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MEASUREMENT AND ANALYSIS OF NOISE LEVELS IN WELDING WORKSHOPS AND ITS POTENTIAL IMPACTS ON ARTESIAN WELDERS

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ABSTRACT

Sound is produced in every human activity. High levels of occupational noise remain a problem in many workplaces all over the world. Therefore, the importance of assessing occupational noise in artesian welding workshops and its impact on the workers cannot be over emphasized. This study measured and analyzed noise levels and its potential impacts among artesian welders in Port Harcourt metropolis. Noise levels produced in twenty artesian welding workshops in Port Harcourt metropolis were monitored using a smart sensor digital sound level meter, model AS 824. Noise descriptors, L_{10}, L_{50}, L_{90}, noise logarithm average (L_{avg}), equivalent noise levels (L_{eq}), noise climate (NC), noise pollution level (L_{np}) were evaluated. The study showed that the used electric generators constituted the highest noise source in the artisan welding workshops. Noise levels in the artesian welding workshops ranged between 68.9 and 106.6dBA. The study showed high fluctuation of noise levels in 80% of the studied artisan welding workshops, with mean noise values exceeding permissible limit. L_{avg} values ranged between 80.2 and 97.6dBA; L_{eq} values ranged between 82.2 and 98.8dBA; L_{10} ranged between 84.4 and 102.6dBA; L_{50} ranged between 76.6 and 96.2 dBA; L_{90} ranged between 72.8 and 90.2dBA. Noise pollution levels (L_{np}) ranged between 86.1 and 125.9dBA. Conclusively, the study demonstrated that a significant number of artisan welding workers in Port Harcourt metropolis are exposed to high noise pollution, which may adversely affect their health. Therefore, the use of hearing protectors is recommended for artesian welders, which should be made mandatory to protect them against high noise exposure.

Keywords: Welding workshops, Noise pollution, Noise descriptors, Equivalent noise levels, Exceedance factor.

1.0 INTRODUCTION

Noise pollution poses a significant and growing threat to human health and environmental quality globally. Considered as unwanted or harmful sound that disrupts normal activities and causes stress or discomfort, noise pollution has become increasingly pervasive across various settings, including urban areas and industrial environment (World Health Organization [WHO], 2018). While much attention is rightfully focused on noise from transportation and urban development, occupational noise generated from industrial activities like artisanal welding/fabrication works have often been neglected in research and regulatory frameworks. Industrial activities have been found to be a major source of noise impacting negatively of workers (Ekott et al., 2021). Studies by Tomiwa and Oladele (2020) and Ekott et al. (2021) have reported high noise levels, exceeding 96 dBA, in welding workshops in Ondo and Akwa Ibom States in Nigeria.

The health implications of prolonged exposure to high noise levels are well-documented (Keerthik et al., 2024). Occupational noise exposure can lead to various adverse health outcomes, including noise-induced hearing loss, tinnitus, stress-related disorders, and interference with communication and concentration (Keerthik et al., 2024). These effects are particularly pronounced in settings where noise levels exceed recommended exposure limits and where workers may not have access to adequate protective measures. Keerthik et al. (2024) estimated noise induced hearing loss (NIHL) among the transporters in a highly polluted city in India. The study employs both quantitative and qualitative methods involving noise measurements and interviews. The study was conducted among exposed and unexposed groups of drivers. The study found a significant level of noise induced hearing loss among the exposed drivers. Ekott et al. (2021) evaluated noise pollution from a welding workshop in Uyo, Akwa Ibom State. The study was conducted to determine the extent to which noise from welding workshops affects neighbouring residents. They reported that welding noise potentially affects residents located approximately 55 meters from welding workshops. In another study, Ishwarya and Kumaraswamy (2022) assessed the level of awareness of on occupational noise hazard among welders in Chennai. The study found a low levels of noise hazard awareness among the welders.

In Nigeria, Port Harcourt is a bustling industrial hub renowned for its oil and gas activities (Oyegun & Adeyemo, 1999), the impact of noise pollution on the health and well-being of artisan welders has been largely overlooked (Ugwoha & Njoku, 2020). This oversight is worrisome given the prevalence of artisanal welding sites within the city, where high noise levels are a common occupational hazard. The need to address this gap in understanding and mitigation strategies forms the basis of this study. Port Harcourt's industrial significance and economic activity make it an ideal location for studying occupational noise pollution. The city hosts numerous workshops and sites dedicated to artisanal activities and welding, creating an environment ripe for assessing the extent of noise exposure and its effects on workers' health. Despite the visible impact of industrial noise on the daily lives of workers, empirical studies specific to artisanal and welding environments in Port Harcourt are scarce. Ideriah, et al. (2020) assessed noise levels around welding workshops in Port Harcourt, Nigeria. They reported an average noise value of 87.0dB (A) around welding workshops and concluded that such noise level poses no hazard to the welder's health. The study compared the noise levels with 90 dB(A) OSHA permissible exposure limit instead of the equivalent continuous noise level (Leq), thereby creating a gap, which this study attempts to bridge. From the available literature and gaps identified, these study aims to fill this critical knowledge gaps by conducting a comprehensive investigation into noise levels within artisanal welding sites across Port Harcourt. By systematically measuring and analyzing noise levels in these workplaces, the study seeks to provide empirical data that elucidates the true extent of occupational noise exposure and its potential impacts on artesian welders in Port Harcourt metropolis. Understanding these noise levels is crucial for assessing associated health risks and informing targeted interventions to mitigate their impacts.

2.0 METHODOLOGY

2.1 Description of Study Area

Port Harcourt is one of the largest cities in Nigeria. It is Rivers State's capital and is located on the Bonny River, an eastern tributary of the Niger River, 66 kilometres upstream from the Gulf of Guinea in Nigeria's coastal region. Port Harcourt is located between latitudes 4^o 45' and 4^o 55' North and longitudes 6^o 55' and 7^o 05' East, at a height of 15.83 metres above sea level. It is frequently referred to be the country's foundation. It covers 1811.6 square kilometres. It serves as the state capital of Rivers. Port Harcourt was founded in 1914 by Lord Lugard's British colony. It is located in the Niger Delta's heartland. The Port Harcourt Town encompass the majority of the Port Harcourt Metropolis's major residential districts. The Port Harcourt Metropolitan Area is a hub of oil and gas, industrial, administrative, and manufacturing activity (Oyegun & Adeyemo, 1999). Also known as the Garden city because of its numerous avenues and ornaments, Port Harcourt is the 3rd most developed metropolis in Nigeria after

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Lagos and Abuja. The Google map of the sampling locations is shown in Figure 1. Also, the sampling locations and their coordinates are shown in Table 1.

A total of Twenty (20) artisanal welding workshops and a control location (CTR) within Port Harcourt metropolis were monitored after due permission was granted. The monitoring locations (ML) and their coordinates are as shown in the Table 1.

Table 1: Coordinates of monitoring locations

Code	Location	Coordinate	
ML1	Love Garden, Uniport	N4° 54′ 26.70″	E6° 55′ 22.34″
ML2	Rumuekini 1	N4° 53′ 13.83″	E6° 56′ 26.69″
ML3	Rumuekini 2	N4° 53′ 46.23″	E6° 56′ 27.82″
ML4	Rumuekini 3	N4° 54′ 28.51″	E6° 56′ 31.28″
ML5	Choba 1	N4° 53′ 32.94″	E6° 54′ 17.74″
ML6	Choba 2	N4° 53′ 25.05″	E6° 54′ 12.28″
ML7	Alakahia 1	N4° 53′ 6.34″	E6° 55′ 27.95″
ML8	Alakahia 2	N4° 53′ 2.28″	E6° 55′ 42.96″
ML9	Rumualogu 1	N4° 52′ 59.28″	E6° 53′ 39.96″
ML10	Rumualogu 2	N4° 52′ 34.14″	E6° 54′ 47.74″
ML11	Rumuosi 1	N4° 52′ 54.77″	E6° 56′ 28.38″
ML12	Rumuosi 2	N4° 52′ 52.85″	E6° 56′ 31.82″
ML13	Ozuoba 1	N4° 52′ 01.39″	E6° 55′ 55.50″
ML14	Ozuoba 2	N4° 51′ 55.75″	E 6° 55′52.61″
ML15	SAR Road 1 Rumuagholu	N4° 53′ 39.01″	E 6° 57′44.30″
ML16	SAR Road 2 Rumuagholu	N4° 53′ 36.75″	E 6° 58′ 00.76″
ML17	SAR Road 3 Rumuagholu	N4° 53′ 33.06″	E 6° 58′ 33.91″
ML18	Aluu 1	N4° 55′ 38.61″	E 6° 56′ 35.78″
ML19	Aluu 2	N4° 55′ 52.16″	E 6° 56′ 14.85″
ML20	Aluu 3	N4° 56′ 05.08″	E 6° 57′ 04.79″
Control (CTR)	Choba	N4° 53′ 23.917″	E 6° 54′ 4.0″

ML = monitoring location

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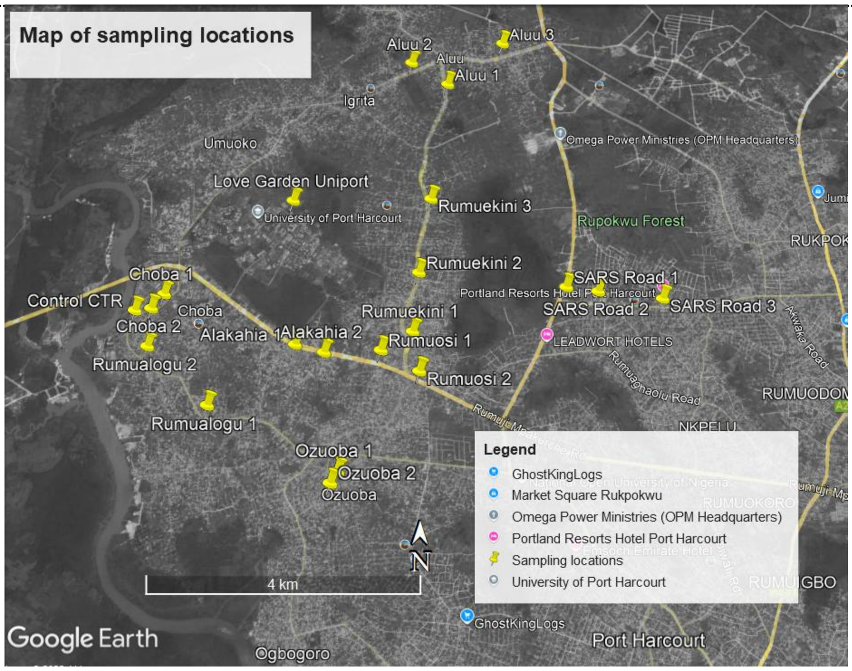

Fig. 1: Google map of the sampling locations

2.2 Noise Measurement/Data Collection

A systematic monitoring of noise levels was conducted for five days at twenty selected welding workshops located within Port Harcourt metropolis (Table 1). In-situ real time measurements of welding noise were carried out for at least one hour each welding workshop using a type 11 Smart Sensor (Model AS824) sound level meter. During the monitoring process, the sound level meter was positioned close to the position of the welders and other noise sources in the welding workshops such as electric generators. Every noise producing activity in the welding workshops was adequately captured during the monitoring process. This monitoring technique provided a comprehensive profile of noise exposure patterns, which formed the basis for accurate characterization of workplace noise hazards in the welding workshops. Recording of displayed noise levels was done at every 10-minute interval in each workshop and a total of 160 dataset was obtained.

The computed Leq values were compared with the National Environmental Standards and Regulations Enforcement Agency (Noise Standards and Control) Regulations 2009" (NESREA, 2009) and the Occupational Safety and Health Administration (OSHA) standards (Tang, 2016). The NESREA maximum permissible noise levels (continuous or intermittent noise) from a factory or workshop applicable to this study is shown in Table 2.

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Table 2: of Equivalent Daily Noise Exposures

Lep,d (dBA)	Duration per day
85	8 hours
88	4 hours
91	2 hours
94	1 hour
97	30 minutes
100	15 minutes

Sources: NESREA (2009) and Tang (2016)

2.3 Data Analysis

The data were analyzed using Microsoft Excel. Mean values and standard deviations of noise levels obtained at for each monitoring location were computed. Noise descriptors (equivalent sound level, L_{eq}, noise pollution levels, L_{np}, noise climate, NC.

2.3.1 Determination of noise descriptors

Noise levels measured in the welding workshops were analyzed by the computation of the logarithm average values and standard deviations using some empirical equations. Environmental noise typically fluctuates over time; thus, the data from noise monitoring was analyzed using various mathematical and statistical methods. The following tools were employed in analyzing the field data:

1. Averaging Sound Pressure Levels: Due to the logarithmic nature of decibels, the average of the measured discrete sound pressure levels was calculated using Equation (1) from Davis and Cornwell (2008).

$$\overline{L}_p = 20\log\frac{1}{N}\sum_{j=1}^{N}10^{L_j/20} \qquad (1)$$

Where $\overline{L}_p$ is the logarithm average sound pressure level in dBA (reference 20µPa), N is the number of discrete measurements, L_j is the j^{th} sound pressure in dBA (reference 20µPa) for j = 1, 2, 3, ……, N.

2. Equivalent continuous noise level (L_{eq})

This represents the equivalent sound pressure level that would contain the same total acoustic energy as the actual varying noise over an identical duration. The equivalent continuous sound level (Leq) was calculated according to the method described by Okpala and Yorkor (2013) and Davis and Cornwell (2008) as shown in Equation (2).

$$L_{eq} = 10\log\left[\frac{1}{T}\sum_{i=1}^{i=n} 10^{L_i/10}(t_i)\right] \qquad (2)$$

Where,

L_i is the noise level of the i^{th} noise measurement (dBA)

T is the total measurement time over which L_{eq} is computed

n is the total number of noise measurements taken

t_i is the fraction of total measurement time

3. Noise Pollution Level, L_{np}

Noise Pollution Level, L_{np} was computed from the values of L_{eq} and standard deviation using the following equation (Tomiwa & Oladele, 2020).

$$L_{np} = L_{eq} + k\sigma \qquad (3)$$

Where k is a constant value given as 2.565 and σ is the standard deviation of the obtained L_{eq} values (Avwiri & Nte, 2003). A study found that the value of L_{np} is higher than the maximum value of field measurements and thus serves as a useful tool in noise pollution modelling and regulations (Nwaogazie & Owate, 2000).

4. Exceedance Factor (EF): the factor by which a computed L_{eq} value exceeds the permissible limit was determined using a bourgeois Exceedance Factor (EF). The EF was calculated using Equation (4) (Central Pollution Control Board [CPCB], 2006). The rating of the exceedance factor is shown in Table 3.

$$\text{Exceedance Factor (EF)} = \frac{\text{Computed Leq}}{\text{Permissible limit}} \qquad (4)$$

Table 3: Exceedance factor rating

S/N	EF	Rating
1	<0.5	Low pollution
2	0.5 – 1.0	Moderate pollution
3	1.0 – 1.5	High pollution
4	1.5 – 2.0	Very High pollution
5	>2.0	Critical pollution

Source: CPCB (2006)

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3.0 RESULTS AND DISCUSSION

3.1 Determination and Description of Noise Levels in Artisanal Welding Workshops

Results of measured noise levels obtained during field monitoring of the selected artisanal welding workshop in Port Harcourt are presented in Table 4. The results (shown in Table 4) indicate that noise level obtained at location ML1 ranges from 82.5 dBA to 102.8 dBA with an average value of 94.7 dBA and a standard deviation of 8.2 dBA. Noise level measured at location ML2 ranges from 71.4 dBA to 100.2 dBA with an average value of 90.7 dBA and a standard deviation of 9.3 dBA. Noise level measured at location ML3 ranges from 82.6 dBA to 85.2 dBA with an average value of 83.4 dBA and a standard deviation of 0.8 dBA. Noise level measured at location ML4 ranges from 85.5 dBA to 99.5 dBA with an average value of 91.1 dBA and a standard deviation of 5.0 dBA. Noise level measured at location ML5 ranges from 70.6 dBA to 100.4 dBA with an average value of 92.3 dBA and a standard deviation of 12.0 dBA. Noise level measured at location ML6 ranges from 84.1 dBA to 102.3 dBA with an average value of 95.3 dBA and a standard deviation of 6.2 dBA. Noise level measured at location ML7 ranges from 82.8 dBA to 106.6 dBA with an average value of 94.0 dBA and a standard deviation of 8.1 dBA. Noise level measured at location ML8 ranges from 84.6 dBA to 98.2 dBA with an average value of 92.0 dBA and a standard deviation of 4.7 dBA. Noise level measured at location ML9 ranges from 79.6 dBA to 96.8 dBA with an average value of 90.7 dBA and a standard deviation of 5.4 dBA. Noise level measured at location ML10 ranges from 73.3 dBA to 89.4 dBA with an average value of 80.2 dBA and a standard deviation of 5.2 dBA. This result corroborated similar study by Ekott et al. (2021) who obtained noise levels up to 96.91dBA a welding workshop.

Table 4: Measured noise levels at selected artisanal welding workshop locations, (dBA)

ML1	ML2	ML3	ML4	ML5	ML6	ML7	ML8	ML9	ML10
82.5	71.4	82.6	84.5	76.2	92.2	83.6	84.6	85.7	73.3
102.5	92.5	83.4	90.3	92.8	90.3	87.3	88.0	92.4	76.8
84.3	79.5	84.4	85.3	78.7	94.9	89.5	90.5	89.4	89.4
90.2	89.0	84.0	99.5	98.3	97.1	82.8	93.3	96.8	74.7
87.2	80.9	83.1	85.7	76.5	87.1	84.9	89.1	79.6	76.4
102.8	94.6	84.5	91.8	97.5	84.1	85.7	95.8	87.2	75.6
84.6	87.8	84.1	87.4	70.6	102.3	96.4	98.2	90.1	80.2
95.6	100.2	85.2	92.6	100.4	99.4	106.6	86.6	94.2	82.2

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ML11	ML12	ML13	ML14	ML15	ML16	ML17	ML18	ML19	ML20	CTR
73.8	75.7	94.3	68.9	83.8	76.5	91.4	85.4	90.2	103.5	42.1
78.4	82.8	88.7	74.5	90.2	78.4	89.3	88.7	87.7	99.6	45.3
89.6	92.5	98.6	79.9	88.5	80.8	93.6	80.5	92.1	90.7	43.8
78.7	84.4	83.5	80.8	87.1	83.1	99.1	84.6	96.3	88.9	48.2
79.4	82.1	101.3	74.6	91.3	76.7	88.6	89.3	94.6	102.3	51.1
77.6	85.2	90.4	100.3	89.4	79.2	86.7	90.4	89.8	96.4	38.5
81.2	98.1	80.8	80.6	81.5	80.3	101.3	95.6	99.2	91.7	40.7
83.2	86.6	90.2	92.3	88.4	89.7	90.9	104.7	97.3	95.9	46.8

ML = monitoring location; CTR = control

As shown in Table 4, the noise level measured at location ML11 ranges from 73.8 dBA to 89.6 dBA with an average value of 81.5 dBA and a standard deviation of 4.7 dBA. Noise level measured at location ML12 ranges from 75.7 dBA to 98.1 dBA with an average value of 88.4 dBA and a standard deviation of 6.8 dBA. Noise level measured at location ML13 ranges from 80.8 dBA to 101.3 dBA with an average value of 93.3 dBA and a standard deviation of 7.0 dBA. Noise level measured at location ML14 ranges from 68.9 dBA to 100.3 dBA with an average value of 87.5 dBA and a standard deviation of 10.2 dBA. Noise level measured at location ML15 ranges from 81.5 dBA to 91.3 dBA with an average value of 88.0 dBA and a standard deviation of 3.3 dBA. Noise level measured at location ML16 ranges from 76.5 dBA to 89.7 dBA with an average value of 81.7 dBA and a standard deviation of 4.3 dBA. Noise level measured at location ML17 ranges from 86.7 dBA to 101.3 dBA with an average value of 94.1 dBA and a standard deviation of 5.1 dBA. Noise level measured at location ML18 ranges from 80.5 dBA to 104.7 dBA with an average value of 93.3 dBA and a standard deviation of 7.5 dBA. Noise level measured at location ML19 ranges from 87.7 dBA to 99.2 dBA with an average value of 94.2 dBA and a standard deviation of 4.1 dBA. Noise level measured at location ML20 ranges from 88.9 dBA to 103.5 dBA with an average value of 97.6 dBA and a standard deviation of 5.4 dBA. Noise level ranges from 38.5dBA to 51.1dBA at the control location. The plot of computed logarithm average noise level (L_{avg}) and equivalent continuous noise level in comparison with NESREA exposure limit for the artisan welding workshops are shown in Figure 2.

Fig. 2: Comparison of computed average noise values with NESREA limit

3.2 Analysis Noise Pollution Levels in Artesian Welding Workshops

The perceived impacts of noise pollution in the artisan welding workshops were evaluated using some noise descriptors or metrics. The estimated percentage of time that the noise levels exceed 10%, 50% and 90% of the measurement time (L_{10}, L_{50} and L_{90} respectively) is shown in Table 5. The logarithm average, equivalent continuous noise level, noise pollution level, noise climate, and exceedance factors were determined and the results shown in Table 6.

Table 5: Computed L_{10}, L_{50} and L_{90} noise metrics, (dBA)

Location/ Metric	ML1	ML2	ML3	ML4	ML5	ML6	ML7	ML8	ML9	ML10	
L_{10}	102.6	95.7	84.6	94.7	98.9	100.3	99.5	96.5	95.0	84.4	
L_{50}	88.7	88.4	84.1	88.9	85.8	93.6	86.5	89.8	89.8	76.6	
L_{90}	83.8	77.1	83.0	85.1	74.5	86.2	83.4	86.0	83.9	74.3	
	ML11	ML12	ML13	ML14	ML15	ML16	ML17	ML18	ML19	ML20	CTR
L_{10}	85.1	94.2	99.1	93.9	90.4	84.4	99.5	97.4	97.7	102.5	49.7
L_{50}	79.1	84.8	90.3	80.3	88.5	79.8	91.2	89.0	93.4	96.2	45.3
L_{90}	76.5	80.2	82.7	72.8	83.1	76.6	88.0	83.37	89.2	90.2	40.0

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Table 6: statistical computation of noise descriptors in the artesian welding workshops

Location	L_{avg} (dBA)	L_{eq} (dBA)	SD (dBA)	L_{np} (dBA)	NESREA limit (dBA)	NC	Exceedance factor	Percentage Exceedance (%)	Pollution Rating
ML1	94.7	97.3	8.2	118.2	85.0	18.8	1.1	14.4	High pollution
ML2	90.7	93.2	9.3	117.0	85.0	18.7	1.1	9.7	High pollution
ML3	84.0	84.0	0.8	86.1	85.0	4.1	0.99	-1.2*	Moderate pollution
ML4	91.1	92.7	5.0	105.6	85.0	10.6	1.1	9.0	High pollution
ML5	92.3	95.0	12.0	125.9	85.0	24.2	1.1	11.8	High pollution
ML6	95.3	96.7	6.2	112.6	85.0	13.8	1.1	13.8	High pollution
ML7	94.0	98.2	8.1	119.0	85.0	15.1	1.2	15.5	High pollution
ML8	91.9	93.0	4.7	104.9	85.0	10.3	1.1	9.4	High pollution
ML9	90.7	91.8	5.4	105.5	85.0	11.2	1.1	8.0	High pollution
ML10	80.2	82.2	5.3	95.7	85.0	16.2	0.97	-3.3*	Moderate pollution
ML11	81.5	82.9	4.7	94.9	85.0	14.2	0.98	-2.5*	Moderate pollution
ML12	88.4	90.8	6.8	108.3	85.0	15.2	1.1	6.9	High pollution
ML13	93.3	95.2	7.0	113.2	85.0	16.5	1.1	12.0	High pollution
ML14	87.5	92.0	10.2	118.2	85.0	21.1	1.1	8.2	High pollution
ML15	88.0	88.4	3.3	96.9	85.0	7.3	1.04	4.0	High

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									pollution
ML16	81.7	83.0	4.3	94.0	85.0	7.8	0.98	-2.4*	Moderate pollution
ML17	94.1	95.5	5.1	108.7	85.0	11.5	1.1	12.4	High pollution
ML18	93.3	96.6	7.5	115.8	85.0	14.1	1.1	13.6	High pollution
ML19	94.2	95.0	4.1	105.5	85.0	8.5	1.1	11.8	High pollution
ML20	97.6	98.8	5.4	112.7	85.0	12.4	1.2	16.2	High pollution
CTR	45.4	46.2	4.1	56.7	85.0	9.6	0.5	-45.6	Low pollution

The negative sign (-) indicates below permissible limit

The analysis of variance (ANOVA) for differences in the noise levels across the monitoring locations within the market is shown in Table 7. Table 8 shows the ANOVA test of significance for differences in the noise levels between the monitoring locations and the Control location.

Table 7: ANOVA test for differences in the noise levels across the monitoring locations

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	278.4086	7	39.77266	1.028703	0.423444	2.203232
Columns	1737.784	7	248.2548	6.421006	2.22E-05	2.203232
Error	1894.483	49	38.66291			
Total	3910.675	63				

Table 8: ANOVA test for differences in the noise levels between monitoring locations and the Control location

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1737.784	7	248.2548	6.398051	1.52E-05	2.178156
Within Groups	2172.891	56	38.80163			
Total	3910.675	63				

3.3 Sources of Noise in the Artesian Welding Workshops

Main sources of noise identified around the artesian welding workshops were sound from generators, the welding process, cutting/grinding of metals and filling of metals. These were ranked and rated as presented in Figure 3.

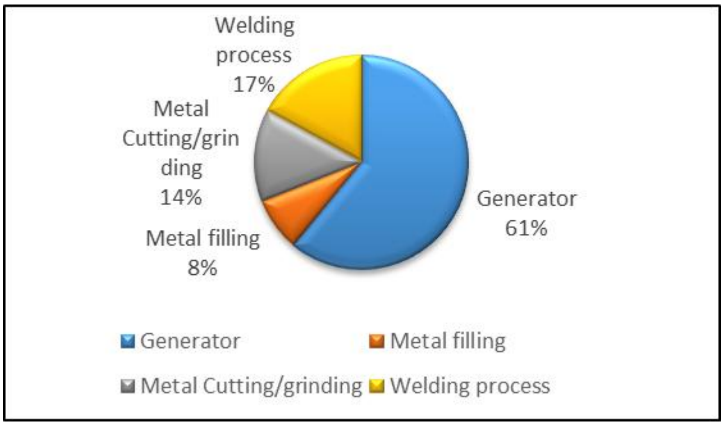

Fig. 3: Identified sources of noise in the artesian welding workshops

3.4 Discussion of findings

The computed results shown in Figure 2. indicate that the logarithm average, L_{avg}, and L_{eq} values exceeded NESREA permissible limit of 85dBA at location ML1 by 11.4% and 14.4% respectively; L_{avg}, and L_{eq} values exceeded permissible limit at location ML2 by 6.7% and 9.7% respectively; L_{avg}, and L_{eq} values fall below permissible limit at location ML3 by 1.2% each; L_{avg}, and L_{eq} values exceeded permissible limit at location ML4 by 7.2% and 9.0% respectively; L_{avg}, and L_{eq} values exceeded permissible limit at location ML5 by 8.6% and 11.8% respectively; exceeded permissible limit at location ML6 by 12.1% and 13.8% respectively; both exceeded permissible limit at location ML7 by 10.5% and 15.5% respectively; both exceeded permissible limit at location ML8 by 8.1% and 9.4% respectively; both exceeded permissible limit at location ML9 by 6.8% and 8.0% respectively; both L_{avg}, and L_{eq} values fall below permissible limit at location ML10 by 5.6% and 3.3% respectively; also, both L_{avg}, and L_{eq} values fall below permissible limit at location ML11 by 4.1% and 2.5% respectively; both exceeded permissible limit at location ML12 by 4.0% and 6.9% respectively; both exceeded permissible limit at location ML13 by 9.8% and 12.0% respectively; both exceeded permissible limit at location ML14 by 2.9% and 8.2% respectively; both exceeded permissible limit at location ML15 by 3.5% and 4.0% respectively; both L_{avg}, and L_{eq} values fall below permissible limit at location ML16 by 3.9% and 2.4% respectively; both exceeded permissible limit at location ML17 by 10.7% and 12.4% respectively; both exceeded permissible limit at location ML18 by 9.8% and 13.6% respectively; both exceeded permissible limit at location ML19 by 10.8% and 11.8% respectively; while both exceeded permissible limit at location ML20 by 14.8% and 16.2% respectively. At the control, Lavg and Leq fall below permissible limit by 46.59% and 45.6% respectively. This result clearly shows that both computed L_{avg}, and L_{eq} values exceeded permissible limit in 80% of the studied artisan welding workshops. This finding corroborated the study by Tomiwa and Oladele (2020) who reported L_{eq} noise values between 87.10 and 94.74dBA in some welding workshops in South West Nigeria. However, Ideriah, et al. (2020) reported an average noise value of 87.0dB (A) around welding workshops in Port Harcourt, which is lower that obtained in this present study and that reported by Ekott et al. (2021) and Tomiwa and Oladele (2020).

Analyzing noise descriptors to determine the levels noise pollution in the artesian welding workshops (Table 5) indicates that the noise levels exceeding 10% of the measurement time (L_{10}) ranged from 84.4 dBA at location ML10 to 102.6dBA at location ML1. The noise levels exceeding 50% of the measurement time (L_{50}) ranged from 76.6dBA at location ML10 to 96.2 dBA at location ML20; while noise levels exceeding 90% of the measurement time (L_{90}) ranged from 72.8dBA at location ML14 to 90.2dBA at location ML20. This implies high levels of noise pollution in the welding workshops, with most of the noise levels falling within the L_{10} range, which is considered hazardous to human health.

It is shown in Table 5 that the L_{10} values fall below NESREA permissible limit of 85dBA at three locations (ML3, ML10 and ML16), representing 15% of the monitored locations. It is also shown in Table 5 that L_{50} values fall below the NESREA permissible limit at six locations (ML3, ML10, ML11, ML12, ML14 and ML16), representing 30% of the monitored locations. Similarly, it is clear from Table 5 that that L_{90} values exceed the NESREA permissible limit at six locations (ML4, ML6, ML8, ML17, ML19 and ML20), representing 30% of the monitored locations. Low L_{10}, L_{50} and L_{90} values were computed for the control location as shown in Table 4. The high L_{10}, L_{50} and L_{90} values show evidence of high noise pollution around the studied artesian welding workshops, which may negatively affect human health. The computed noise climate (Table 6) around the artesian welding workshops varied between 4.1dBA at workshop ML3 and 24.2dBA at workshop ML5. Welding workshops with low values of noise climate is an indication that noise levels fluctuate less around those workshops; while workshops with high values of noise climate indicates more fluctuation of noise levels. The computed noise climate values showed that there is high noise fluctuation in 80% of the studied artisan welding workshops, which could be cause by grinding and filling activities in the workshops.

The computed noise pollution levels (L_{np}) and exceedance factors for the artesian welding workshops (Table 6) indicates that workshop ML1 has L_{np} of 118.2 dBA, with an exceedance factor of 1.1and percentage exceedance of 14.4%, which is described as high pollution. Workshop ML2 has L_{np} of 117.0dBA, with an exceedance factor of 1.1 and percentage exceedance of 9.7%, which is described as high pollution. Workshop ML3 has L_{np} of 86.1dBA, with an exceedance factor of 0.99 and a below limit percentage of 1.2%, which is described as moderate pollution. Workshop ML4 has L_{np} of 105.6dBA, with an exceedance factor of 1.1and percentage exceedance of 9.0%, which is described as high pollution. Workshop ML5 has L_{np} of 125.9dBA, with an exceedance factor of 1.1and percentage exceedance of 11.8%, which is described as high pollution. Workshop ML6 has L_{np} of 112.6dBA, with an exceedance factor of 1.1and percentage exceedance of 13.8%, which is described as high pollution. Workshop ML7 has L_{np} of 119.0dBA, with an exceedance factor of 1.2 and percentage exceedance of 15.5%, which is described as high pollution. Workshop ML8 has L_{np} of 104.9dBA, with an exceedance factor of 1.1and percentage exceedance of 9.4%, which is described as high pollution. Workshop ML9 has L_{np} of 105.5dBA, with an exceedance factor of 1.1and percentage exceedance of 8.0%, which is described as high pollution. Workshop ML10 has L_{np} of 95.7dBA, with an exceedance factor of 0.97and a below limit percentage of 3.3%, which is described as moderate pollution. Workshop ML11 has a L_{np} of 94.9dBA, with an exceedance factor of 0.98and a below limit percentage of 2.5%, which is described as moderate pollution. Workshop ML12 has L_{np} of 108.3dBA, with an exceedance factor of 1.1and percentage exceedance of 6.9%, which is described as high pollution. Workshop ML13 has L_{np} of 113.2dBA, with an exceedance factor of 1.1and percentage exceedance of 12.0%, which is described as high pollution. Workshop ML14 has L_{np} of 118.2dBA, with an exceedance factor of 1.1 and percentage exceedance of 8.2%, which is described as high pollution.

Workshop ML15 has L_{np} of 96.9dBA, with an exceedance factor of 1.04 and percentage exceedance of 4.0%, which is described as high pollution. Workshop ML16 has L_{np} of 94.0dBA, with an exceedance factor of 0.98and a below limit percentage of 2.4%, which is described as moderate pollution. Workshop ML17 has L_{np} of 108.7dBA, with an exceedance factor of 1.1 and percentage exceedance of 12.4%, which is described as high pollution. Workshop ML18 has a L_{np} of 115.8dBA, with an exceedance factor of 1.1 and percentage exceedance of 13.6%, which is described as high pollution. Workshop ML19 has L_{np} of 105.5dBA, with an exceedance factor of 1.1 and percentage exceedance of 11.8%, which is described as high pollution. Workshop ML20 has L_{np} of 112.7dBA, with an exceedance factor of 1.2 and percentage exceedance of 16.2%, which is described as high pollution. The control location shows the least L_{np} and exceedance factor, indicating low noise pollution. This result agrees with that obtained by Tomiwa and Oladele (2020) in a similar study conducted in some welding workshops in Ondo State. The L_{np} values are high enough to evoke hearing impairment in the artesian welders (Keerthik et al., 2024). Judging from this result, it evident that 80% of the studied artisan welding workshops have high noise pollution, while 20% have moderate pollution. This implies that significant number of artisan welding workshops in Port Harcourt metropolis have high noise pollution, which may affect the health of the artisan welding workers. This finding suggests that the artisan welding workers are exposed to high noise pollution and, thus may be at risk of accelerated presbycusis process.

The study also assessed the contributions of each noise source to the overall noise levels in the artesian welding workshops. The result (Figure 3) shows that sound from the use of electric generators for welding operation was found to constitute 61% of noise generated in the artesian welding workshops. Fifteen (75%) of the studied artesian welding workshops used diesel generators, while five (25%) used petrol generators. Welding workshops that used diesel generators were found to have higher noise levels compared to welding workshops that used petrol generators. The welding process was found to produce loud noise and constitutes 17% of noise produced in the welding workshops; cutting/grinding of metals was also found to produced loud noise and constituted 14% of noise produced in the welding workshops; while filling of metals was found to produced loud noise, constituting 8% of noise produced in the welding workshops. The ANOVA analysis (Table 7) shows that the differences in the noise levels across the monitored welding workshops are not statistically significance (*p-value > 0.05, 95% CI*). However, it is clearly shown in Table 8 that there is a significant difference between noise levels in the welding workshops and the control location (*p-value < 0.05, 95% CI*).

3.4.1 Potential Impacts on Artesian Welding workers

Excessive noise has the ability to cause nuisance, including sleep deprivation, stress and increased blood pressure, as well as other physical, physiological and psychological effects. (Toronto Public Health, 2000; Concha-Barrientos et al. 2004; WHO, 2011). This study has shown evidences of unhealthy noise pollution in artisan welding workshops, which poses hazards to the health of artisan welders. Noise pollution exerts a wide range of effects on the exposed population, ranging from auditory, social, physical, physiological to psychological effects (Toronto Public Health, 2000; Concha-Barrientos et al., 2004; WHO, 2011). The artisan welding workers may be suffering health effects from noise pollution related diseases without knowing it. They may be experiencing hearing impairment due to prolong exposure high noise levels (Concha-Barrientos et al., 2004; WHO, 2011). Noise pollution diseases such as annoyance, headache, hearing impairment, speech interference, irritation, and fatigue may be common among the artisan welding workers (Toronto Public Health, 2000; Concha-Barrientos et al. 2004; WHO, 2011). Other possible health effects among the artisan welding workers may be cardiovascular disease, muscle constriction, nervousness, elevated blood pressure, tinnitus, etc., (Concha-Barrientos et al. 2004; WHO, 2011; Yuen, 2014).

The study also envisaged cases of acoustic trauma, auditory fatigue, nervousness, sleep awakening, task interference to be prevalence among the artisan welding workers (Concha-Barrientos et al. 2004; WHO, 2011). Short time exposures to high noise pollution can temporary threshold shift (TTS) resulting in temporary hearing impairment (THI). Long time exposure to high noise levels such as that obtained across the artisan welding workshops can contribute to the development of noise induced permanent threshold shift (NIPTS), resulting in irreversible permanent hearing loss (Concha-Barrientos et al. 2004; WHO, 2011). Most of the artisan welding workers may be at risk of developing hearing impairment or presbycusis process, which is a noise induced hearing impairment that occurs with age (WHO, 2011). It may even cause damage the central nervous system resulting in permanent disability (Concha-Barrientos et al. 2004; WHO, 2011; Yuen, 2014). Judging from the above, noise pollution in artisan welding workshops Port Harcourt metropolis should be of public health concern to decision and policy makers in the City.

4.0 CONCLUSION

The study has shown that artesian welding workshops generated high noise levels that surpassed stipulated permissible standard. Logarithm average noise varied between 80.2 and

97.6dBA. L_{eq} values varied between 82.2 and 98.8dBA. Leq values ranged between 82.2 and 98.8dBA; L_{10} ranged between 84.4 and 102.6dBA; L_{50} ranged between 76.6 and 96.2 dBA; L_{90} ranged between 72.8 and 90.2dBA. Noise pollution levels (L_{np}) ranged between 86.1 and 125.9dBA; noise dose ranged between 4.3 and 198.2%.

The study revealed high noise pollution in 80% of the studied artisan welding workshops. The study revealed that a significant number of artisan welding workers in 80% of the studied artisan welding workshops in Port Harcourt metropolis are exposed to high noise pollution. This situation may, by implication, adversely affect the health of the artesian welders. Risk analysis revealed that artesian welders are exposed to noise levels varying from moderate to very high noise pollution, which pose significant risk to their health.

However, they may be unaware of this adverse damage to their health. They are at high risk of developing hearing impairment. Envisaged potential occupational noise impacts on the health of the artesian welders could be auditory and non-auditory or physiological and psychological, subject to further investigation. The finding of this study underscores the need to protect artesian welders against the high noise levels generated in their workshops. Therefore, the use of hearing protectors should be made mandatory for workers in artesian welding workshops to protect against high noise exposure.

5.0 RECOMMENDATIONS

Prolonged exposure to high noise pollution in artisan welding workshops is a major health concern, therefore, the following recommendations are made:

i. The provision of steady public power supply in the welding workshops could help reduce the use of electric power generators and hence substantially reduce the levels of noise generation in welding workshops.
ii. Regular noise auditing of artesian welding workshops should be conducted to ensure compliance to NESREA guidelines and standards on noise pollution control.
iii. Government agencies responsible for the enforcement of laws or guidelines on noise should monitor artisan welding workshops for compliance.
iv. Increasing awareness and training programmes for artesian welding workers on noise safety and other pollution impacts should be carried out regularly.
v. A regular Medical Assessment/Test should be conducted on artesian welding workers for early signs of presbycusis and noise exposure related diseases.

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vi. Provide artesian welding workers with training about hearing damage and to wear hearing protection or safety devices.

vii. The artesian welding workers should be provided with suitable hearing protection devices, which must be worn.

Competing Interests:
Authors have declared that no competing interests exist.

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