World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

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Assessment of Total Suspended Particulate Matter (TSPM) Emissions from Sawmills in Akwa Ibom State, Nigeria

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World Journal of Advanced Research and Reviews, 2025, 26(02), 2599-2609

Publication history: Received on 14 April 2025; revised on 11 May 2025; accepted on 13 May 2025

Article DOI: https://doi.org/10.30574/wjarr.2025.26.2.1879

Abstract

This research evaluated the total suspended particulate matter (TSPM) emissions and other pollutants in sawmills located within Akwa Ibom State, Nigeria as well as the occupational health effects on the workers. The study utilized real-time air quality assessment tools alongside structured questionnaires which were implemented in a mixed methods cross sectional approach. These tools together with Geographic Information Systems (GIS) were used to gather spatial, environmental, and demographic information from a total of 384 sawmill workers in 12 sawmills across the three senatorial districts of the state. Findings indicated that particulate matter concentrations at the sources of wood dust almost always surpassed WHO limits with measurements between 2.08 mg/m^3 to 3.12 mg/m^3 especially in areas such as Idu Uruan and Ikot Ekpene. Several workplaces also breached the OSHA's 85 dB (A) limit for noise with some exceeding 110 dB (A). Most of the workers were men aged between 31 to 45 years, poorly educated, and had more than six years of work experience which indicated chronic exposure coupled with low health literacy and inadequate protective measures. All these factors underline the need for ordinances pertaining to social governance in occupational health and safety, environmental protection, and didactic policy. This study calls on health policymakers, occupational health experts, and sawmill owners to take comprehensive measures for sustainable policy to contain pollution and the health risk among workers for the wood processing industry in Nigeria.

Keywords: Assessment; Emissions; Matter; Akwa Ibom; Sawmills; Suspended particles

1. Introduction

The health consequences of air pollution, particularly concerning public health, should be of grave concern. Particulate Matter (PM) is one of the most dangerous among air pollutants because it has the potential to infiltrate the deepest recesses of human respiratory systems and even get into the bloodstream. PM consists of a complex mixture of solid and liquid particulates suspended in the atmosphere, and it results from industrial works, automobiles, and burning biomass. The World Health Organization (WHO) has reported time and again the troubling PM exposure effects, known to cause respiratory and cardiovascular diseases, including premature mortality (WHO, 2021). In the wood processing industry, workers face the risk of inhaling large quantities of wood dust. Wood dust is one of the major components of PM. It is produced during saw, sand, and mill operations. Exposure to wood dust has been shown to result in multiple

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health complications, such as respiratory problems, lower lung function, and higher chances of developing particular cancers over time. According to the International Agency for Research on Cancer (IARC), wood dust is a Group 1 human carcinogen, which means there is adequate evidence for its carcinogenicity in humans (IARC, 1995). The wood processing industry in Nigeria is a vital part of the economy as it offers job opportunities and aids in the development of infrastructure. In the South-South region of Nigeria, Akwa Ibom State has a lot of forests, which makes it home to many sawmills. Unfortunately, a lot of these sawmills are poorly monitored regarding water and air pollution, as well as the health and safety standards at the workplace. Research shows that such workers face higher-than-normal risks of acquiring respiratory diseases due to constant exposure to wood dust and other contaminants (Tobin et al., 2016). Despite the health concerns, very few comprehensive studies focus on measuring and mapping out the particulate matter concentration found within the sawmills in Akwa Ibom State. Filling this gap is important for developing proper occupational health frameworks to protect the employees within the wood processing industry. The purpose of this research is to determine the particulate matter concentration in selected sawmills in Akwa Ibom State and examine the health effects of such exposure on the employees. The use of geospatial analysis in combination with field measurements aims to determine the pollution hotspots and offer guidance to policymakers to enhance occupational health advances within the region.

2. Materials and methods

2.1. Study Area

As shown in Figure 1, Akwa Ibom State is placed within 5° 53'N 'n and 4° 32' latitude and 7°25' and 8°25' East longitude. The state is bounded on the east by Cross River State, Rivers and Abia State on the West, and the Atlantic Ocean to the South, extending in length from Ikot Abasi in the west to Oron in the east for 129 kilometres. The name of the state originates from the Qua Iboe River that flows within the state and empties into the Bight of Bonny (Onyeakagbu, 2021). The entire area of the study is the Qua Iboe River Basin, which has an area of 8,412 km2. It the western part of the lower Cross River basin in combination with the eastern region of the Imo River basin, this region is what defines the state. Flat, low-lying lands is one of the three distinctive terrains found in Akwa Ibom state. The second terrain is an expansive elevated region decorated with hills that stunningly contrast with the flat plains. The altitude of Akwa Ibom State ranges from 45 to 70 meters above sea level. It has three senatorial districts made up of 31 Local Government Areas (Petters et al. 1994).

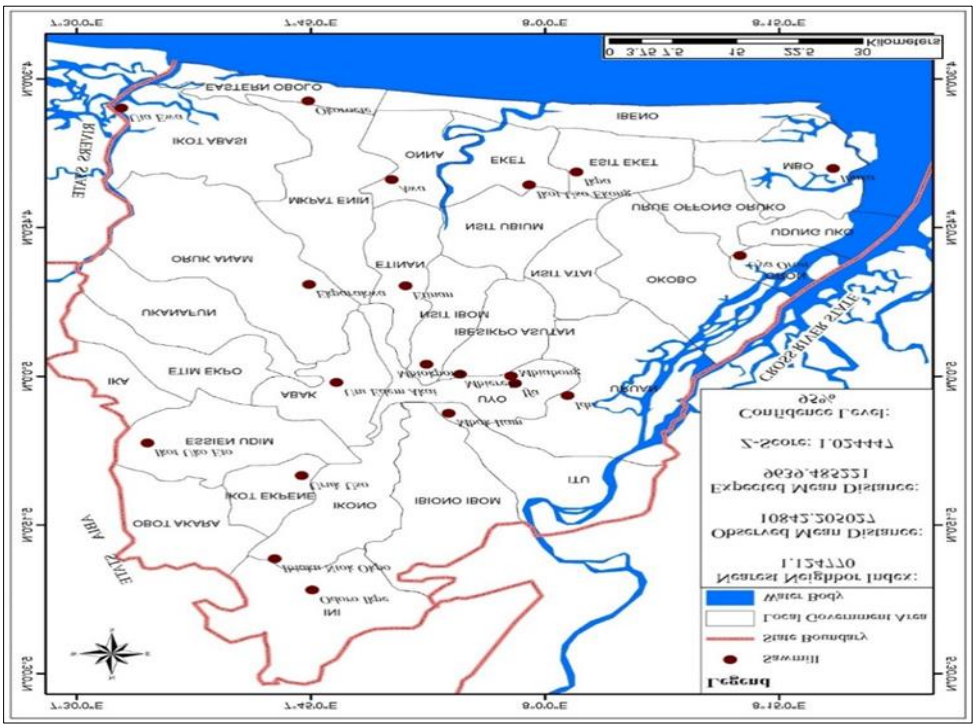

Figure 1 Map of Akwa Ibom State showing locations of the sampled sawmills

2.2. Research design

The research design employed in evaluating the study to identify and map the spatial distribution of sawmills in Akwa Ibom State was a cross-sectional study with a mixed-methods approach.

2.3. Source of data

To successfully achieve the study objective, a combination of quantitative and qualitative data was obtained. Quantitative data includes counts and statistical analyses, while qualitative data involves descriptions, interviews, and observations. The research also paid attention to ethical issues when collecting, storing, and analysing sensitive data related to individuals, their health, and safety. Therefore, codes such as SMW (Sawmill Workers) with numbers such as (001-00384) were used to represent the sampled sawmill workers in each of the sampled sawmills within the three Senatorial Districts of the study area.

Method of data collection: Data were collected using the Geographic Information System Approach, semi-structured questionnaires, checklists, Key Informant Interviews (KII), field observations, and scientific measurements, which were done in situ.

Techniques of data analysis: The data collected from the field were analysed using both descriptive and inferential statistical techniques, and the following procedures and methods were employed to produce conclusions pertinent to the study's goals. Descriptive analysis, which included simple averages, percentages, tables, maps, and charts, was used to show the summary of details from attribute data. Conventional and geo-statistical inferential statistical techniques were adopted to test the formulated hypothesis. Further, the photo-elucidation technique was also employed to show the medical examination processes carried out with sawmill workers during the fieldwork exercise. The techniques adopted for testing the hypotheses are as follows:

- Hypothesis one: H0: The locational pattern of sawmills in Akwa Ibom State is not random.
- H1: The locational pattern of sawmills in Akwa Ibom State is random.

The Average Nearest Neighbor ratio is given as:

$$ANN = \frac{\bar{D}_O}{\bar{D}_E} \quad (1)$$

where $\bar{D}_O$ is the observed mean distance between each feature and its nearest neighbor:

$$\bar{D}_O = \frac{\sum_{i=1}^{n} d_i}{n} \quad (2)$$

and $\bar{D}_E$ is the expected mean distance for the features given in a random pattern:

$$\bar{D}_E = \frac{0.5}{\sqrt{n/A}} \quad (3)$$

In the above equations, d_i equals the distance between feature i and it's nearest neighboring feature, n corresponds to the total number of features, and A is the area of a minimum enclosing rectangle around all features, or it's a user-specified Area value.

The average nearest neighbor z-score for the statistic is calculated as:

$$z = \frac{\bar{D}_O - \bar{D}_E}{SE} \quad (4)$$

where:

$$SE = \frac{0.26136}{\sqrt{n^2/A}} \quad (5)$$

The analysis of the spatial distribution of sawmills in Akwa Ibom State was carried out using Average Nearest Neighbor (ANN) spatial analytic tool. This tool measures “average nearest neighbor distance” which is the distance from each feature centroid to its nearest neighbor centroid. The average is less than that of a random distribution, clustered distribution is attributed to features being analyzed. If the average distance is higher than random distribution, features are said to be dispersed. In ANN analysis, the criterion of the z-score and p-value gives measures of statistical significance, thus, the decision to reject the null hypothesis (Environmental Systems Research Institute, (ESRI), 2013). While collecting the field data, a Garmin Etrex 10 portable Global Positioning System (GPS) was used to record the X (longitude), Y (latitude), as well as Z (name and attribute) coordinates of the sawmills in the three senatorial districts

of Akwa Ibom State. These coordinates were subsequently processed using Microsoft Excel and then were prepared for mapping and spatial analysis using GIS.

Two sets of data were collected: one consisted of twelve major sawmill branches across the regions, with two sawmills sampled from each local government area, and another described the spatial distribution of sawmill machines within these branches. Using ArcGIS, the data were mapped and visually represented to show the distribution of sawmills and machines. Sawmill workers' exposure to machines concerning the hearing, sight, and lung health of workers was evaluated with mean center analysis evaluated in ArcToolbox focusing on their distances to the machines. This analysis finds a geographic center produced by averaging the X and Y coordinates of feature centroids, calculating a center of concentration among features.

2.4. Sampling techniques

The study sawmills were purposively selected, and the research adopted a stratified random sampling method to select 32 sawmill workers (respondents) from the target population (sawmill workers) within the 12 sawmills across the twelve 12) LGAs within the three 3) senatorial districts of Akwa Ibom State. The list of sawmill workers was obtained from the workers registered at the Akwa Ibom State Sawmill Association Secretariat at Itam Sawmill, and respondents were chosen based on the different sections that they worked in.

2.5. Measurement of Noise Level, Particulate Matter and Gaseous Pollutants

The assessment of noise levels among selected sawmill workers was conducted through meticulous data collection using a sound level meter. Using a sound level metre of the D-1422C type, noise levels were measured at specific sawmill locations during the day when operations were underway. Field assistants, under the guidance of the researcher, employed a systematic approach to ensure accurate measurements. The researchers used a comprehensive approach to gain a thorough understanding of the noise levels experienced by sawmill workers during their daily workdays. Before beginning any measurement, the selected workers were informed about the purpose and procedures of the noise assessment and their consent was obtained. The sound level metre, a calibrated instrument designed to measure sound intensity, was then strategically placed in the work environment. Measurements were taken at various locations

Highly sensitive digital portable meters, Gasman gas monitor and HAZ-DUST Particulate Monitor, respectively, were used for the measurement of gaseous pollutants (NO2, SO2 and CO) and suspended particulate matter (SPM) at sawmills. The collection of particulate matter from selected sawmills involved a systematic approach utilising air sampling equipment. Researchers and field assistants employed a portable particulate matter sampler equipped with filters to capture airborne particles. Before the commencement of sampling, the field assistants positioned the samplers strategically within the sawmill premises, taking into account factors such as proximity to machinery, workstations, and prevailing wind directions. The samplers were left operational for a predetermined period to collect a representative sample of particulate matter suspended in the air. After the sampling duration, the field assistants carefully retrieved the filters from the samplers. These filters were then transported to a laboratory for analysis, where the concentration and composition of particulate matter were determined. This method allowed for an accurate assessment of the particulate matter levels in the sawmill environment, allowing researchers to assess any dangers to respiratory health from workplace exposure and put the appropriate preventive measures in place for sawmill workers' safety.

3. Results

Table 1 Population of Sawmills and Workers in Akwa Ibom State

Sawmills in Akwa Ibom State	The population of sawmill workers
Abak Sawmill	1,250
Ikot Ekpene Timber Market	900
Ikono Sawmill	750
Essien Udim Timber Market	1,300
Oruk Anam Timber Market	620
Ini Timber Market	1,150
Ibiaku Ntuk Okpo Sawmill	800

Ibesikpo Timber Market	985
Idu Uruan Timber	1770
Itam Timber Market	1510
Mbiabong Sawmill	720
Mbiokporo Sawmill	690
Etinan Sawmill	450
Eket Timber Market	575
Uya Oron Sawmill	400
Ikot Abasi Timber Market	430
Ibaka Mbo Sawmill	500
Awa Sawmill	700
Mkpat Enin Sawmil	1,200
Ikpa Sawmill Esit Eket	1412
Total	18,112

Table 2 Sample Size

Sample sawmills	**The population of sawmill workers**	**Sample size**
Itam Timber	1,250	32
Idu Uruan Sawmill	900	32
Ibesikpo Timber Market	750	32
Mbia-Obong Sawmill	1,300	32
Ikot Ekpene Timber Market	620	32
Ikono Sawmill	1,150	32
Essien Udim Timber Market	800	32
Abak Sawmill/Wood Market	520	32
Eket Timber	770	32
Ikot Abasi Sawmill	510	32
Oron Timber Market	720	32
Mkpat Enin Sawmill	690	32
Total	10,040	384

Table 3 Demographic characteristics of sawmill workers

Gender of sawmill workers	**Frequency**	**Percentage (per cent)**
Male	264	68.7
Female	120	31.3
Total	384	100
The ages of sawmill workers	Frequency	Percentage (per cent)

18-30 years	84	21.9
31-45 years	176	45.8
46-60 years	108	28
60 years and above	16	4.2
Total	384	100
Marital status	Frequency	Percentage (per cent)
Single	117	30.5
Married	182	47.4
Divorced	48	12.5
Windowed	37	9.6
Total	384	100
Educational profile	Frequency	Percentage (per cent)
No Education	12	3
FSLC/JSS/SSCE	118	30.7
OND/NCE	166	4.3
Degree	62	16
Post graduate	26	6.8
Total	384	100
Average monthly income	Frequency	Percentage (per cent)
Less than 100.000	41	10.7
100.000-200.000	125	32.6
201.000-300.000	149	38.8
301.000-400.000	38	9.9
Above 401.000	31	8
Total	384	100
Years of work experience	Frequency	Percentage (per cent)
Less than a year	16	4.2
1-5 years	86	22.4
6-10 years	166	43
11-15 years	74	19.3
Above 15 years	42	10.9
Total	384	100

Table 4 Weekly data on the noise level for the sampled sawmills in Akwa Ibom State

Sampled Sawmill	**Sub-area within the sawmill**	**WEEK I Minimum/Maximum (Noise Level)**		**WEEK II Minimum/Maximum**		**WEEK III Minimum/Maximum**		**WEEK IV Minimum/Maximum**	
Mbia-obong	i.	96.00	112.5	94.08	110.7	88.8	96.7	88.7	106.3
	ii.	89.6	109.5	85.00	107.05	72.0	76.00	70.06	77.04
	iii.	72.8	79.4	70.06	80.2	69.0	73.08	65.07	70.02
	iv.	68.7	77.3	69.06	78.7	65.5	74.02	63.2	68.00
Itam Timber Market	i.	94.02	109.5	98.07	104.6	96.5	108.7	99.04	110.07
	ii.	83.00	102.00	81.04	83.6	80.7	90.3	82.00	89.05
	iii.	68.04	72.00	70.05	75.4	72.07	75.3	70.02	78.08
	iv.	70.00	76.01	68.2	73.4	64.8	70.3	68.7	74.04
Ido Uruan Sawmill	i.	94.00	108.7	95.07	102.7	98.7	112.4	95.4	106.00
	ii.	86.04	96.3	73.4	81.3	80.6	89.2	82.3	86.05
	iii.	70.06	81.02	69.5	73.00	70.06	77.00	75.02	82.09
	iv.	67.05	74.5	64.7	70.8	68.4	73.7	64.3	69.02
Ibesikpo Timber Market	i.	94.02	103.5	92.06	109.7	86.8	94.5	83.7	102.3
	ii.	87.4	105.6	83.04	103.05	71.0	74.00	72.06	74.04
	iii.	70.4	76.2	72.04	79.03	67.0	71.08	63.05	72.02
	iv.	63.6	75.2	67.03	79.5	63.4	72.05	62.07	64.00
Abak Timber Market	i.	91.04	101.6	90.04	106.7	85.6	92.4	81.5	101.1
	ii.	82.3	103.2	81.02	102.5	73.0	72.00	70.03	72.04
	iii.	71.2	74.1	70.03	74.05	69.0	70.08	62.04	74.03
	iv.	64.5	73.3	65.02	78.3	65.6	70.03	61.05	62.02
Ikot Ekpene Timber Market	i.	92.01	106.6	94.07	106.8	88.7	96.6	88.7	103.3
	ii.	82.4	95.7	87.06	101.03	73.0	77.04	74.06	78.04
	iii.	68.4	73.4	76.06	78.03	69.0	73.06	69.05	73.03
	iv.	65.4	72.3	68.02	77.5	65.5	75.04	68.07	71.00
Ikono Timber Market	i.	92.02	104.4	93.04	106.7	85.6	92.4	81.5	101.1
	ii.	85.3	107.3	88.03	102.5	73.0	72.00	70.03	72.04
	iii.	73.2	78.1	72.04	74.05	69.0	70.08	62.04	74.03
	iv.	69.6	75.4	65.02	78.3	65.6	70.03	61.05	62.02
Essien Udim Timber Market	i.	93.04	107.4	99.07	102.3	94.4	107.4	99.04	109.04
	ii.	82.03	101.5	84.05	84.5	82.7	94.4	80.00	87.05
	iii.	69.05	73.00	73.05	73.3	71.05	76.5	71.02	79.08
	iv.	72.04	78.00	69.02	72.4	66.8	72.7	67.03	77.06
Eket Timber Market	i.	93.03	106.4	98.03	112.3	96.5	102.2	93.02	108.01
	ii.	87.05	92.6	75.8	84.02	83.5	92.6	81.03	89.07
	iii.	73.06	82.05	67.4	72.04	72.03	70.01	74.05	84.05
	iv.	68.04	78.7	63.04	72.3	65.2	72.07	61.02	68.05
Ikot Abasi Sawmill	i.	93.02	104.5	94.02	104.2	81.5	94.5	87.03	102.1
	ii.	84.05	102.0	85.02	109.3	68.0	75.06	68.03	73.06
	iii.	70.03	72.04	69.04	77.04	66.0	74.03	64.05	75.02

	iv.	61.7	75.03	64.03	75.5	64.5	72.08	63.02	69.04
Oron Timber Market	i.	91.02	107.6	97.04	108.5	83.4	95.02	89.6	104.2
	ii.	87.5	93.5	85.06	102.02	71.03	75.03	72.05	79.02
	iii.	69.2	72.2	75.08	79.03	67.05	76.03	66.03	72.05
	iv.	67.3	74.02	69.06	79.4	66.06	74.02	64.05	73.03
Mkpat Enin Sawmill	i.	93.03	102.2	96.03	104.6	84.04	93.2	87.5	99.01
	ii.	87.03	101.03	89.02	101.3	72.03	78.00	67.03	74.02
	iii.	76.02	81.02	70.00	72.07	63.02	71.02	63.02	70.03
	iv.	67.06	76.04	67.03	75.02	64.06	69.03	59.05	63.02

Source: Researcher's fieldwork (2023)

Table 5 Total suspended particulate matter from sampled sawmills in Akwa Ibom State

Sampled Sawmill	**Sub-Area within the sawmill**	**Instrument Readings (Mg/m^3)**
Mbia-Obong Sawmill	Source of wood dust	3.04
	Operating spot within source of wood dust	1.03
	Wood sales point	0.46
	Wood storage spot	0.20
Itam Timber Market	a. Source of wood dust	2.10
	b. Operating spot within source of wood dust	0.82
	c. Wood sales point	0.32
	d. Wood storage spot	0.25
Idu Uruan Sawmill	Source of wood dust	3.10
	Operating spot within source of wood dust	0.78
	Wood sales point	0.43
	Wood storage spot	0.29
Ibesikpo Sawmill	Source of wood dust	3.05
	Operating spot within source of wood dust	2.03
	Wood sales point	0.77
	Wood storage spot	0.28
Abak Timber Market	Source of wood dust	2.08
	Operating spot within source of wood dust	1.07
	Wood sales point	0.48
	Wood storage spot	0.23
Ikot Ekpene Timber Market	Source of wood dust	3.12
	Operating spot within source of wood dust	1.09
	Wood sales point	0.56
	Wood storage spot	0.23
Ikono Timber Market	Source of wood dust	3.09
	Operating spot within source of wood dust	1.05
	Wood sales point	0.75
	Wood storage spot	0.28
Essien Udim Timber	Source of wood dust	3.06

	Operating spot within source of wood dust	1.05
	Wood sales point	0.33
	Wood storage spot	0.22
Eket Timber Market	Source of wood dust	2.09
	Operating spot within source of wood dust	1.03
	Wood sales point	0.48
	Wood storage spot	0.31
Ikot Abasi Sawmill	Source of wood dust	3.07
	Operating spot within source of wood dust	2.02
	Wood sales point	0.34
	Wood storage spot	0.23
Oron Timber Market	Source of wood dust	3.06
	Operating spot within source of wood dust	2.01
	Wood sales point	0.33
	Wood storage spot	0.22
Mkpat Enin Sawmill	Source of wood dust	3.09
	Operating spot within the source of wood dust	2.05
	Wood sales point	0.36
	Wood storage spot	0.24

Source: Researcher's fieldwork (2023)

4. Discussion

In Akwa Ibom State, as illustrated in Table 1, a considerable number of sawmills are hosted, employing a total of 18,112 people. The largest populations were noted in Idu Uruan (1770 workers), Itam Timber Market (1510), and Ikpa Sawmill Esit Eket (1412) which demonstrates greater concentration of economic activities in those areas. These workers may be at higher exposure risk to particulate matter while employing greater amounts of machines due to higher quantities of wood being processed and poor ventilation. Ogunwande et al. (2013) noted that sawmills located within heavy populated timber markets in Southern Nigeria tend to lack sufficient dust control systems and, as a result, worsen the health risks of the employees. The existence of more than 18,000 workers, in addition, provides compelling evidence for the need for active measures in public health, especially considering that suspended particulates in the air for a long time can cause respiratory and cardiovascular issues (World Health Organization, 2021). The inclusion of 384 respondents from 12 major sawmills provides representativeness from all three senatorial zones of the Akwa Ibom State into the sampling strategy. From every sawmill, 32 respondents were selected, which ensured capture of diverse exposures needed to assess different operational contexts. The ability to conduct comparative analysis across locations is enhanced by uniformity of sample distribution.

The application of stratified sampling is in accordance with Creswell and Plano Clark's (2018) recommendations on mixed-method research where the cross-site exposition and results relationships are critical. It also depicts the sample male predominant workforce (68.7%), which corroborates Adeniyi et al. (2015) finding on gender disparity within timber occupations in Nigeria, stemming from the physically demanding nature of the timber-related work. The age distribution of the workers shows that most of them were aged between 31 and 45 years (45.8%) which means the workforce is relatively young and economically active. As regarding education, only 16 percent were university degree holders and 30.7 percent were secondary school graduates, which raises the suspicion of low health literacy in regard to occupational safety issues. This is a critical finding to lower education thresholds which heightens the risk for inadequate PPE utilization alongside misconception of occupational hazards (Choi & Pak, 2006). The average salary levels (where 38.8% earn N201,000–300,000 a month) are not commensurate with the risks involved; over 43% of the respondents have worked for over six years, indicating chronic exposure. Pope & Dockery's (2006) study asserts that this cumulative exposure increases the risk of PM-related illnesses. Captured during all sample sawmills, the noise levels not only reached but consistently surpassed the 85 dB(A) mark set by OSHA (2013) as the upper limit of occupational noise for proper sawmill operation. In places like Mbia-Obong and Itam Timber Markets, peaks of over 110 dB(A) were recorded. Such levels of occupational noise exposure have been associated with NIHL and greater strain on

cardiovascular systems (Basner et al., 2014). These findings align with Olopade et al.'s (2015) research which documented extreme noise pollution in timber processing facilities in Western Nigeria. Prolonged exposure to such sound levels, especially in the absence of ear protection, predisposing one to auditory harm, exacerbates stress while simultaneously decreasing productivity. Concentrations of particulate matter in all the sawmills were recorded to be alarming relative to the World Health Organization's (2021) PM10 limit of 0.050 mg/m^3. The readings were particularly high in the source regions of wood dust, where concentrations reached 2.08 – 3.12 mg/m^3, most notably in Ikot Ekpene Timber Market and Idu Uruan Sawmill. These findings support Oguntoke and Adekoya's (2016) study which identified the same unregulated concentration levels in Oyo State's uncontrolled sawmills. These areas are characterized by elevated concentrations of suspended particulate matter, which are known to increase respiratory illnesses, including asthma, bronchitis, and chronic obstructive pulmonary disease (COPD). In addition, the increased particulate matter concentrations associated with wood storage and sales also indicate that PM emission is not limited to the space surrounding the machinery but permeates the work environment and increases the risk of non-operational staff and customers shielding away from active machineries being passively exposed.

5. Conclusion

This study has highlighted the troubling occupational and environmental health impacts associated with high levels of PM, noise, and poor working conditions in the Akwa Ibom State sawmills, Nigeria. Geospatial analyses and demographic studies strongly suggest that the dust (PM10) and noise pollution in the surveyed sawmills exceed the international and national health and safety benchmarks established by the World Health Organisation and OSHA. The demographic characteristics of the respondents indicate that the majority are productive, aged males with minimal education and substantial work experience. These factors combined create a profile which predisposes individuals to suffer from the health consequences of chronic exposure to workplace pollutants. Absence of regulatory control, lack of PPE, and inadequate safety measures at the workplace increase the risk. For Instance, Itam Timber Market and Idu Uruan are examples of sawmills whose spatial locations demonstrate clustering spatial patterns, which endanger nearby workers and residential communities because of poor air quality. These results support previous research verifying the linkage of wood dust exposure to respiratory illnesses, reduced lung function, and long-term conditions such as COPD and cancer. Governmental and non-governmental stakeholders need to take immediate action to improve occupational health and safety in the sawmill industry. Suggested measures include active management of air quality for the specific occupational environment, enforcement of OHS legislation, provision of adequate PPE, educational changes where workers are taught more comprehensive and relevant materials, and more comprehensive state policies that restructure timber processing at the legislative level into safer and more sustainable frameworks. Failure to address these health and safety issues for the sawmill workers in Akwa Ibom State undermines public health; however, they also highlight social equity dimensions of economically sustainable development.

Recommendations

In light of this study, the following recommendations are suggested to lessen workplace exposure to particulate matter and enhance the health and safety of sawmill workers in Akwa Ibom State: PPE like respirators, ear protection, and eye protection must be supplied by employers and sawmill associations, professionally endorsed for all workers. There must also be periodic instructional sessions on the care and correct usage of the provided equipment. There is a requirement to measure the concentration of PM10 and PM2.5 within sawmill workspaces and evaluate air quality with standardized instruments regularly. Such evaluations should be made available to the public and acted upon following the policy.

Compliance with ethical standards

Disclosure of conflict of interest

The authors confirm they have no competing interests regarding this article.

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