Toxic Gas Emission Rate of Small-Scaled Industrial Generators

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Publication Date: 2025/02/13

Abstract: This study identified various components of flue gas emission from small-scaled sound proof and locally coupled generators with different capacities. The analysed gases included methane (CH_4), nitrogen dioxide (NO_2), carbon monoxide (CO), Sulphur dioxide (SO_2), hydrogen sulphide (H_2S) and ammonia (NH_3). The noise level and volatile organic carbon (VOC) were also analysed. The capacity of soundproof generators ranged from 20 to 60 KVA, while that of the locally coupled generators ranged from 7.5 to 10 KVA. The distances of the generator exhaust and the point of analysis ranged between 1m and 10m. The results indicated that the generators (locally coupled or sound proof) have greater influence on the emission rate gases, but the soundproof generators slightly released more gases than the locally coupled generators due to aging. For instance, the concentration of CO emitted from the soundproof generators at 1m distance ranged from 2 – 26 ppm, while for the locally coupled generators, it ranged from 8 – 15 ppm. The average value of 95.7Hz, from locally coupled generators shows that soundproof generators are better in sound pollution with an average value of 80.26H_2. Generally, generators used beyond 7yrs have higher rate of gaseous emission.

Keywords: *Flue Gas, Soundproof, Pollution, Hazards, Concentration, Distance, Capacity.*

How to Cite: Jinyemiema Tamuno K.; Godam, Salem B. (2025). Toxic Gas Emission Rate of Small-Scaled Industrial Generators. *International Journal of Innovative Science and Research Technology*, 10(1), 2318-2325. https://doi.org/10.5281/zenodo.14862902.

I. INTRODUCTION

The issue of power generations and consumption is a global problem, whereas the developed world has catered for her power generation and effective distribution needs, sub-Saharan African still struggles with power generation for her teeming population. Erratic power supply has become part of social life in most part of Nigeria and most part of west Africa which warrants both individuals and corporate bodies to acquire their own generation plants in order to meet up their daily power needs. This has caused a lot emission of toxic gases into the immediate environment.

Though there are several sources of emission into the society, for the purposes of this study, only small scaled industrial generators are considered. In order to achieve the millennium development goals, most governments in sub-Sahara Africa are now encouraging the development of small and medium scaled enterprises (SMES), without meeting up the power needs of these industries. With this situation, the choice of generators is not optional, if they must continue in business. In our oil rich city of Port Harcourt, every company and home have a generator. Investigation reveals that, there is one generator within 4-meter space i.e., a line density of 0.25 gen per meter (Robert & Dibia, 2022). Although, this figure is alarming, it is likely to increase with population, as more enterprises come into the scene. Unless some measures are taken to cocktail this ugly incidence.

The essence of this study is to identify the various components of flue gases emitted from generators, identify the hazards associated with such emissions and possibly suggesting safer measures for both users and passers-by.

➢ *Ojectives of the Study Include the Following:*

- Identify the various constituents of flue gas from small scaled generators
- To investigate the relationship between age of generator and emission rate
- To predict safer distance for such generators, during usage
- To inform the general public on the dangers of generator usage in an industrial environment
- To predict appropriate age for generator usage and disposal

II. REVIEW OF LITERATURE

Fuels used for small-scaled generators are mostly processed from petroleum hydrocarbon, which contains carbon, hydrogen, oxygen as major constituents, and Sulphur, phosphorus as impurities. During combustion of hydrogen, carbon dioxide and water are expected under complete

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14862902

combustion. However, virtually all combustion processes under normal conditions appears incomplete, producing carbon dioxide (CO_2), carbon monoxide (CO) water (H_2O), nitric oxide (NO) as constituents (Ifeanyi & Nnaji, 2023). Carbon monoxide is a highly toxic gas; it combines with hemoglobin in red blood cells, instead of oxygen (Kassa *et al*., 2023). The emission of harmful gases and particulate matters from small-scaled generators causes dizziness, respiratory tract infections, carbon monoxide poisoning, fatigue, headache, and depression (Ezetoha *et al*., 2020).

During combustion, oxygen, nitrogen and other gases in air reacts with the fuel. As combustion progresses, the oxygen is progressively used up and the proportion of nitrogen and other gases available to oxygen increases. To ensure complete combustion, it is necessary to supply air in excess which will completely burn all the combustible elements in the fuel. The unconsumed oxygen and other gases, which did not take part in the reaction, pass leaves through the exhaust as flue gasses.

A study conducted by Giwa *et al*. (2019) to investigate the level gases emitted from the exhaust of gasoline powered generator and their impacts on the environment, revealed that their efficiency had a greater impact on the concentrations than their age. Additionally, they found that the average concentrations of CO and $PM_{2.5}$ in the generators exhaust were higher than their maximum required limits, indicating their risks to human health. Also, the study Robert and Dibia (2022) reported that the average level of CO emission from gasoline generators in selected business centers in Rivers State exceeded the standard limits of 50ppm.

However, studies have recommended ways of reducing exhaust gas emission. Thus, Ezetoha *et al*. (2020) noted that the health effects of harmful gases emitted from generator exhaust can be reduced by ensuring the proper use and safe maintenance practices, while Emmerich *et al*. (2022) recommended that CO poisoning associated with generator gaseous emission can be addressed by shutting off generator when specific CO concentration is detected beyond emission rate requirement.

In another study conducted to reduce gaseous emissions from internal combustion engines, it was reported that fuel blended with 5 to 20% bioethanol reduced the emission of harmful gases (Frank *et al*., 2022). Overall, Robert and Dibia (2022) proposed that government should consistently provide power supply to discourage the use of gasoline generators.

III. MATERIALS AND METHODS

The approach adopted for the experiment is quite simple. Test was conducted for each generator at varying distances of 1m, 5m and 10m away from the generator.

Instrument used for the flue gas emission measurement was calibrated IBIRID MX6 industrial scientific meter, while Extech sound level meter was used for the measurement of sound pollution rate.

➢ *For the Purposes of Analysis, the Generators were Categorized as:*

- Locally coupled generators (non-sound proof generators)
- Sound proof generators

Before carrying out the experimental analysis, the apparatus (MX6 industrial scientific meter and Extech sound level meter), Model 407745, was carefully placed before the flue gasses from the exhaust at the distances of 1m, 5m and 10m respectively. At each point, the pollution rates between the exhaust and apparatus were recorded. At the same the sound intensity was measured using the sound meter.

IV. RESULTS AND DISCUSSION

The results obtained from the experiments on the generators are shown in Tables 1 &2.

Table 1: Exhaust Gas Volumes, Distance and Noise Content from IBIRID MX6 Industrial Scientific/Extech Sound Level Meter

S// NN	CAPACITY (KVA)	DISTANCE (m)	CH_4	NO_2	CO	SO_2	H_2S	NH_3	VOC	NOISE	GPS(DST)	YRS
1	30	1	0.0	0.6	19	1	0.0	0.0	0.8	77.4	4.8127^0N	2
		5	0.0	0.0	1	0.0	0.0	0.0	0.0	68.5	6.99894^0E	
		10	0.0	0.0	1	0.0	0.0	0.0	0.0	73.3		
2	25	1	0.0	0.3	2	0.3	0.0	1	0.1	84.1	4.81199^0N	11/2
		5	0.0	0.1	0.0	0.0	0.0	1	0.0	75.9	7.00140^0E	
		10	0.0	0.0		0.0	0.0	2	0.0	72.1		
3	60	1	0.0	1.2	13	0.0	0.0	2	0.4	90.7	4.81235^0N	
		5	0.0	0.3	1	0.0	0.0	2	0.0	87.1	7.0096^0E	
		10	0.0	0.0	0	0.0	0.0	2	0.0	79.8		
4	27	1	0.0	1.8	13	1.2	0.0	2	0.6	89.6	4.81235^0N	
		5	0.0	0.6	8	0.6	0.0	3	0.4	83.6	7.00389^0E	
		10	0.0	0.4	3	0.3	0.0	3	0.2	78.9		
5	20	1	0.0	0.2	2	0.0	0.0	0.0	0.1	79.3	4.80608^0N	3
		5	0.0	0.1	1	0.0	0.0	0.0	0.1	70.3	7.00971^0E	
		10	0.0	0.1	1	0.0	0.0	0.0	0.0	79.3		
6	60	1	0.0	0.9	26	0.5	0.5	1	0.8	96.0	4.81317^0N	7

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14862902

		5 10	0.0 0.0	0.7 0.3	12 4	0.0 0.0	0.0 0.0	1 1	0.4 0.2	92.8 86.2	6.99502^{0}E	
7	30	1 5 10	0.4 0.2 0.0	0.1 0.2 0.1	3 2 1	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.2 0.1 0.0	72.6 73.5 78.3		3

Table 2: Exhaust Gas Volume, Distance and Noise Content from Locally Coupled Generators

S/N	CAPACITY (KVA)	DISTANCE (m)	CH_4	NO_2	CO	$S0_2$	H_2S	NH_3	VOC	NOISE	GPS (DST)	YRS
1	7.5	1 5 10	0.0 0.0 0.0	0.20 0.30 0.10	12.00 8.0 3.0	0.00 0.00 0.00	0.60 0.00 0.20	1.0 0.0 1.0	0.40 0.00 0.01	97.8 92.3 86.6	4.79140^{0}N 6.98186^{0}E	3
2	10	1 5 10	0.0 0.0 0.0	2.20 1.60 1.4	15.00 10.00 8.00	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.2 0.1 0.1	93.5 85.6 77.3	4.79744^{0}N 6.98186^{0}E	1
3	7.5	1 5 10	0.0 0.0 0.0	0.4 0.2 0.1	8 4 1	1.3 0.3 0.0	1 1 1	1 1 1	0.4 0.1 0.0	96.4 84.4 79.2	4.81218^{0}N 7.00140^{0}E	

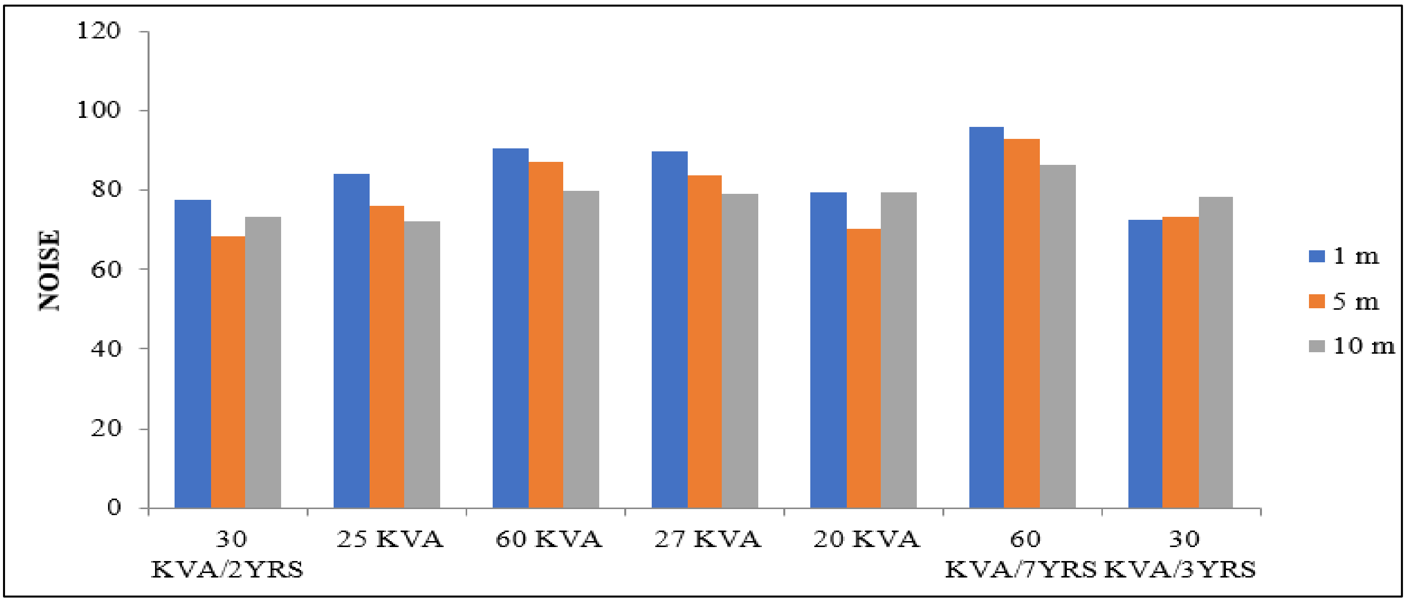

Fig 1: Sound Intensity of Sound Proof Generators

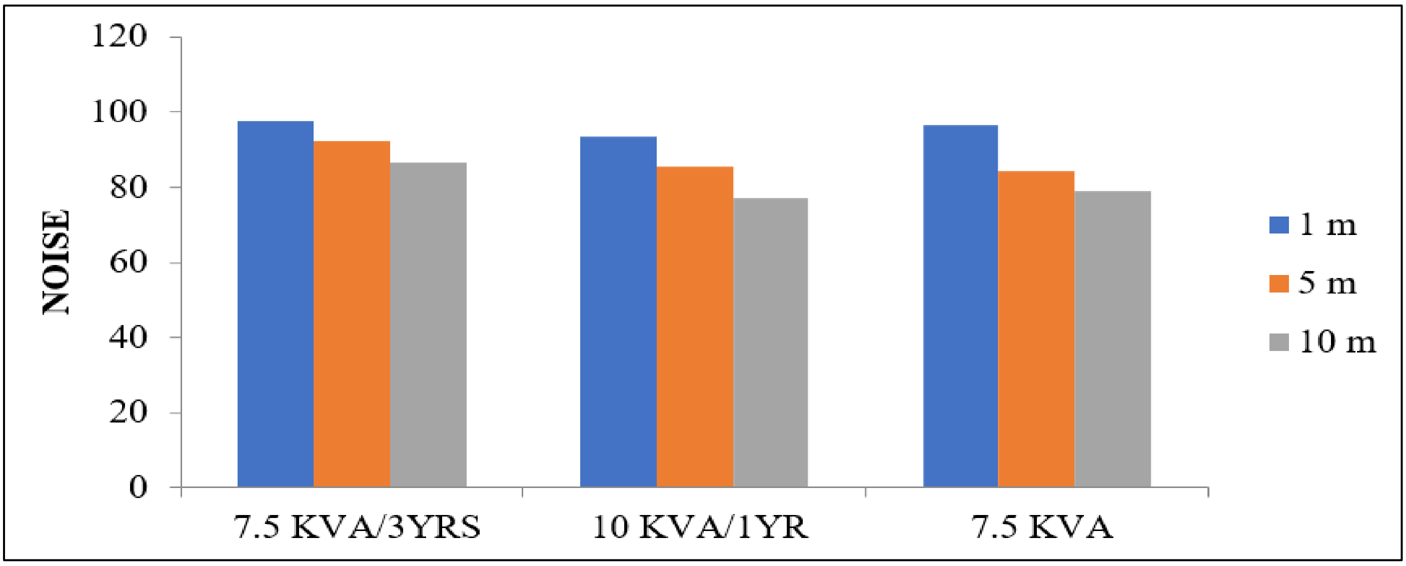

Fig 2: Sound Intensity of Locally Coupled Generators

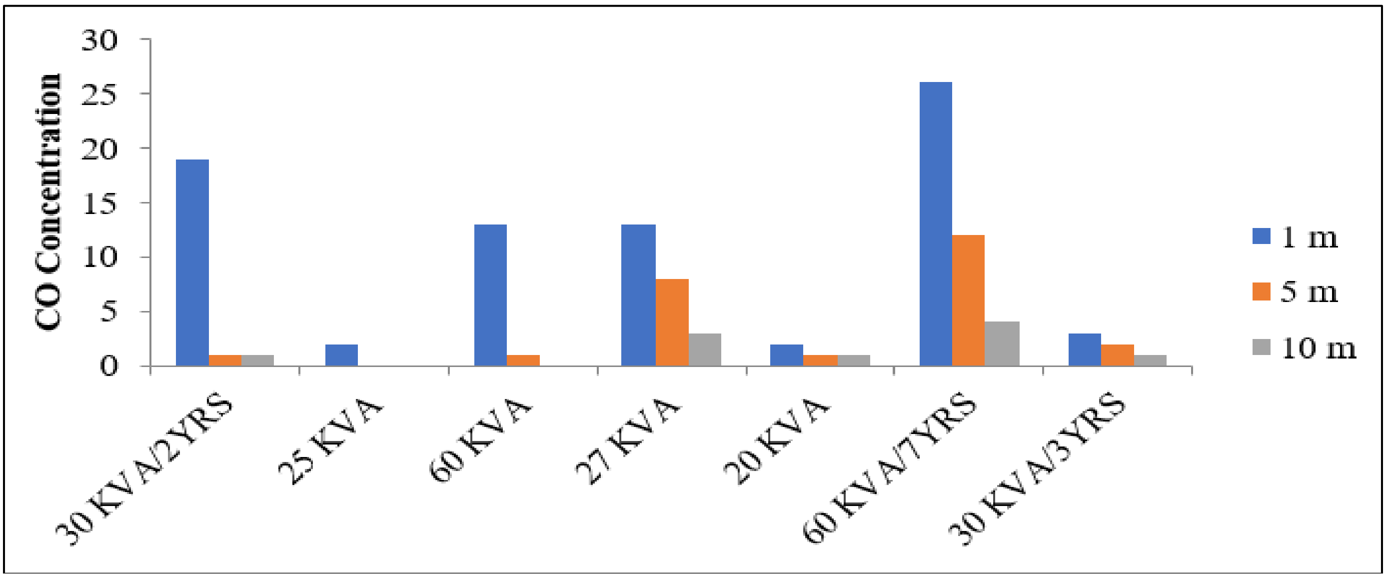

Fig 3: Emission Rate of CO Concentration from the Sound Proof Generators

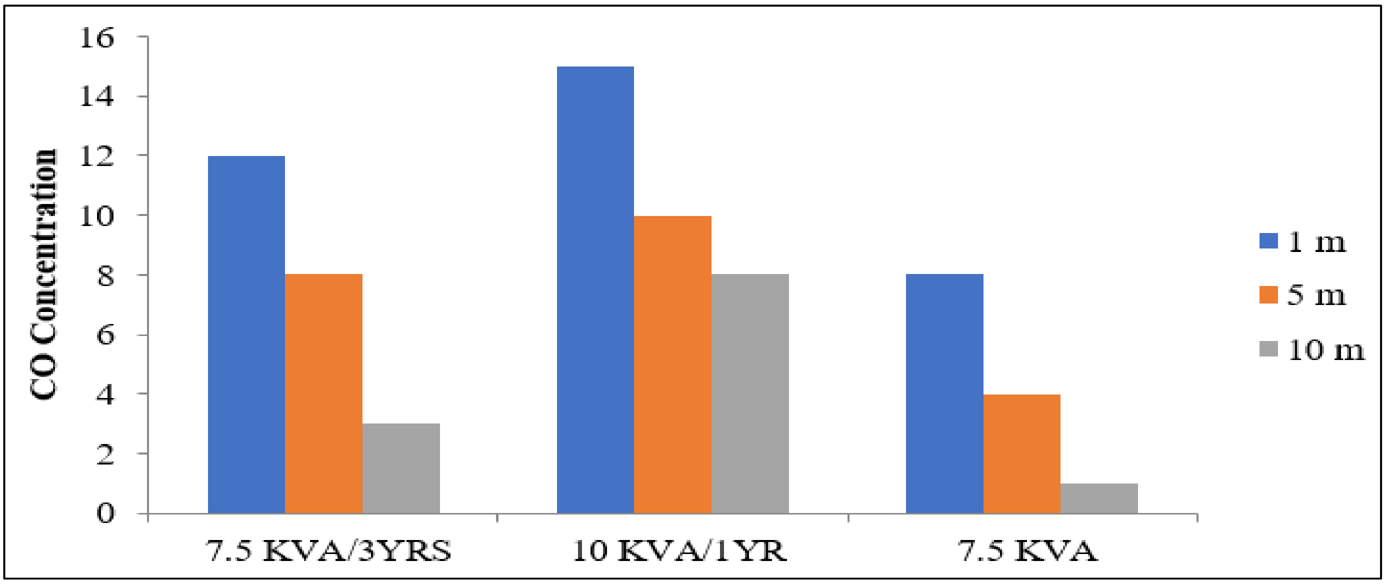

Fig 4: Emission Rate of CO Concentration from Locally Coupled Generator

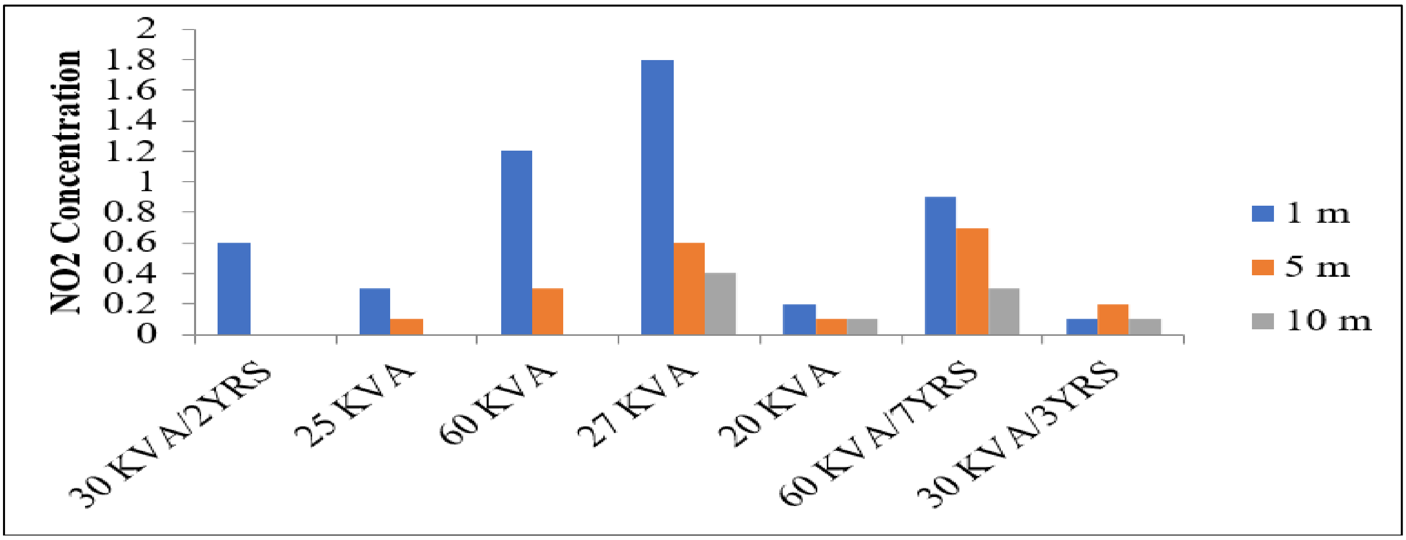

Fig 5: Emission Rate of NO_2 Concentration from the Sound Proof Generators

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14862902

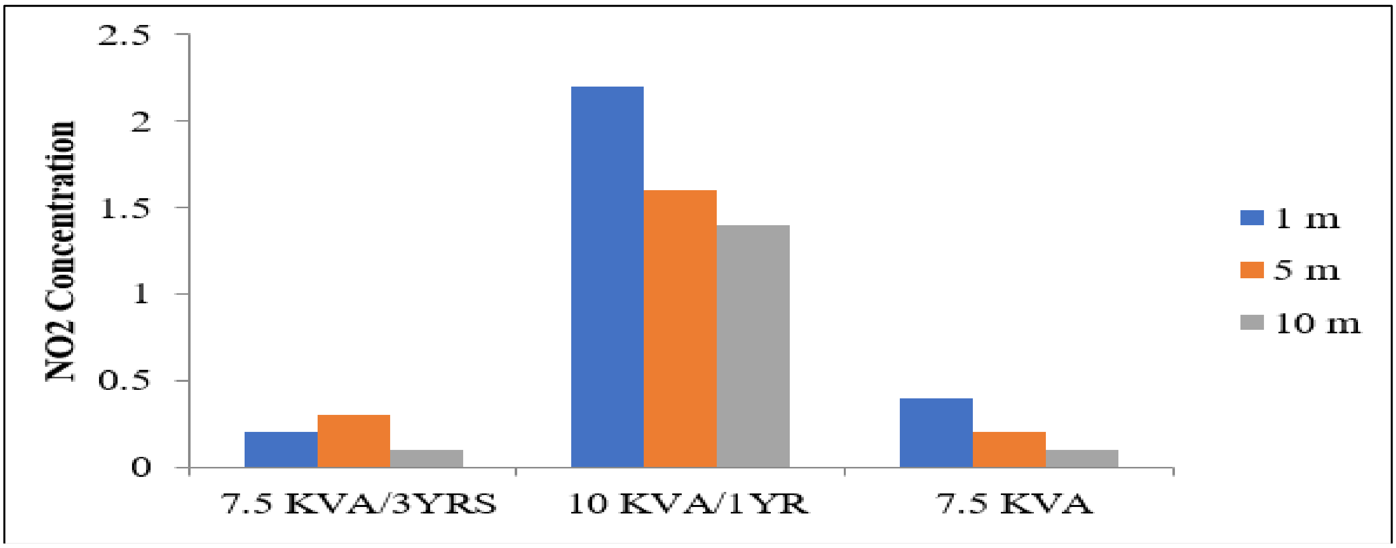

Fig 6: Emission Rate of NO_2 Concentration from Locally Coupled Generator

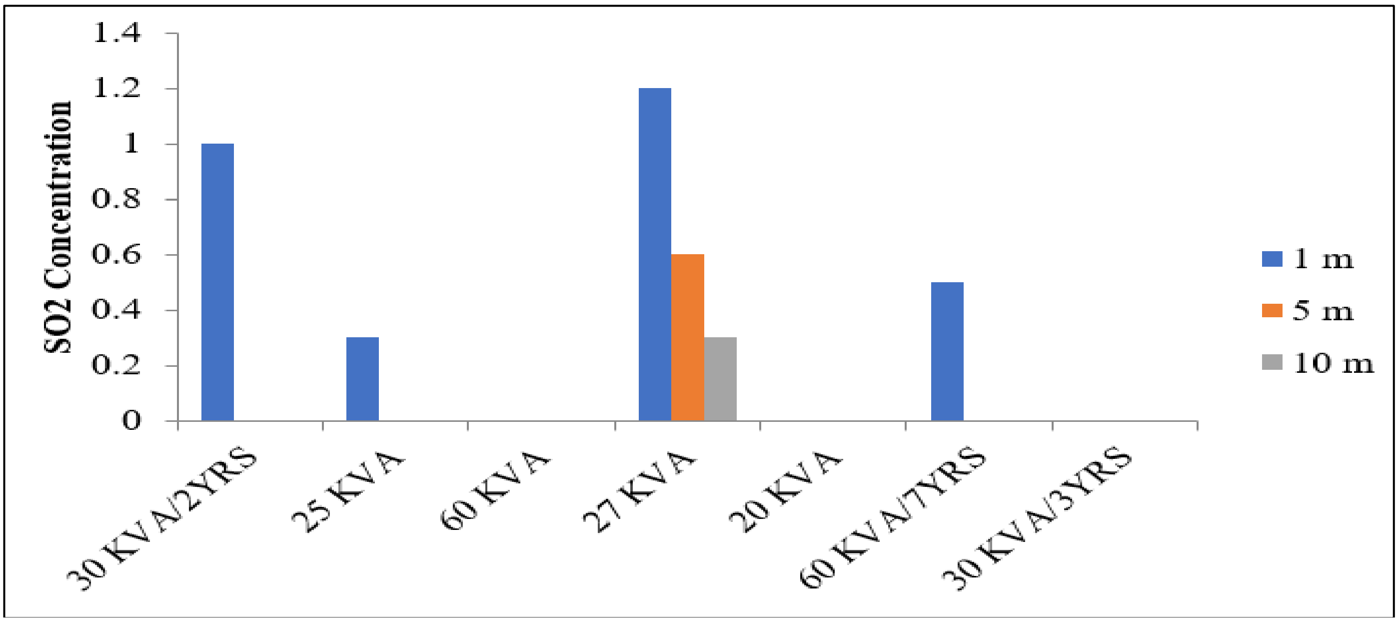

Fig 7: Emission Rate of SO_2 Concentration from the Sound Proof Generators

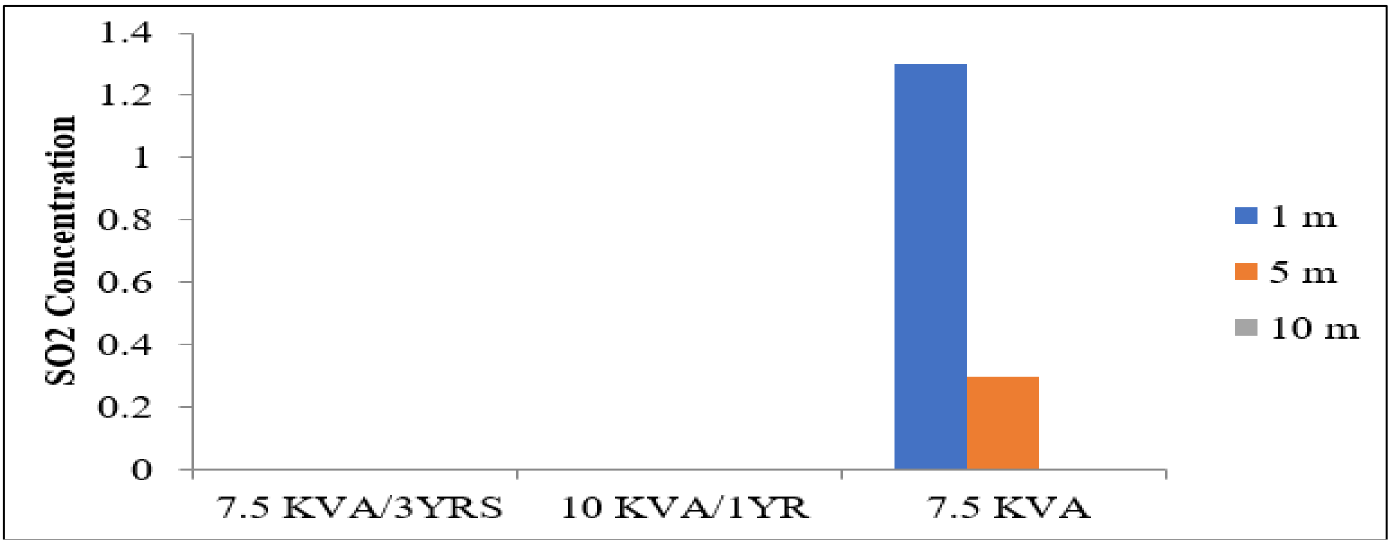

Fig 8: Emission Rate of SO_2 Concentration from Locally Coupled Generator

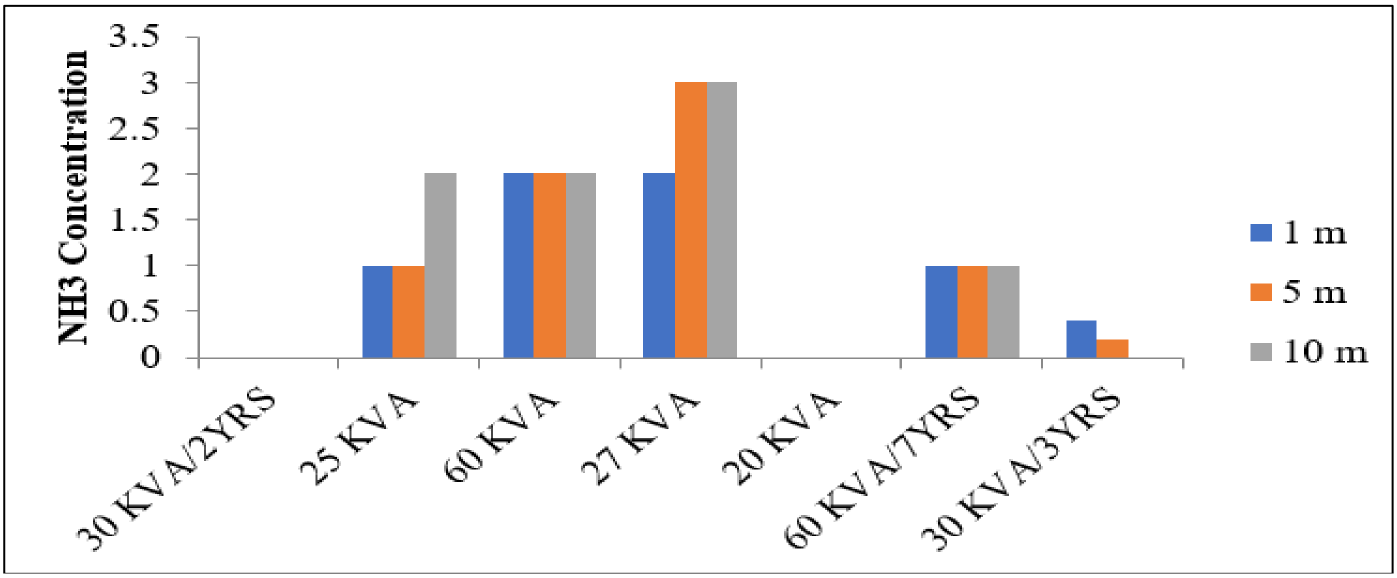

Fig 9: Emission Rate of NH_3 Concentration from the Sound Proof Generators

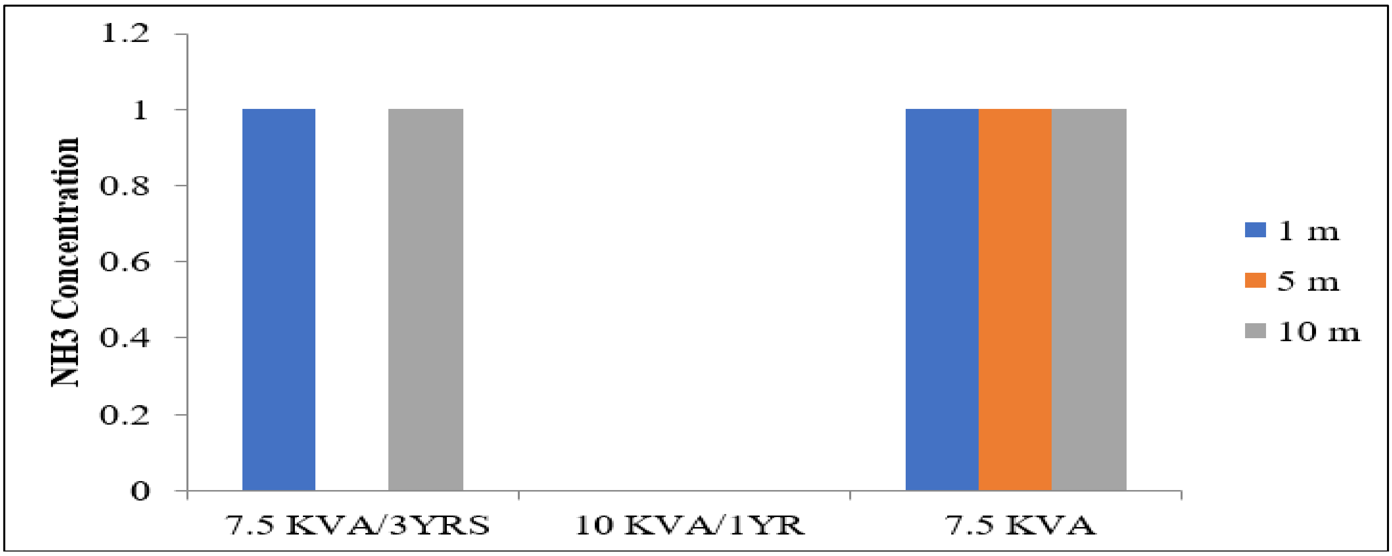

Fig 10: Emission Rate of NH_3 Concentration from Locally Coupled Generator

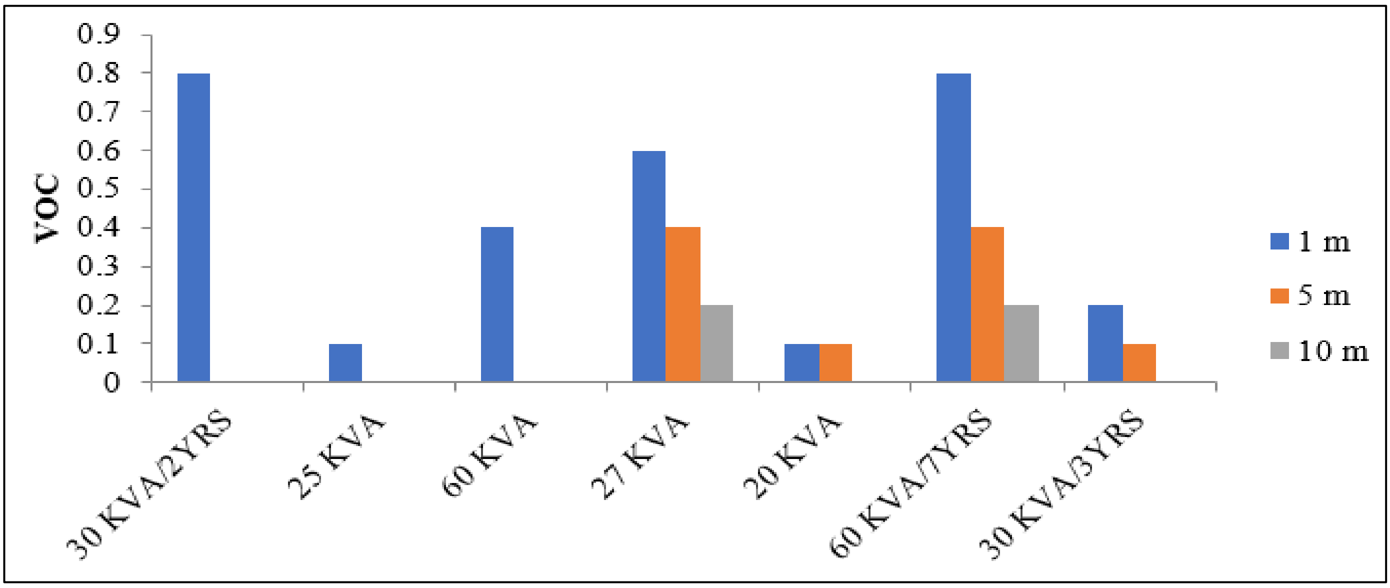

Fig 11: Emission Rate of VOC from the Sound Proof Generators

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14862902

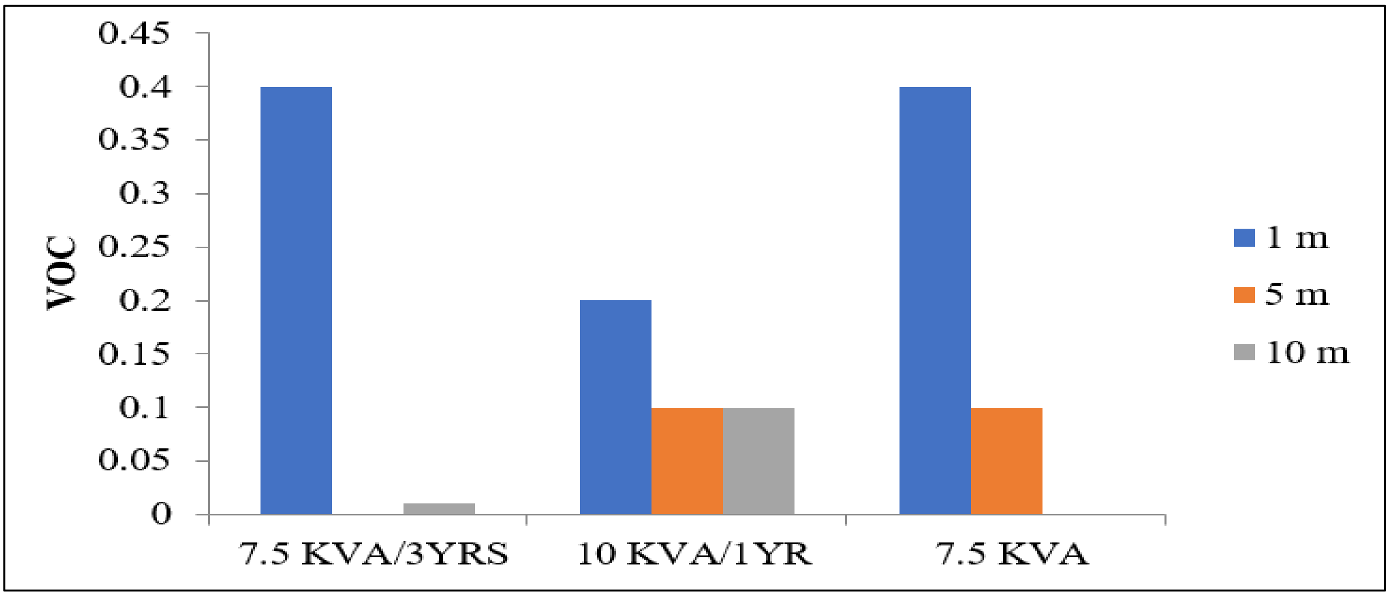

Fig 12: Emission Rate of VOC Concentration from Locally Coupled Generator

From Fig 1, the sound pollution rate of sound proof generators indicate that following; the maximum sound pollution of 96Hz is from a 60KVA generator of 7yrs. Others produced 90.7Hz, 90.7Hz and 89.6Hz for a distance 1m, but at 5m, the intensity reduced to 92.8Hz, 87.1Hz and 83.6Hz respectively. On the other hand, in Fig 2. the local ones with lower capacity produced 97.8Hz, 93.5Hz and 96.4Hz at 1m distance, though of a lower capacity. Another factor one can deduce is that the make of a generator is a major factor on the pollution rate as shown of on Fig 1. Two generators of the same capacity and age clearly show variance in the emission rate. This is also true for S/No.1 on the curve.

From fig 3, the emission rate of carbon monoxide (CO) from a 60KVA generator of 7yrs was the highest at 27ppm at 1m, 12ppm at 5m and 3ppm at 10m. At 5m and 10m the concentration is zero for the 25KVA, the other 60KVA of 2yrs produced less CO with the age of generator may have a role in the emission rate. Fig.4 is a plot of emission from local ones, though of lower capacity, the 10KVA emitted 15ppm at 1m, which is less than the ones of 27KVA, 30KVA, and 25KVA that are 13ppm, 3ppm and 2ppm respectively.

From Fig 5, the nitrogen dioxide emission follows a different pattern other flue gas emission rate. It shows that the highest emissions are from 27KVA at 1.8ppm, 60KVA at 1.25ppm and 60KVA at 0.96ppm. the locally coupled one of 10KVA emitted 2,20ppm at 1m, 1,60ppm at 5m and 1.40ppm at 10m which are relatively higher.

Fig 7 indicates that the 27KVA emitted 1.25ppm as the highest while the 60KVA of 7yrs emitted 0.50ppm at 1m, and the 30KVA of 3yrs emitted 0.97ppm. Some did not emit any amount of SO_2

In Fig 8, is a chart of locally coupled ones, their emission rates were 1.30ppm for 7.5KVA at 1m, other do not emit SO_2.

In Fig. 9, the ammonia, NH_3 concentration the farther the distance the more ammonia produced, 3.2ppm for the 27KVA at 5m and 10m. this deviation may be due to environmental factors. In Fig. 10, for the two that emitted NH_3, distance did not affect the emission rate which remains at 1.0ppm.

For the volatile organic matters plot displayed in Fig. 11, the 60KVA of 7yrs emitted 0.80ppm, while the 30KVA of 2yrs was next at 0.78ppm. In Fig, 12, the two 7.5KVA generators emitted 0.40ppm and 0.39ppm respectively as against 0.19ppm for the 10KVA generator.

V. CONCLUSION

The results indicate that the make of diesel generators (locally coupled or sound proof) have greater influence on their emission rate. That the average value of 95.7Hz from locally coupled generators shows that sound proof generators are better in sound pollution with an average value of 80.26 Hz. the results also shows that generators that are used beyond 7yrs releases more hazardous emissions, above the threshold limits 25ppm as observed from both locally-coupled and sound proof generators.

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