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Case Study

Assessment of Occupational Hazards in Sawmills: A Case Study

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The aim of this study was to assess the occupational hazards most of the Sawmills in Delta State, Nigeria exposed to. The study area was limited to 21 sawmill sites in three selected sawmill locations at Sapele, Warri and Udu, actively in operation within Delta State. The study involved both descriptive and inferential statistical approach. Purposive sampling technique was employed for identifying the three sawmill locations, while simple random sampling was used to select the participants for the study. The major instruments employed for data collection included Sound Level Meter (SLM) Integrated Averaging Sound Level Meter, standardize with 90 dBA and a structured questionnaire. The method of data analyses included descriptive and inferential statistics with Microsoft Office Excel. The major physical, chemical and mechanical hazards identified from the sampled sawmills were noise generated from machinery used within the mills, generated sawdust and unguarded machines, respectively. The estimated Noise Pollution Level (NPL) for the three sawmill locations was 101.08, 105.54 and 102.36 dBA for Sapele, Warri and Udu, respectively. These values are far higher than the acceptable limits by National Institute of Occupational Safety and Health (NOISH), Occupational Safety and Health Administration (OSHA) and National Environmental Standards and Regulations Enforcement Agency (NESREA) with the equivalent noise levels (L_{eq}) of 101.02 dBA, 97.72 dBA and 100.91 dBA for Sapele, Warri and Udu sawmills, respectively. This study revealed that 56.6% of the workers are at risk of induced deafness due to unhealthy exposure to noise doses of 258%, 202% and 256% for Sapele, Warri and Udu sawmills, respectively over a nine hours working duration. Among others, safety education intervention, shift schedules and workers being properly kitted before being allowed to work were recommended.

Key Words: Occupational Hazards, Sawmill, Noise Pollution Level, Delta State, Noise Doses.

INTRODUCTION

Occupational hazard varies from one occupation to another. Workers are often confronted with different hazards on a daily basis ranging from physical, chemical, biological to mechanical. There are 2.9 billion workers globally exposed to hazards and risk at work places (Meswani, 2008). Sawmill workers are one of those group of workers who are exposed to numerous risks in their places of work**.**

Sawmilling processes tend to expose workers to hazards relating to log handling, wood cutting unguarded machineries, wood dust, wood treatment chemical, electrical hazards, fire and explosion (Anaele et al., 2014). According to Ayodele and Olubayo-Fatiregun (2013), majority of sawmill workers with respect to their educational level and background are not well educated or trained in the areas of occupational hazard identification and evaluation. Thus, the rate of occupational hazard exposure from this industry is very high. According to Faremi et al., (2014), in a study conducted on workers awareness and safety measures to health hazards in sawmill, it was submitted that majority of sawmill workers in Ile-Ife, Nigeria, have poor awareness of occupational hazards inherent in sawmill works, its processes and environment.

In a bid to minimize cost and maximize productivity, many sawmill workers work at the expense of their health. They tend to give little or no attention to the state of their health. Selmon (2001), opined that a worker whose health is affected in the process of executing his/her duty suffers the loss of joy and pleasure. Hence, this study is aimed at assessing the occupational hazards sawmill workers in Delta State are faced with.

MATERIALS AND METHODS

Study Area

The study area is limited to the three sawmill locations in Delta State, Nigeria. Delta State lies approximately between Longitude 5^0 00' and 6^0 45' east and Latitude 5^0 00' and 6^0 30' north. Delta State has a land area of 16,842 square kilometers (6, 503 sq. miles), of which more than 60% is land and the rest is swamp and water bodies. It is bounded in the North and West by Edo State, the East by Anambra, Imo and Rivers States, Southeast by Bayelsa State and on the Southern flank is the Bight of Benin which covers about 160 kilometres of the state's coastline. Delta State has twenty-five (25) Local Government Areas. The State is divided into three (3) National Senatorial Districts (Delta South, North and Central) with diverse ethnic groups, people with seven (7) major languages and dialects spoken. Most parts of the Delta central and south senatorial districts are coastal area interlocked with rivers and as such, sawmill industries in the state are mainly located in them. Figure 1, presents the map of the study area.

Data Collection

The study sites were limited to a total of twenty one (21) sawmills from the three locations that were purposively selected. Within each location, seven (7) sawmills with active sawmilling operations were randomly selected for noise data measurements. The three selected locations were Ogun-aja in Sapele Local Government Area, Market Road in Warri – South Local Government Area and Udu Road in Udu Local Government Area (see Appendix A for sample points coordinates). It is interesting to note that from literature, there are two hundred and ten (210) registered sawmill industries in Delta State (MAFDDS, 2016). Thus, the rationale of using ten percent (i.e, 21 sawmills) is in line with the recommendations of Owie (2006); Elendu (2010) and Kothari and Garg (2014) which stated that 10% of the entire population of a study is appropriate for generalization.

For data collection process, a preliminary walkthrough survey (physical observation) was carried out using a checklist guide to collect qualitative data. The process involved site visitation, initiation of noise measurement modalities, and interaction / interview of officers and workers in sawmills. The instruments used for data collection for this study were Sound Level Meter (SLM) Integrated Averaging Sound Level Meter (CR: 262A, Cirus Research PLC UK) standardize with 90 dBA, close ended structured questionnaires, informal interviews with group discussions and physical observation. The SLM (Integrated Averaging Sound Level Meter) was used to collect data on sound level measurement while the structured questionnaire was employed for hazards identification.

The noise sampling of the twenty-one (21) sawmills was done in line with the Canadian Centre for Occupational Health and Safety noise measurement procedure for standing position, the SLM was held 1.5m from the ground and 1.1m for sitting working position. In each location a typical sawmill site with the maximum number of milling machines was identified and was used to collect data that represented that location.

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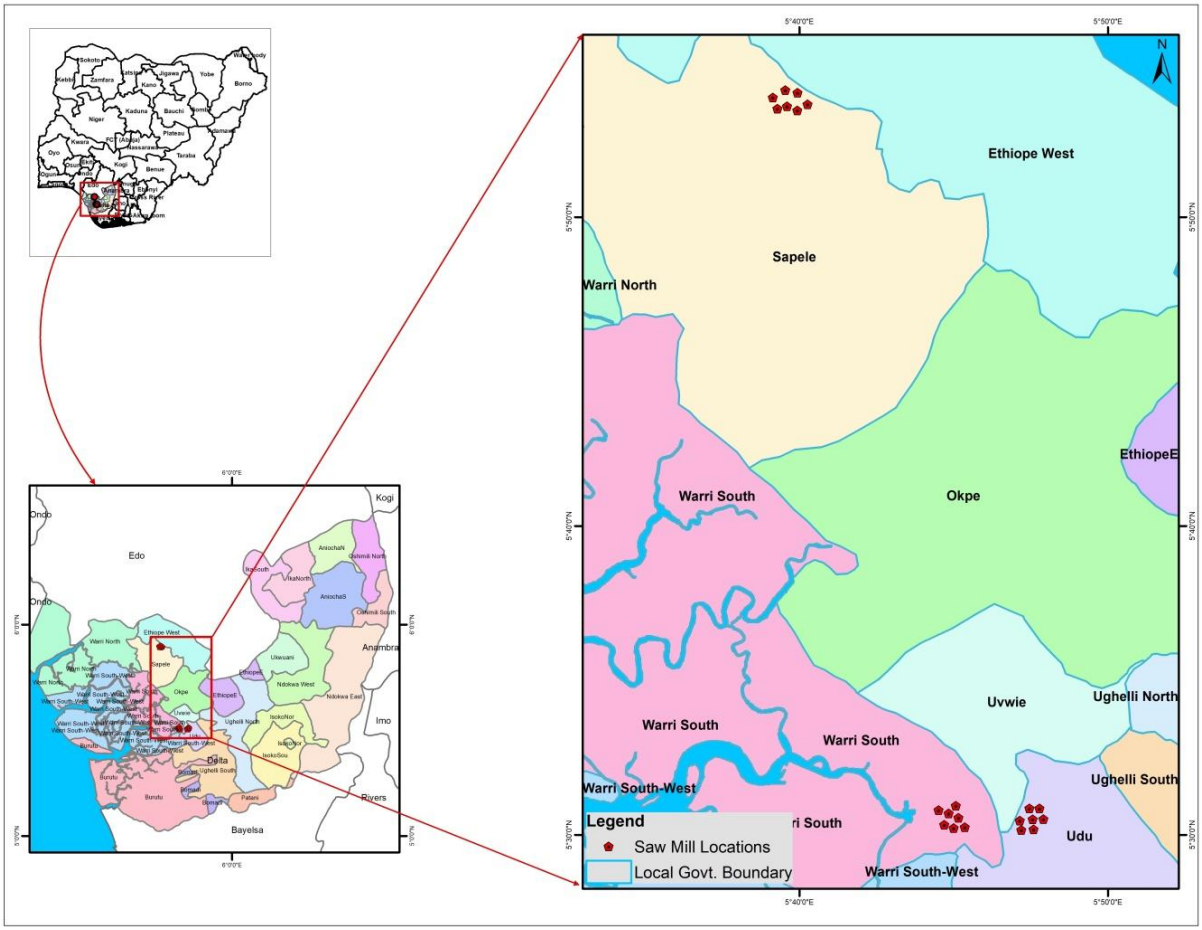

Figure 1. Map of the Sawmill Sites and Locations, Sapele, Warri and Udu in Delta State, Nigeria.

Data Analyses

Data obtained from the noise measurements were computed and analyzed using Percentages, Mean ± Standard Deviation (Standard error of the mean SEM). Furthermore, the occupational impact analyses (noise) were carried out with the aid of Microsoft excel spreadsheet templates. This includes analysis of noise pollution level (Equation 1) (Nwaogazie and Owate, 2000; Nwaogazie, 2011), equivalent daily noise exposure level (Equation 2) and the reference time a worker should be exposed to the identified equivalent noise level (Equation 3) and worker's noise dosage (Equation 4). The excel template was developed in line with OSHA standards.

$$NPL(dBA) = NL_{50} + (NL_{10} - NL_{90}) + \frac{(NL_{10} - NL_{90})^2}{60} \quad (1)$$

$$L_{eqT} = 10\log_{10}\left[\frac{1}{T}\sum_{i=1}^{n} 10^{0.1L_i} t_i\right] \quad (2)$$

$$T_L = \frac{T_C}{2^{(L_T - L_C)/Q}} \quad (3)$$

$$D = \frac{C}{T_C} \quad (4)$$

Where:
NPL (dBA) = Noise Pollution Level
NL_{10} = Noise level at 10% time exceeded
NL_{50} = Noise level at 50% time exceeded
NL_{90} = Noise level at 90% time exceeded
L_{eq} = Equivalent Noise level
t = time over which L_i was determined

Table1. Percentage Distribution of Respondents' Demographic Characteristics.

Variable	Option	Frequency	Percentage	Total
Gender	Male	199	94.8	210
	Female	11	5.2	
Age (years)	15 – 20	14	6.7	210
	21 – 30	106	50.5	
	31 – 40	54	25.7	
	41 & above	36	17.1	
Marital Status	Married	123	58.6	210
	Single	87	41.4	
Level of Education	No formal Education.	0	0	210
	Primary	0	0	
	Secondary	181	86.2	
	Tertiary	29	13.8	
Job Type	Technical staff	74	35.2	210
	Administrator	28	13.3	
	Operator	63	30	
	Loader	45	21.4	
Working Experience (in years)	1 – 5	60	28.6	210
	6 – 10	78	37.1	
	11 & above	72	32.3	
Average Time (hour) Spent per Day in the Mill	3 – 5	30	14.3	210
	6 – 8	59	28.1	
	9 & above	121	56.6	
Medical History	Eye problem	38	18.1	210
	Chest problem	17	8.1	
	Fracture	8	3.8	
	None	147	70	

*L_i = Noise level of the i*th term
T = cumulative time of sampling
T_L = Permitted exposure duration at a Noise level L_T
D = worker's noise dose; and C = total time of exposure to a particular noise level
T_C = Allowable exposure at the criteria level of L_C
L_C = Criteria Noise level;
Q = Amplitude weighing function (or exchange rate factor).

The results obtained from the occupational impact analyses were compared with International Standards and Organizations such NIOSH, NESREA and OSHA acceptable noise levels.

RESULTS

Table 1 gives a summary distribution of responses extracted from the questionnaire given out to 210 respondents. Similarly, the percentage (%) respondents that identified various physical, chemical and mechanical hazards as per the questionnaire instrument are reflected on top of each identified hazard in the bar graphs for Sapele, Warri and Udu locations in Figures 2-4 (also Table A1). Furthermore, the means with standard

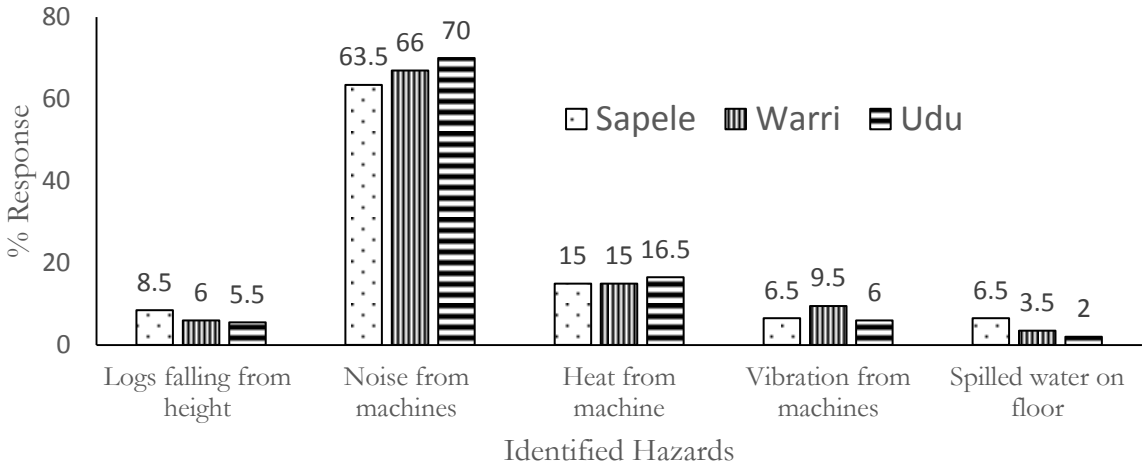

Figure 2. Identified Physical Hazards.

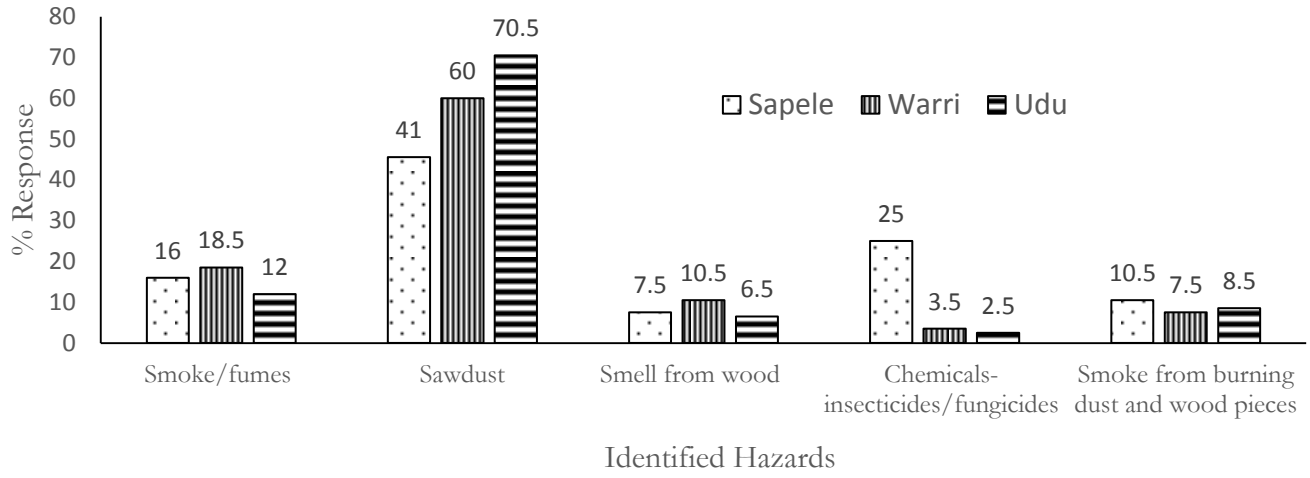

Figure 3. Identified Chemical Hazards.

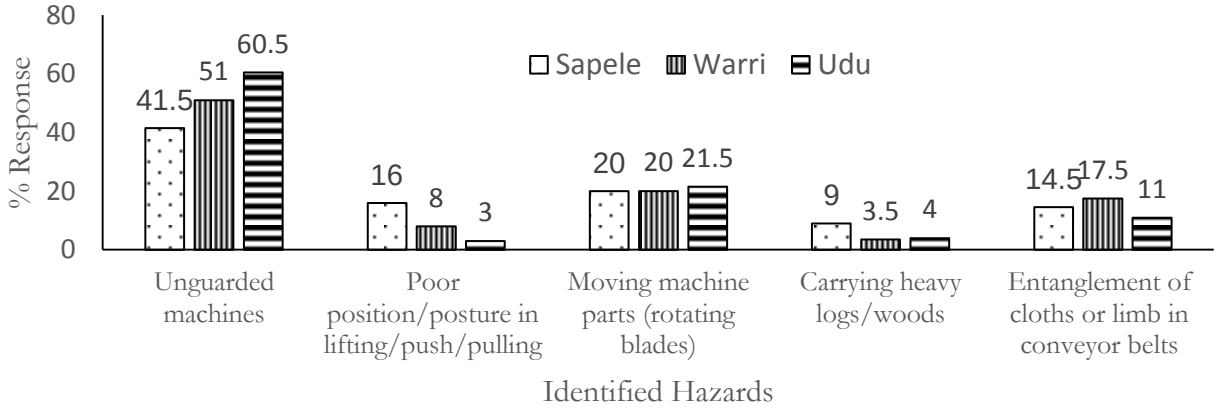

Figure 4. Identified Mechanical Hazards.

Table 2. Noise levels at typical sawmill at Sapele, Warri and Udu locations (Means ± SD).

Sawmill Machines	Sapele	Warri	Udu
CD Band Saw	94.36±1.25[a]	91.70±2.05[a]	93.25±1.53[a]
	91.20 - 96.10[b]	85.40 - 96.70[b]	89.90 - 95.30[b]
Plane machine	95.67±1.37[a]	97.10±1.26[a]	98.55±0.64[a]
	94.30 - 95.86[b]	96.80 - 97.40[b]	98.50 - 98.60[b]
Blade sharpener	90.15±0.14[a]	94.57±0.17[a]	97.50±0.26[a]
	90.10 - 90.20[b]	93.20 - 94.60[b]	97.20 - 97.80[b]
Hard wood	99.15±1.31[a]	97.32±1.75[a]	95.05±1.49[a]
	98.80 - 99.80[b]	96.40 - 97.50[b]	94.30 - 95.80[b]
Control	75.90±0.14[a]	69.15±0.33[a]	67.35±0.16[a]
	75.80 - 76.00[b]	68.60 - 69.70[b]	66.90 - 67.80[b]

[a] Mean ±Standard Deviation; [b] Range of Noise Levels.

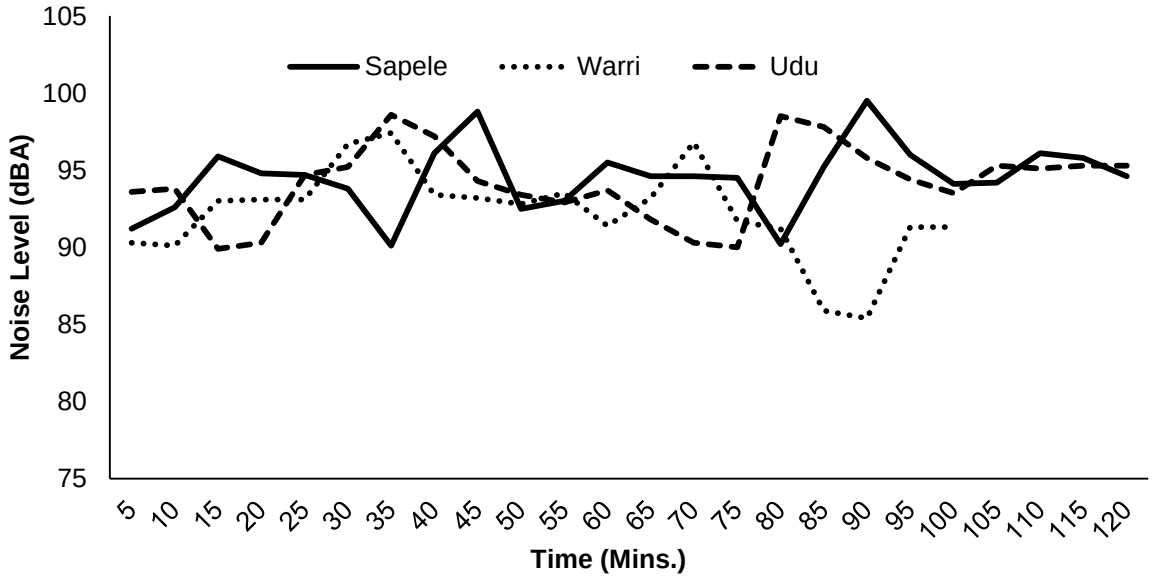

Figure 5. Noise level at interval of 5 minutes from three typical sawmills each, in Sapele, Warri and Udu locations.

deviations and ranges of the noise level from a typical sawmill in Sapele, Warri and Udu locations are as presented in Table 2.

Figure 5 presents a plot of noise levels of various machines from three typical sawmills each in Sapele, Warri and Udu locations at an interval of 5 minutes.

Figure 6 presents plot of the percentage noise level through ranking against percentage exceedance for the three locations (Tables B1 – B3).

Noise Analyses for Sapele sawmill Location

Applying Equation (1) for the analysis of Noise Pollution Level (NPL), for $NL_{50} = 94.6$; $NL_{10} = 96.1$; $NL_{90} = 90.2$ (read off from Figure 6).

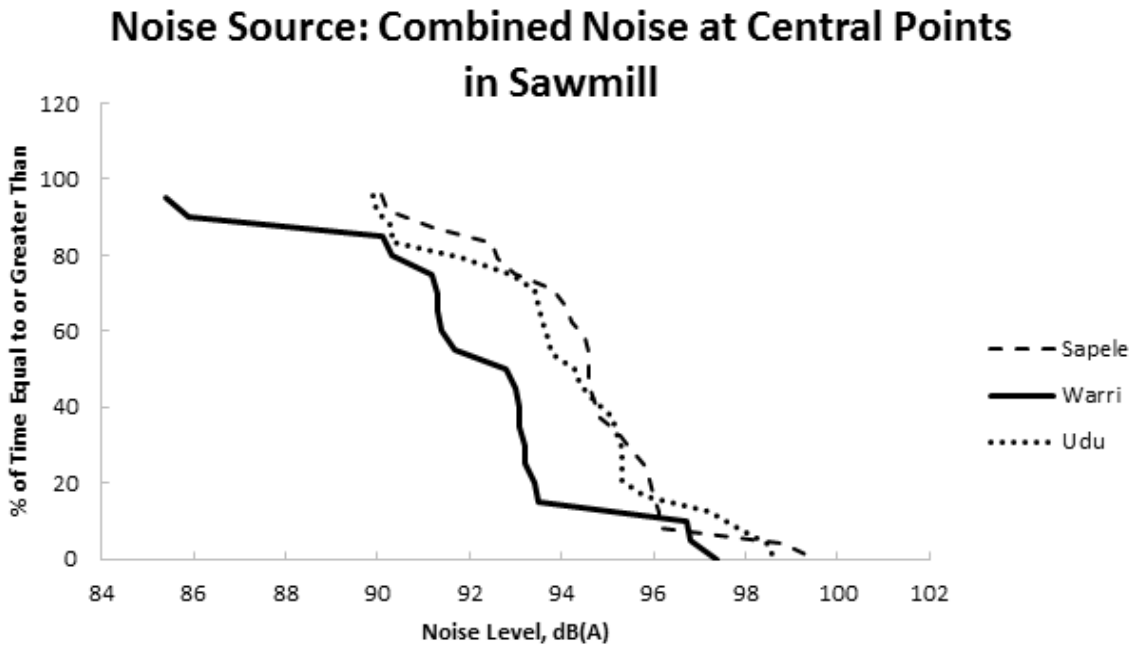

Figure 6. Combined Noise at Central Points in Sawmill (Sapele, Warri, and Udu).

Thus, the Noise Pollution Level yields:

$$NPL(dBA) = 94.6 + (96.1 - 90.2) + \frac{(96.1 - 90.2)^2}{60} = 101.08dBA$$

Evaluating Equation (2), Equivalent Noise level L_{eq} at 8hrs = 101.02 dBA

Taking T_C = 8hrs, L_C = 90dBA and 5dBA exchange rate in accordance with OSHA occupational noise exposure standard, the allowable duration of exposure:

$$T_L = \frac{8}{2^{(101.02-90)/5}} = 1.74hrs$$

From available records, it was found out that majority of the workers work for 9 hours (Table 1) thus, at an average noise level of 96.07dBA (see Appendix B), where the reference duration of exposure is 3.49hrs (Table B4), the noise dose on the workers at the mills will be :

$$D = \frac{9}{3.49} = 2.58(258\%).$$

Analogous to Sapele, noise pollution level computations, Warri and Udu computation results are as follow: for Warri, NPL = 105.54 dBA, L_{eq} = 97.72 dBA, T_L = 2.74 hrs, D = 202% and for Udu, NPL = 102.36 dBA, L_{eq} = 100.91 dBA, T_L = 1.76 hrs, D = 256%, respectively.

Figure 7 presents the comparison of the resultant Noise pollution levels (L_{np}), Equivalent Noise Levels (L_{eq}), Average continuous noise level (L_T) against standards (OSHA, 1981 and NESREA, 2009).

DISCUSSION

The demographic data collected on the respondents, revealed that 56.6% of the sawmill workers have been in these sawmills for about 6-10 years working 9 hours and more every day. It was gathered from the data collected, that the major physical hazard identified from the twenty-one sampled sawmills in the three locations was noise (66.5%) generated from machinery used within the mills (Figure 2). Also, identified as prominent chemical hazards within the sawmills was sawdust generation (57.2%) (Figure 3) which has a chronic

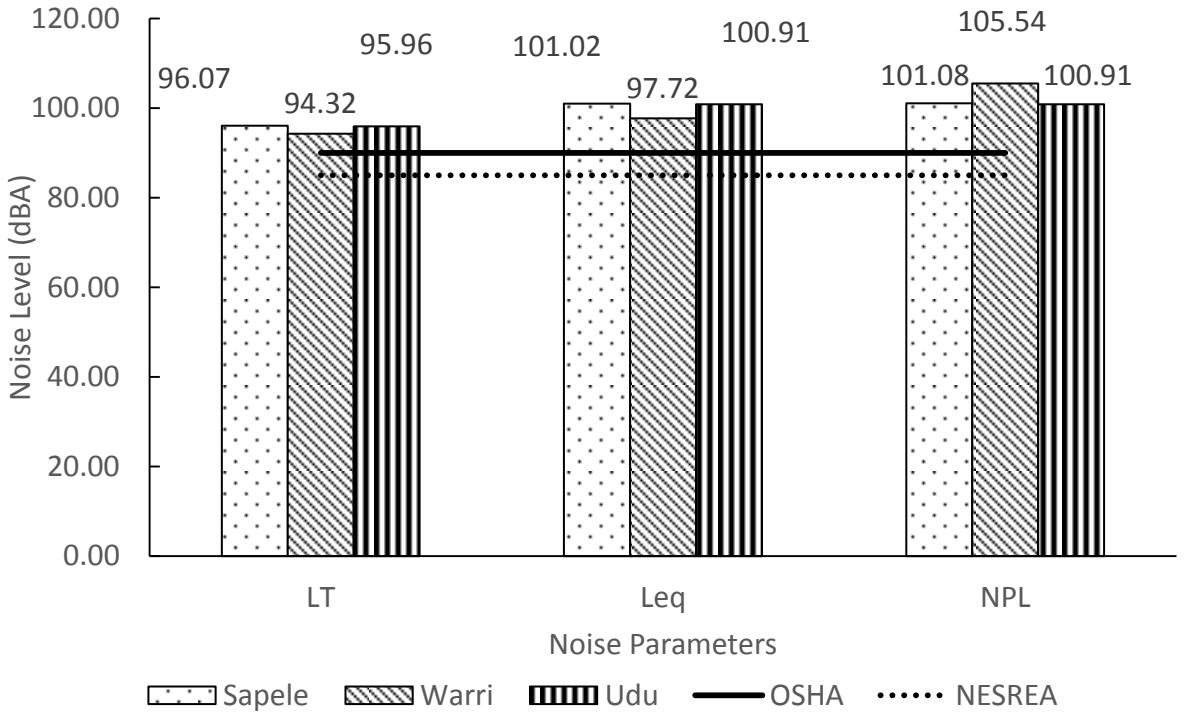

Figure 7. Noise pollution levels (NPL), Equivalent Noise Levels (L_{eq}), Average continuous noise level (L_T) against standards (OSHA, 1981 and NESREA, 2009).

effect on workers when inhaled overtime without provided with proper kit. Furthermore, the hazard posed by unguarded machines (51%) tend to be the prevailing mechanical hazard identified from the three sampled sawmills in the study area (Figure 4). Among the three sawmill locations, the average noise levels of machines at Sapele sawmill ranged 91.20 - 96.10 dBA with mean value of 94.36 ± 1.25 dBA for CD band saw machine, with the highest value recorded for the planer machine (95.67 ± 1.37) and the lowest value recorded for the sharpening machine (90.15 ± 0.14). As per the Noise Pollution Level, the computed values for the three sawmill locations were far higher than the acceptable limits by NIOSH, 1998; OSHA, 1981; NESREA, 2009 (Table B4 and Figure 7). The estimated average noise levels for Sapele, Warri, and Udu were 96.07, 94.32 and 95.96 dBA, respectively. At 8 hours working duration, Sapele, Warri and Udu sawmills have an Equivalent Noise Level (Leq) of 101.02 dBA, 97.72 dBA and 100.91 dBA, respectively. Taking the work duration of majority of the sampled workers who work for 9hours, the resultant allowable duration for exposure with respect to the average noise level at Sapele, Warri, and Udu were 1.74, 2.74, and 1.76 hours. The difference between these allowable durations of exposure and the actual duration of work hours or exposure of most of the workers is not only very wide but unacceptable. It is interesting to note that the daily noise dose on the workers (258%, 202% and 256% for Sapele, Warri and Udu sawmills, respectively) compared to acceptable dosage (50% for 85 dBA and 100% for 90 dBA) is beyond acceptable limits. Thus, there is an urgent need for a safety intervention to protect the workers against this occupational hazard. The findings from this study agrees with that of Ugbebor and Yorkor (2015) and Ugwoha et al., (2016) from their findings (resultant noise level at the sampled sawmills ranged from 89.76 ± 0.09 - 100.49 ± 0.20 dBA, 89.81 ± 0.13 - 97.00 ± 0.46 dBA and 89.76 ± 0.07 - 100.10 ± 0.53 dBA), majority of the workers at sawmills in Port Harcourt were exposed to excess doses of noise which was unhealthy and beyond acceptable noise exposure limits. Also, a study by Aremu et al.(2015) examining the noise pollution from sawmilling in Ilorin metropolis, Nigeria is in

agreement with the findings of this study. The outcome from their study revealed that approximately 73% of all the noise measurements (range 81.1 – 112.3 dBA) from the sawmilling were above recommended standards of 85 dBA. Within the sampled sawmills, most of the workers were unprotected, disturbed and complained of noise-related ailments such as tinnitus (96.6%), headache (86.6%) and hearing impairment (71.9%). Furthermore, the findings of Ogungbe and Amosu (2016) revealed that the prevalence of occupational noise-induced hearing loss among the industrial workers (which includes sawmill factory) in Lagos was high due to exposure to high noise level above 85 dBA, poor usage of hearing protective device and a prolonged exposure to noise (10-12 hours per day) above recommended standard. This is above the 8 hours working period recommended by OSHA and also shows an over time workers are subjected to which is in agreement to our study.

CONCLUSION

The following conclusions were drawn from this study:

i) The major physical hazard identified from the 21 sampled sawmills in the 3 locations- Sapele, Warri and Udu was noise generated from machinery used within the mills.

ii) While others were heat, vibrations from machines, log falling from height and water spill on the floor in this order.

iii) The prominent chemical hazards identified within sawmills was sawdust generation from the activities carried out at the mills.

iv) Other identified chemical hazards were chemical (insecticides and fungicides), smoke/fumes, smoke from burning dust and wood pieces and smell from wood in that order.

v) Unguarded machines tend to be the prevailing mechanical hazard identified from the 21 sampled sawmills in the study area.

vi) Other identified mechanical hazards were moving machine parts /rotating blades, entanglement of clothes or limb in conveyor belts, poor position/posture in lifting, pushing and pulling and carrying heavy logs/woods in that order.

vii) The Noise Pollution Level for the 21 sawmills in the 3 locations were far higher than the acceptable limits by NOISH, OSHA and NESREA with the equivalent noise levels (L_{eq}) of 101.02 dBA , 97.72 dBA and 100.91 dBA for Sapele, Warri and Udu sawmills, respectively.

viii) It was gathered that 56.6% of the total respondents sampled worked at the sawmills daily for 9 hours as against the allowable noise exposure durations of 1.74, 2.74, and 1.76 hours based on the generated measured noise levels of 96.07, 94.32 and 95.96dBA for Sapele, Warri, and Udu, respectively.

RECOMMENDATIONS

The recommendations from this study include:

i) Sawmill worker should be provided with proper kits with the right personal protective equipment (PPE) as related to his / her work description or else not be allowed to work.
ii) The work hours of the sawmill workers should be in accordance with stipulated standards and exposure durations. Furthermore, shifts schedule is recommended to reduce exposure duration.

COMPETING INTERESTS

The authors of this article have declared that no competing interests exist while in the course of preparing this document.

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APPENDIX

HAZARD IDENTIFICATION SAMPLE COLLECTION

Table A1. Coordinate of sample locations

S/N	Latitude	Longitude	Sampling points
1	N5.908612	E5.668833	Ogun-aja, Sapele
2	N5.909375	E5.668517	Ogun-aja, Sapele
3	N5.909955	E5.667813	Ogun-aja, Sapele
4	N5.908551	E5.668668	Ogun-aja, Sapele
5	N5.907087	E5.667758	Ogun-aja, Sapele
6	N5.908674	E5.668736	Ogun-aja, Sapele
7	N5.909982	E5.667642	Ogun-aja, Sapele
8	N5.509712	E5.749305	MKT Road, Warri
9	N5.509055	E5.749477	MKT Road, Warri
10	N5.507732	E5.750883	MKT Road, Warri
11	N5.508252	E5.750776	MKT Road, Warri
12	N5.508587	E5.752795	MKT Road, Warri
13	N5.508656	E5.752648	MKT Road, Warri
14	N5.508549	E5.753711	MKT Road, Warri
15	N5.515238	E5.785468	Udu Road, Udu
16	N5.515218	E5.786700	Udu Road, Udu
17	N5.515455	E5.787858	Udu Road, Udu
18	N5.514803	E5.785062	Udu Road, Udu
19	N5.513988	E5.739133	Udu Road, Udu
20	N5.516436	E5.786701	Udu Road, Udu
21	N5.514527	E5.783486	Udu Road, Udu

Table A2. Hazard Identification Statistics.

Physical Hazards	Sapele	Warri	Udu
Logs falling from height	6/8.5%	4/6%	4/5.5%
Noise from machines	44/63.5%	46/66%	49/70%
Heat from machine	11/15%	11/15%	12/16.5%
Vibration from machines	5/6.5%	7/9.5%	4/6%
Spilled water on floor	5/6.5%	2/3.5%	1/2%

Table A2. Contd.

∑	70/100	70/100	70/100
Chemical Hazards			
Smoke/fumes	11/16%	13/18.5%	8/12%
Sawdust	29/41%	42/60%	49/70.5%
Smell from wood	5/7.5%	7/10.5%	5/6.5%
Chemicals- insecticides/fungicides	18/25%	2/3.5%	2/2.5%
Smoke from burning dust and wood pieces	7/10.5%	5/7.5%	6/8.5%
∑	70/100	70/100	70/100
Mechanical Hazards			
Unguarded machines	29/41.5%	36/51%	42/60.5%
Poor position/posture in lifting/push/pulling	11/16%	6/8%	2/3%
Moving machine parts (rotating blades)	14/20%	14/20%	15/21.5%
Carrying heavy logs/woods	6/9%	2/3.5%	3/4%
Entanglement of cloths or limb in conveyor belts	10/14.5%	12/17.5%	8/11%
∑	70/100	70/100	70/100

NOISE ANALYSES

Table B1. Noise Data Analysis for a typical sawmill in Sapele.

Noise levels	Duration (mins.)	Rank No.	P=m/n	(1-P)*100	$0.1L_i$	$10^{0.1L_i}\frac{t_i}{60}$ x 10^9
90.1	5	1	0.04	95.83	9.01	0.085
90.2	10	2	0.08	91.67	9.02	0.175
91.2	15	3	0.13	87.50	9.12	0.330
92.5	20	4	0.17	83.33	9.25	0.593
92.6	25	5	0.21	79.17	9.26	0.758
93	30	6	0.25	75.00	9.30	0.998
93.8	35	7	0.29	70.83	9.38	1.399
94.1	40	8	0.33	66.67	9.41	1.714
94.2	45	9	0.38	62.50	9.42	1.973
94.5	50	10	0.42	58.33	9.45	2.349
94.6	55	11	0.46	54.17	9.46	2.644
94.6	60	12	0.50	50.00	9.46	2.884
94.6	65	13	0.54	45.83	9.46	3.124
94.7	70	14	0.58	41.67	9.47	3.443
94.8	75	15	0.63	37.50	9.48	3.775

Table B1. Continue.

95.2	80	16	0.67	33.33	9.52	4.415
95.5	85	17	0.71	29.17	9.55	5.027
95.8	90	18	0.75	25.00	9.58	5.703
95.9	95	19	0.79	20.83	9.59	6.160
96	100	20	0.83	16.67	9.60	6.635
96.1	105	21	0.88	12.50	9.61	7.129
96.1	110	22	0.92	8.33	9.61	7.469
98.8	115	23	0.96	4.17	9.88	14.539
99.5	120	24	1.00	0.00	9.95	17.825
Cumulative sampling Time, T (mins)	1500					101.144
T (hr)	25			**Avg. Continuous Noise Level (L_T)**		96.070

Table B2. Noise Data Analysis for a typical sawmill in Warri.

Noise levels	**Duration (mins.)**	**Rank No.**	**P=m/n**	**(1-P)*100**	**$0.1L_i$**	$10^{0.1L_i}\frac{t_i}{60}$ **x 10^9**
85.4	5	1	0.05	95	8.54	0.029
85.9	10	2	0.1	90	8.59	0.065
90.1	15	3	0.15	85	9.01	0.256
90.3	20	4	0.2	80	9.03	0.357
91.2	25	5	0.25	75	9.12	0.549
91.3	30	6	0.3	70	9.13	0.674
91.3	35	7	0.35	65	9.13	0.787
91.4	40	8	0.4	60	9.14	0.920
91.7	45	9	0.45	55	9.17	1.109
92.8	50	10	0.5	50	9.28	1.588
93	55	11	0.55	45	9.30	1.829
93.1	60	12	0.6	40	9.31	2.042
93.1	65	13	0.65	35	9.31	2.212
93.2	70	14	0.7	30	9.32	2.438
93.2	75	15	0.75	25	9.32	2.612
93.4	80	16	0.8	20	9.34	2.917
93.5	85	17	0.85	15	9.35	3.172
96.7	90	18	0.9	10	9.67	7.016
96.8	95	19	0.95	5	9.68	7.578
97.4	100	20	1	0	9.74	9.159

Table B2. Continue.

Cumulative sampling Time, T (mins)	1050					47.308
T (hr)	17.5	**Avg. Continuous Noise Level (L_T)**				94.319

Table B3. Noise Data Analysis for a typical Sawmill in Udu.

Noise levels	**Duration (mins.)**	**Rank No.**	**P=m/n**	**(1-P)*100**	**$0.1L_i$**	$10^{0.1L_i}\frac{t_i}{60}$ x 10^9
89.9	5	1.00	0.04	95.83	8.99	0.081
90	10	2.00	0.08	91.67	9.00	0.167
90.3	15	3.00	0.13	87.50	9.03	0.268
90.3	20	4.00	0.17	83.33	9.03	0.357
91.8	25	5.00	0.21	79.17	9.18	0.631
92.9	30	6.00	0.25	75.00	9.29	0.975
93.4	35	7.00	0.29	70.83	9.34	1.276
93.5	40	8.00	0.33	66.67	9.35	1.492
93.6	45	9.00	0.38	62.50	9.36	1.718
93.7	50	10.00	0.42	58.33	9.37	1.954
93.8	55	11.00	0.46	54.17	9.38	2.199
94.3	60	12.00	0.50	50.00	9.43	2.692
94.4	65	13.00	0.54	45.83	9.44	2.984
94.7	70	14.00	0.58	41.67	9.47	3.443
95.1	75	15.00	0.63	37.50	9.51	4.045
95.2	80	16.00	0.67	33.33	9.52	4.415
95.3	85	17.00	0.71	29.17	9.53	4.800
95.3	90	18.00	0.75	25.00	9.53	5.083
95.3	95	19.00	0.79	20.83	9.53	5.365
95.8	100	20.00	0.83	16.67	9.58	6.336
97.2	105	21.00	0.88	12.50	9.72	9.184
97.8	110	22.00	0.92	8.33	9.78	11.047
98.5	115	23.00	0.96	4.17	9.85	13.567
98.6	120	24.00	1.00	0.00	9.86	14.489
Cumulative sampling Time, T (mins)	1500					98.570
T (hr)	25	**Avg. Continuous Noise Level (L_T)**				95.958

Table B4. Standard Guidelines for Noise Exposure in Workplaces.

NESREA, 2009		OSHA, 1983		NIOSH, 1998	
Duration(hrs) per day	Exposure limits (dBA)	Duration per day, Hours	Exposure Limits dBA	Duration per day, Hours	Exposure Limits dBA
8	85	8	90	25 hours 24 minutes	80
4	88	6	92	20 hours 10 minutes	81
2	91	4	95	16 hours	82
1	94	3	97	12 hours 42 minutes	83
0.5	97	2	100	10 hours 08 minutes	84
0.25	100	1.5	102	08 hours	85
0.125	106	1	105	06 hours 21 minutes	86
		0.5	110	05 hours 02 minutes	87
		0.25 or Less	115	04 hours	88
				03 hours 10 minutes	89
				02 hours 31 minutes	90
				< 1 second	Up to 140