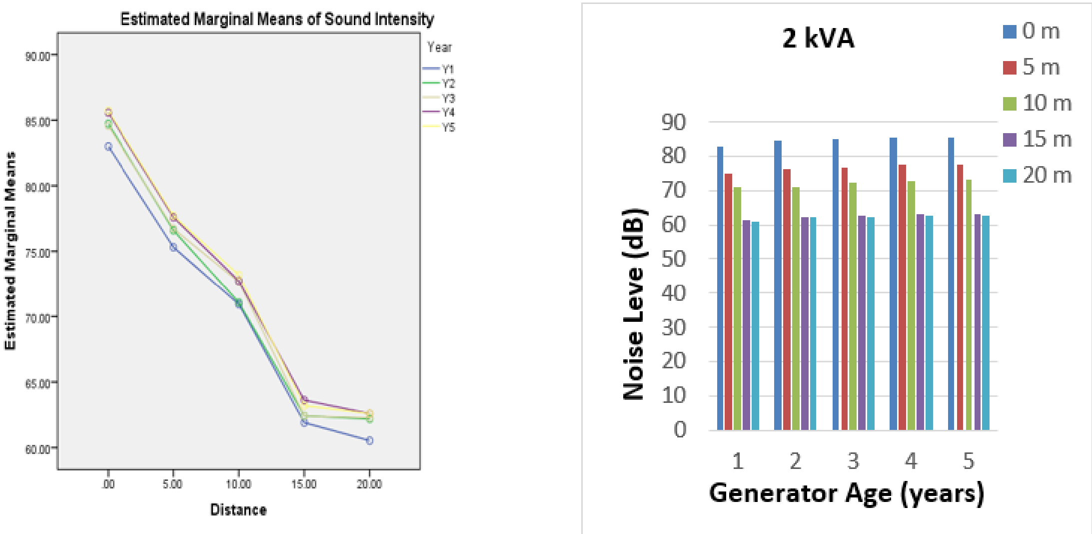
2. MATERIALS AND METHODS

2.1 Experimental Procedure

The experiment was carried out at the Department of Agricultural and Food Engineering, Faculty of Engineering, University of Uyo, Nigeria, lying between latitude $4^{0}32^{I}$ and $5^{0}33^{I}$ N and longitude $7^{0}25^{I}$ and $8^{0}25^{I}$ E. Five petrol generators of varying capacities 2, 3, 6, 10 and 14 kilo Volt Ampere (kVA), and age 1, 2, 3, 4, 5 years respectively were used for the experiment. A digital sound level meter with model no. UT353 mini sound meter [range (30-130 dB); 0.1 dB resolution; ± 1.5 accuracy; response rate (31.5-8 Hz)] was used to measure the ambient sound level. Thereafter, the sounds levels from the generators were measured at varying distances of 0, 5, 10, 15 and 20 m respectively. The experiment was carried out in three replications. The mean differences of the experimental results were analyzed using Two-way Analysis of Variance (ANOVA) to test the difference between generators of different ages at the varying distances at (α = 0.05).

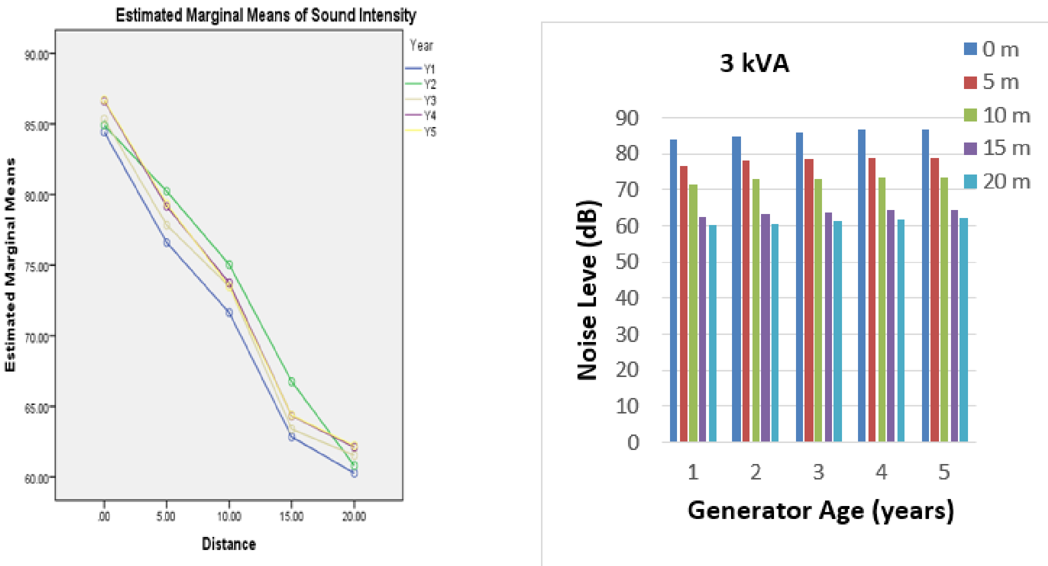
3. RESULTS AND DISCUSSION

The results of the estimated marginal mean of sound intensity generated from the various generators at varying distances and years are presented in Figs. 1-5. The model relationship of sound loudness from generator capacities against age and distance is as shown in Table 1. The two-way (ANOVA) relationship at (α = 0.05) between the ages of generators and distances from the generator and sound level is shown in Table 2.



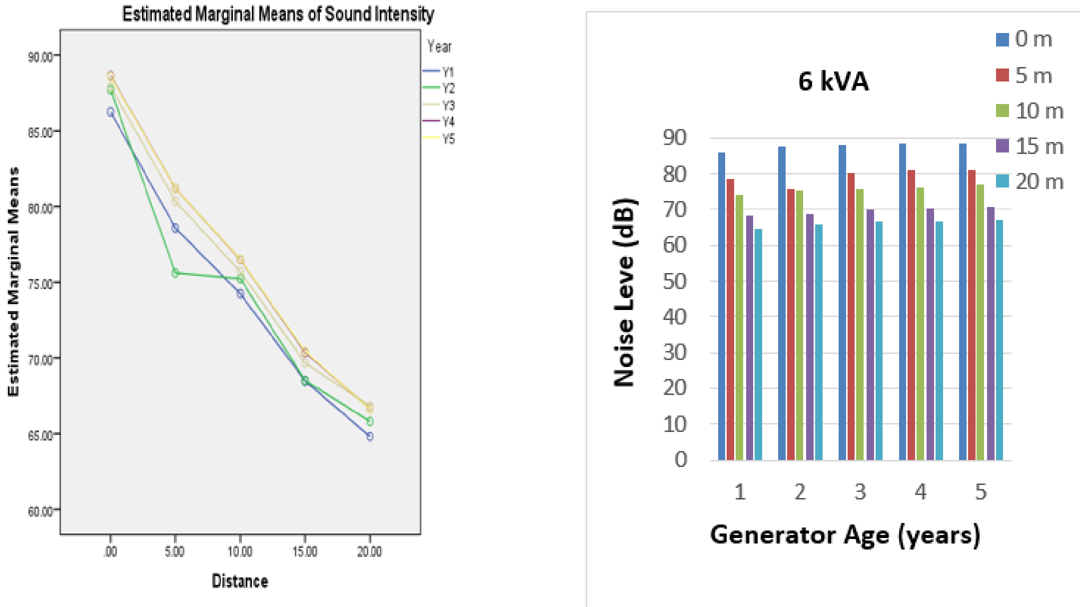
(a) (b)

Fig. 1 (a; b). Estimated marginal mean of sound intensity generated from 2 kVA generator set at different distances and years



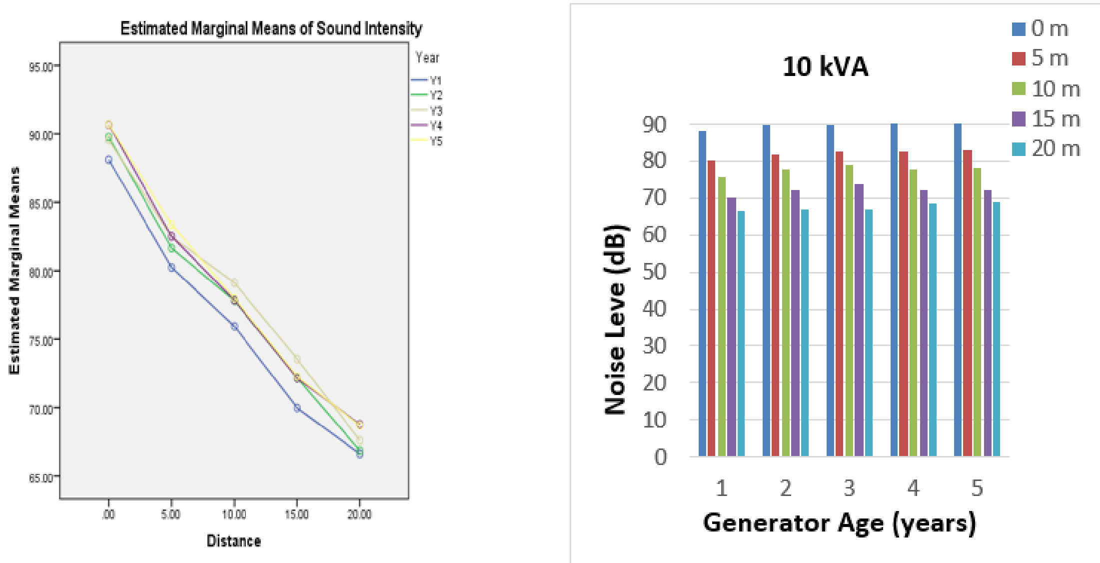
(a) (b)

Fig. 2 (a; b). Estimated marginal mean of sound intensity generated from 3 kVA generator set at different distances and years



(a) **(b)**

Fig. 3 (a; b). Estimated marginal mean of sound intensity generated from 6 kVA generator set at different distances and years



(a) **(b)**

Fig. 4 (a; b). Estimated marginal mean of sound intensity generated from 10 kVA generator set at different distances and years

As shown in Fig. 1, the sound intensity decreased as distance from the 2 kVA generator increased. The lowest noise was recorded for the generators at age 1, and increased as the age of the generators increased. This trend was the same for the higher capacity generators as shown in Figs. 2, 3, 4 and 5 respectively. For the capacity of generators tested, the sound level produced by 1 year old generators at distances 0-20 m from the generator ranged from 60.9-83 dB for 2 kVA generator; 60.2-84.1 dB for 3 kVA generator; 64.7-86 dB for 6 kVA generator; 66.52-88.02 dB for 10 kVA generator; 70-91.8 dB for 14 kVA generator respectively. This trend was the same for all the other generator capacities for 2-5 years. The results are within the range of 85.33 ± 1.47 dB at 3 m distance obtained by (Jibiri et al.,2015) Similarly, (Azodo et al.,2018). obtained mean values of 109.86, 85.95, 83.09, 80.68 and 81.69 decibels at 1-3 m distances from generators capacities of 0.5-5.0 kVA. The noise levels observed in this study are above the World Health Organization specified noise limits of 30 and 70 decibels for both indoor and outdoor cases respectively. Exposure to excessive or repetitive noise over a long duration of time can result in loss of hearing. According to Osuntogun and Koku, 2007 exposure to sound level above the range of 70 to 75 decibels can cause high blood pressure, abnormal fetal changes, extreme emotions and behaviour. Study by (Segerink et al., 2011) indicated that the degree of the effect of vibration on man and animal depends the intensity and extent of exposures. It was observed that the sound levels from the generator increases as the age of the generator increases as shown in Table 1.

Reports of noise as occupational hazard in many workplaces, is common in the iron and steel industry, foundries, sawmills, textile mills, airports, and aircraft maintenance shops, crushing mills, and more (Gerges and Sehrndt,2001). These adverse developments have brought about the need for noise suppression solutions. These include studies on occupational sound levels from some noise sources with respective reference values reported (Berger et al., 2021). For instance, mechanical noises from machine parts such as turbines can be listed as accruing from auxiliary equipment such as gearbox, generators, drift drivers, cooling fans, hydraulics (Fıcıcı et al.,2007), Some machine parts considered as auxiliary equipment constitute considerable amount of noise source which steps are to be taken to minimize to the barest minimum (Victoria,2011) Evaluation of the effects of noise pollution on the environment for effective control

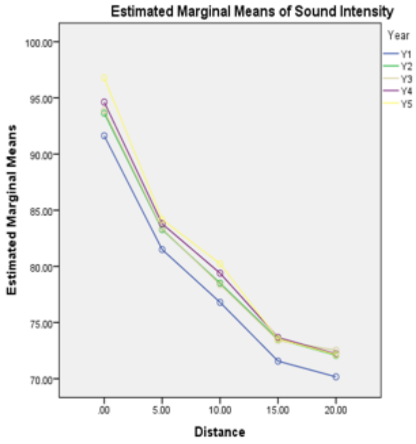
Table 1. Model relationship of sound loudness from generator capacities against age and distance

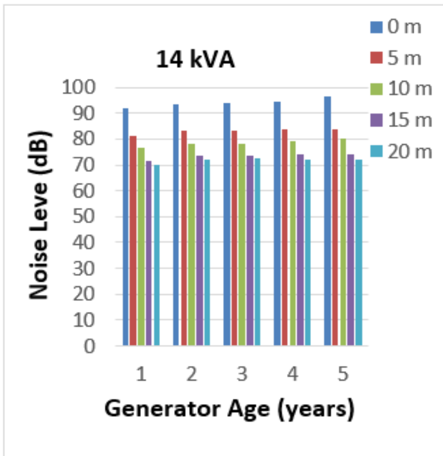
Capacity of generator (kVA)	Sound Loudness (decibel)			
	Age of Generator (year)		Distance (m)	
2	1	70.34 ± 8.70	0	84.72 ± 1.01
	2	71.40 ± 8.91	5	76.79 ± 0.92
	3	71.73 ± 8.87	10	72.12 ± 0.98
	4	72.42 ± 8.96	15	62.71 ± 0.73
	5	72.48 ± 9.10	20	62.03 ± 0.82
3	1	71.15 ± 9.20	0	85.61 ± 1.00
	2	73.54 ± 9.50	5	78.64 ± 2.00
	3	72.32 ± 9.30	10	73.48 ± 1.55
	4	73.19 ± 9.47	15	64.33 ± 2.57
	5	73.23 ± 9.48	20	61.38 ± 0.80
6	1	74.46 ± 7.81	0	87.80 ± 0.90
	2	74.57 ± 7.85	5	79.38 ± 2.19
	3	76.07 ± 7.82	10	75.63 ± 0.89
	4	76.66 ± 8.07	15	69.48 ± 0.89
	5	76.66 ± 8.05	20	66.13 ± 0.79
10	1	76.18 ± 7.87	0	89.76 ± 0.99
	2	77.65 ± 8.14	5	82.05 ± 1.11
	3	78.46 ± 7.77	10	77.74 ± 1.07
	4	78.38 ± 8.01	15	72.02 ± 1.02
	5	78.60 ± 8.12	20	67.71 ± 0.97
14	1	78.33 ± 8.04	0	94.11 ± 1.72
	2	80.21 ± 8.07	5	83.22 ± 0.96
	3	80.31 ± 8.09	10	78.67 ± 1.20
	4	80.74 ± 8.37	15	73.14 ± 0.85
	5	80.19 ± 8.20	20	71.82 ± 0.89

Table 2. ANOVA effect of age of generator and distance from generator on sound loudness

Generator Capacity (kVA)	Source	Sum of Squares	df	Mean Square	F	Sig.
2	D	5546.983	4	1386.746	16720.404	0.000
	Y	46.020	4	11.505	138.720	0.000
	D * Y	6.486	16	0.405	4.887	0.000
	Error	4.147	50	0.083		
	Total	**5603.636**	**74**			
	R Squared =0.999					
3	D	6009.094	4	1502.274	645.479	0.000
	Y	56.663	4	14.166	6.087	0.000
	D * Y	33.538	16	2.096	0.901	0.573
	Error	116.369	50	2.327		
	Total	**6215.663**	**74**			
	R Squared =0.981					
6	D	4353.927	4	1088.482	44631.855	0.000
	Y	72.131	4	18.033	739.412	0.000
	D * Y	36.698	16	2.294	94.047	0.000
	Error	1.219	50	0.024		
	Total	**4463.975**	**74**			
	R Squared =1.000					
10	D	4442.118	4	1110.529	24367.252	0.000
	Y	61.175	4	15.294	335.578	0.000
	D * Y	16.758	16	1.047	22.981	0.000
	Error	2.279	50	0.046		
	Total	4522.329	74			
	R Squared =0.999					
14	D	4876.314	4	1219.078	29307.587	0.000
	Y	77.591	4	19.398	466.338	0.000
	D * Y	16.482	16	1.030	24.766	0.000
	Error	2.080	50	0.042		
	Total	**4972.467**	**74**			
	R Squared =1.000					

Note: D = Day, Y = Year





(a) **(b)**

Fig. 5. Estimated marginal mean of sound intensity generated from 14 kVA generator set at different distances and years

can be achieved by arranging noise maps (Wabarakatuh and Sejahtera,2007). According to Caliskan et al., 2007, noise maps, either regional or local are ideal to be prepared at certain times of the day. Noise map should be made for the stage, tent, generators and other structures that are planned to be used temporarily on the facility or an area. Noise Mapping Guide, (Noise Mapping Guide, 2008) studied noise map for generators. Hermes, [36] evaluated the noise generated from commercial and industrial generators, commercial workplaces and industrial production areas. They noted that the parameters such as the source and the path of sound and the receiver should be evaluated distinctly. They observed that the most important factor in reducing noise pollution is to control it at source. Thus, the environment can be protected from the noise generated at the source. Furthermore, noise can be reduced in the area where it spreads. However, noise reduction at the source is more effective. Noise was reduced in different generator types using with different materials with acoustic properties (Toprak and Akturk, 2002).

The values of Probability of F lower than 0.05 as shown in Table 2 indicates a significant difference in noise level of the generators as they age. The probability values are less than 0.05 for all the generators 2, 3, 6, 10 and 14 kVA at age 1, 2, 3, 4 and 5 years respectively across all the distances investigated. Also, the very high of coefficient determination R^2 values are greater 0.9990 indicates a large significant effect. The sound intensity was lowest between year 1-2 and loudest between year 4-5.

4. CONCLUSION

Investigation of sound levels from different petrol generators of varying capacities and age was carried out. The range of sound levels observed in the study fall into loud and very loud levels relatively to sensitivity to human ears. This makes electrical generators a source of noise pollution to the environment**.** The sound levels were above the World Health Organization (WHO) specified noise limits for both indoor and outdoor cases respectively. Sound levels beyond the (WHO) recommended limit of 70-75 dB have been associated with disturbances and ailments such as irritation, interference with communication, distraction or loss of concentration, insomnia and high blood pressure, Noise-Induced Hearing Loss (NIHL) and deafness. Nigeria's dependence on electricity generators has caused an increase in noise pollution, both in homes and workplaces, which has a negative environmental impact on human, animal and plant. The noise pollution caused by petrol generators necessitates the development of solutions for noise mitigation.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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