RESEARCH PORTAL CENTRAL

Journal of Biomedical Research and Clinical Reviews

OPEN ACCESS

Research Article

Ambient Air Quality in Wood Processing Industries in Calabar Metropolis, Cross River State, Nigeria.

Oyama Vincent Ofuka[1], Inyang-Ogim Favour Achi[1]*, Okoi Iferi Ubi[1], Awa Theresa[1], Agba Sylvia Anokie[1], Ayim Cosmos Inok[2], Elizabeth-Jane Egbelo[3], Obogo Patrick Aloyi[1]

1. Department of Public Health, Faculty of Allied Medical Sciences, University of Calabar, Calabar, Nigeria.
2. Federal Polytechnic Ugep, Cross River State, Nigeria
3. College of Health Technology, Calabar, Cross River State, Nigeria.

How to cite this article: Oyama, Vincent O. I. O, Favour A. I. O, Okoi, Iferi U. (2026). Ambient Air Quality in Wood Processing Industries in Calabar Metropolis, Cross River State, Nigeria. Journal of Biomedical Research and Clinical Reviews. RPC Publishers, 1(1); DOI: https://www.doi.org/rpc/2025/jbrcr/00480

***Address for correspondence:** Favour Achi Inyang-Ogim, Department of Public Health, Faculty of Allied Medical Sciences, University of Calabar, Calabar, Nigeria.

Email: inyangogimfavourachi@unical.edu.ng

Submitted: October 25, 2025
Approved: November 15, 2025
Published: March 30, 2026

Abstract

Introduction: Air pollution remains a significant environmental and public health challenge, particularly in occupational settings. This study assessed ambient air quality in wood processing industries in Calabar Metropolis, Cross River State, Nigeria.

Method: Using direct-reading gas monitors (Crowcon AS8900) and particulate monitors (Casella-AMS 95015), concentrations of NO_2, SO_2, CO, H_2S, PM_{10} and PM_2.5 were measured at four sampling stations across three major wood processing sites. Participation was voluntary with each respondents giving informed verbal consent.

Results: Result revealed that while mean levels of CO, NO_2, SO_2, and PM_2.5 were within national/international standards, PM_{10} concentrations exceeded acceptable limits in all sites. There was not statistically significant difference in the mean concentration of air quality at the different processing points. Tthe mean difference in the mean concentration of air quality of wood processing points showed that Akim- Akai Effa (p=.002) and Akim 8 miles (p=.001) was statistically significant except for Akai effa 8miles (p=.579) which was not statistically significant. Mean concentration of air quality parameters at major points in the processing sites revealed that CO and PM_2.5 were elevated at sawing points and 43.6% had abnormal lung function. Difference in the mean lung function of wood processing workers revealed that there was a statistically significant difference in FVC (L) (t=8.575, p=, <.001 and FEV1 (L) (t=2.420, P=0.160) except for FEV1% (T=1.165, P=.245) and PEFR(L/min) (t=0.730, p=466) that were not significant.

Conclusion: Findings indicate that emissions from wood processing pose significant occupational health risks. Regular air quality monitoring, are imperative to safeguard workers' respiratory health.

Keywords: ambient air quality; wood processing; lung function

Background of Study

Wood processing has become a fast-growing business in Nigeria due to high demand by local and international market. This growing demand by timber consumer has caused wood processing to become a daily occupation to many in Nigeria and Cross River State in particular. Wood processing involves procedures and technique of converting raw wood into a usable or finished product. That is cutting raw wood into logs and planks. Wood processing procedures such as sanding, cutting or milling generate dust which might result in several health problems including carcinogenicity (National Toxicology Program Report, 2021; [6]. Air borne, wood dust is the most prevalent occupational exposure hazard in the wood industry. [11]; [14]. [12] Asserted that wood dust inhalation has been associated with upper and lower respiratory symptoms in humans including cough, wheezing, sputum production and shortness of breath. The major syndromes associated with constant inhalation of fine particles, particulate and ultra-fire particulate matter produces by the wood dust and related chemicals used in fumigation of wood and maintenance of machines the industry includes; mucus membrane irritation syndrome, extrimic – allergic alveolities, organic dust toxic syndrome, occupational asthma, non-asthmatic chronic airflow obstruction, simple chronic bronchitis (Mucus hypersecretin), cryptogenic fibrosing alveolitis, adenocarcinomia of the nasal and paranasal sinuses, cancer of the laryrix and pharynx (Enarson & Chan, 1990 as cited by [16]; [2]; [15].

Methods

Study Design

A cross-sectional environmental health assessment was carried out in three major wood processing zones (Akim, Akai Effa, Ikot-Enobong). Four geo-referenced sampling stations were designated in each zone. Air quality was assessed using handheld Gasman Gas Detectors (Crowcon AS8900) and Casella AMS 95015 Particulate Monitors. Parameters measured included NO_2, SO_2, CO, H_2S (in ppm), and PM_{10} and $PM_2.5$ (in mg/m^3). Data were analyzed using SPSS v23 with ANOVA applied to determine spatial and functional differences in pollutant concentrations.

Sample Size

The minimum sample size for the study for each group was calculated using the formula for the comparison of two proportions which are Operators and Administrators. [4] 202 Operators and 202 Administrators will be used for the study to compare the lung function gradients of the two groups of workers.

Instrument for Data Collection

Data was collected using a semi structured self-administered questionnaire by trained research assistants. The questionnaire was adopted and modified to suit the study from Occupational Hazard, Safety Measures and Lung Function of Sawmill Workers in Kwara Central, Nigeria by [1].

Method of Data Analysis

Descriptive and inferential statistics was used to describe and analyze the data obtained. Data were entered using MS Excel and SPSS version 20 software package before the analysis of the data. Results were presented in frequency and percentages using tables, and charts. Chi-squared test was used for qualitative data such as sex, duration of service, marital status, occupation and respiratory symptoms, while t-test was used for continuous variables that were normal in distribution such as age, lung function indices. F-test was used to determine level of statistical association between level of exposure and lung function and duration of employment and lung function. Fisher Exact statistical test of association was used when any of the expected cells is <5.

Ethical Approval: The research protocol was approved by the Cross River State Health Research Ethics Committee, Ministry of Health (CRS/MOH/RP/REC/2023/366). All participants were informed that their participation was voluntary and that they could opt out of the study at any time... Confidentiality and anonymity were ensured.

Result and Discussion

Table 1: Socio-demographic characteristics of wood workers

Characteristic	Frequency (n= 404)	Percentage (%)
Age (in years)		
18-27	92	22.8
28-37	173	42.8
38-47	99	24.5
48-57	40	9.9
Mean age	36.62 ± 8.67	
Sex		
Male	299	74.0
Female	105	26.0
Marital status		
Single	192	47.5
Married	212	52.5
Social habits		
Snuffing	12	1.0
Drinking	202	50.0
Smoking	185	45.8
Multiple habits	5	1.2
Role in industry		
Administrator	202	50.0
Operator	202	50.0
Occupation		
Carpenter	5	1.2
Carrier	57	14.1
Sawyer	105	26.0
Loader	15	8.6
Dealer	97	24.0
Sale person	56	13.9
Clerk	37	9.2

Driver	12	3.0
Work experience		
< 1 year	41	10.2
1-5 years	125	30.9
6-10 years	124	30.7

Table 2: Air quality at wood processing industries

Timber Site	Parameters	Range	Mean	SD	FMEV Standard	WHO standard
Akim	$PM_{2.5}$ (mg/m3)	18-52	33.75	19.40	32	35
	PM_{10} (mg/m3)	34-86	40.75	25.05	25	50
	H_2S (ppm)	0	0	0	0.5	20
	SO_2 (ppm)	0.5-0.8	0.62	0.13	8.0	20
	NO_2(ppm)	1.44-1.49	1.47	0.02	10	40
	CO (ppm)	9-10	9.25	0.50	0-10	10
Akai Effa	$PM_{2.5}$ (mg/m3)	17-21	18.75	2.06	32	35
	PM_{10} (mg/m3)	30-52	40.75	8.99	25	50
	H_2S (ppm)	0	0	0	0.5	20
	SO_2 (ppm)	0.4-0.7	0.58	0.13	8.0	20
	NO_2(ppm)	1.38-1.43	1.41	0.02	10	40
	CO (ppm)	9-11	9.25	1.26	0-10	10
Ikot-Enobong	$PM_{2.5}$ (mg/m3)	29-34	14	1.41	32	35
	PM_{10} (mg/m3)	13-16	31.25	2.63	25	50
	H_2S (ppm)	0	0	0	0.5	20
	SO_2 (ppm)	0.4-0.7	0.58	0.13	8.0	20
	NO_2(ppm)	1.40-1.41	1.4	0.01	10	40
	CO (ppm)	9-10	9.25	1.26	0-10	10

Table 3: Lung function status of wood processing workers

LOCATIONS	FVC(L)		FEV1(L)		FEV1% (L)		PEFR (L/MIN)	
	Operators	Admin.	Operators	Admin.	Operators	Admin.	Operators	Admin.
AKIM	3.22±0.51	2.81±0.21	3.01±4.26	2.31±0.48	76.22±16.94	82.62±12.38	297.69±118.39	283.0±98.06
AKAI-EFA	3.26±0.51	2.79±0.52	3.08±4.44	2.27±0.47	76.03±17.19	81.93±12.40	303.47±118.94	271.33±84.96
IKOT-ENOBONG	3.25±0.52	2.78±0.55	3.08±4.53	2.29±0.53	75.56±17.34	82.52±12.80	298.98±115.72	276.68±97.09
TOTAL	3.24±0.51	2.79±0.43	3.06±4.41	2.29±0.49	75.94±17.16	82.36±12.53	300.05±117.68	277.0±93.37

Note: *FVC= Forced Vital Capacity; FEV1 = Forced Expiratory Volume in one second; FEV1% = FEV1/FVC – Forced Expiratory Volume in one second/Forced Vital Capacity Ratio; PEFR= PEFR - Peak Expiratory Flow Rate*

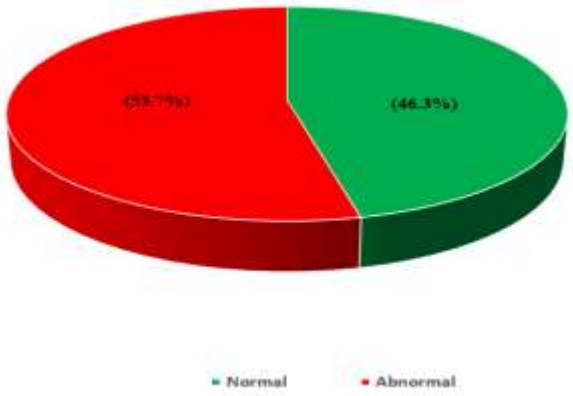

Figure 1: Categorization of Lung Function Test

Table 4: Anova test comprising the mean concentration of air quality

Parameters	Akim	Akai Effa	Ikot-Enobong	Total	F value	p-value
$PM_{2.5}$ (mg/m3)	33.75	18.75	14	21.17	3.334	.083
PM_{10} (mg/m3)	40.75	40.75	31.25	37.58	2.504	.137
H_2S (ppm)	0	0	0	0	-	-
SO_2 (ppm)	0.62	0.58	0.58	0.59	0.211	.814
NO_2(ppm)	1.47	1.41	1.4	1.43	13.746	.002*
CO(ppm)	9.25	9.25	9.25	9.25	.364	.705

Table 5: Fisher's LSD Post hoc test of the mean difference in the mean concentration of air quality parameter of the wood processing industries for NO2

Sites (I)	Sites (J)	Mean difference (I-J)	SEM	p-value	95% Confidence Interval	
					Lower bound	Upper bound
Akim	Akai Effa	0.055	0.013	.002*	.026	.084
	Ikot Enobong	0.063	0.013	.001*	.033	.092
Akai Effa	Akim	-0.055	0.013	.002*	-.084	-.026
	Ikot Enobong	0.008	0.013	.579	-.022	.037
Ikot Enobong	Akim	-0.063	0.013	.001*	-.092	-.033
	Ikot Enobong	-0.08	0.013	.579	-.037	.022

Table 6: Association of air quality at the sawing point and within wood processing industries in study area

Sawing point		GPS Reading of location	Away from sawing point	GPS Reading of location		
Akim		(426061.753Me /548576.562mN)	0	(426157.650mE /548462.272mN)	2.364	.038*
H_2S	0					
SO_2	0.6		0.6			
NO_2	1.48		1.46			
CO	9.0		9.3			
PM_{10}	86		45			
$PM_{2.5}$	52		71			
Akai Effa		(427931.814mE/ 552454.853mN)	0	(427948.416mE /552427.200mN)	2.254	.046*
H_2S	0					
SO_2	0.6		0.6			
NO_2	1.42		1.41			
CO	9.0		9.3			
PM_{10}	52		37			
$PM_{2.5}$	21		18.3			
Ikot-Enobong		(428996.874mE /558909.666mN)	0	(429031.939mE/558839.656mN)	2.275	.044*
H_2S	0					
SO_2	0.6		0.6			
NO_2	1.41		1.40			
CO	8.0		9.0			
PM_{10}	33		30.7			
$PM_{2.5}$	14		10.5			

Table 7: Association of socio-demographic characteristics of wood processing workers and their Lung function status

	Administrators	Operators	Total	t-test	P-value
Mean± SD		Mean± SD			
FVC (L)	2.80±0.52	3.24± 0.51	3.02 ± 0.52	8.575	<.001

FEV_1 (L)	2.30±0.48	3.04± 4.35	2.67 ± 2.42	2.420	.016
FEV_1%(L)	82.44±12.42	91.98± 115.68	3.02 ± 0.52	1.165	.245
PEFR (L/min)	288.96±165.82	299.39± 117.35	294.98 ± 141.59	0.730	.466

Table 8: Association of lung function with socio-demographic characteristics of participants in the study area

	Lung function	Total	χ^2	Df	p-value	
Age (in years)	Abnormal	Normal		10.749	3	.013*
18-27	52 (56.5)	40 (43.5)	92 (100.0)			
28-37	72 (41.6)	101 (58.4)	173 (100.0)			
38-47	51 (51.5)	48 (48.5)	99 (100.0)			
48-57	12 (30.0)	28 (70.0)	40 (100.0)			
Sex				0.298	1	0.585
Male	136 (45.5)	163 (54.5)	299 (100.0)			
Female	51 (48.6)	54 (51.4)	105 (100.0)			
Marital status				1.376	1	.241
Single	83 (43.2)	109 (56.8)	192 (100.0)			
Married	104 (49.1)	108 (50.9)	212 (100.0)			
Social habits				21.038	3	<.001*
Snuffing	12 (100.0)	0 (0.0)	12 (100.0)			
Drinking	92 (45.5)	110 (54.5)	202 (100.0)			
Smoking	78 (42.2)	107 (57.8)	185 (100.0)			
Multiple habits	5 (100.0)	0 (0.0)	5 (100.0)			
None						
Role in industry				18.408	1	<.001*
Administrator	115 (56.9)	87 (43.1)	202 (100.0)			
Operator	72 (35.6)	130 (64.4)	202 (100.0)			
Occupation				21.035	7	.004*
Carpenter	3(60.0)	2 (40.0)	5 (100.0)			
Carrier	34 (59.6)	23 (40.4)	57 (100.0)			
Sawyer	56 (53.3)	49 (46.7)	105 (100.0)			
Loader	20 (57.1)	15 (42.9)	35 (100.0)			
Dealer	36 (37.1)	61 (62.9)	97 (100.0)			
Salesperson	19 (33.9)	37 (66.1)	56 (100.0)			
Clerk	11 (29.7)	26 (70.3)	37 (100.0)			
Driver	8 (66.7)	4 (33.3)	12 (100.0)			
Work experience				4.617	3	.202
< 1 year	20 (48.8)	21 (51.2)	41 (100.0)			
1-5 years	48 (38.4)	77 (61.6)	125(100.0)			
6-10 years	63 (50.8)	61 (49.2)	124(100.0)			
> 10 years	56 (49.1)	58 (50.9)	114(100.0)			

Note: *Abnormal- FEV1% (FEV1/FVC ratio) = <80*

Normal- FEV1% (FEV1/FVC ratio) = > 80

Source: *World Health Organization*

Discussion

This study was aimed at determining air quality, and lung function among workers in wood processing industry in Calabar Metropolis, Cross River State, Nigeria.

The study comprised of participants who were majorly within 28-37 years. This result is nearly similar to the study conducted by [8], where most of the sawmill workers were majorly aged 31-40 years. Nevertheless, this falls below the predominant age group of participants in a similar study where the majority age group was above 45 years [10]. This deviation may be due to the younger population commonly associated to the type and nature of work done in the wood processing environment. The ratio of males to females in the study was 7:3 of which more males were observed among wood operators compared to administrators. Even though participants that were married were more than those that were single in the study, both marital statuses were nearly almost the same proportion. More so, drinking was the common social habit among participants although, wood operators engaged more in snuffing than drinking. Participants were grouped into wood operators and administrators. This is similar to a study conducted by [1], on Occupational hazards,

safety measures and lung function of sawmill workers In Kwara State, North Central, Nigeria, where 177 (90.3%) were male and 19 (9.7%) female and married Participants were more than single.

Results of air quality assessment within the various wood industries showed that mean concentrations of H2S, SO2, NO2, CO, were within Federal Ministry of Environment and WHO standard range except for other measured parameters such as PM2.5 and PM10 observed to be higher majorly in Akim, Ikot-Enoobong (8miles) and Akai-Effa timber markets in decreasing order. This is similar to the findings of a study conducted in Kwara state, Nigeria where the mean concentrations of CO, O2 and other measured parameters were commonly lower [13] the high value of the particulate matters are attributed to the amount of pollutant present in the wood processing sites and can also be due to the input of influents it receives from activities within the wood processing environment. This is why there have been some cases of air pollution in parts of the wood processing sites in Calabar municipality. Inferential statistics results using a one-way Analysis of variance (ANOVA) showed that there is no statistically difference in the mean concentration of the air quality parameters between the wood processing industries except for NO2 which was statistically significant. The Post hoc test showed that this statistical significance was between Akim - Akai Effa and Akim – Ikot-Enobong timber markets.

In accessing the lung function parameters of administrators and operators in wood processing sites in Calabar metropolis, the mean values observed were higher among operators compared to administrators. This may be as a result of the constant exposure of the operators to particulate matter generated by wood processing activities which is indicated by the air quality assessment which are higher than stipulated permissible levels. These findings are in agreement with the study carried out by [6] in Pakistan. Further findings showed that the mean scores of the forced vital capacity and forced expiratory volume in the first one second of the lungs among administrators and wood operators were statistically significantly different. Meanwhile, the mean scores of FEV1% and PEFR were not statistically different among wood administrators and operators that took part in the study. Similarly, findings from a study conducted in Nigeria showed that sawmill workers had significantly lower FVC compared to furniture workers which is closely related to our category of wood operators and administrators respectively.

Conclusion

This study which aimed at determining the air quality, and lungs function of workers in wood processing industry in Calabar metropolis indicated that all except one air quality parameters NO2 were not within tolerable national and global standards. There was a statistically significant difference in the lung function indices of wood operators and administrators and also a statistically significant difference in in the mean lungs function of the workers. Therefore, emissions from wood processing pose significant occupational health risks. Regular air quality monitoring, are imperative to safeguard workers' respiratory health.

Acknowledgements

The authors are eternally grateful to all those who participated in this research. Special thanks to our student researchers-in-training and graduate assistants for their assistance in data collection and analysis.

Declarations

Funding: This research was self-funded

Conflicts of Interest/Competing Interests: There was no conflict of interest among the authors

Ethics Approval: The research protocol was approved by the Cross River State Health Research Ethics Committee, Ministry of Health (CRS/MOH/RP/REC/2020/107). All participants were informed that their participation was voluntary and that they could opt out of the study at any time... Confidentiality and anonymity were ensured.

Consent to Participate: Informed consent was taken from each of the respondent; all participants were informed that their participation was voluntary and that they could opt out of the study at any time... Confidentiality and anonymity were ensured.

Consent for Publication: Consent was also taken from the respondent to publish the data that was collected

Availability of Data and Material: Data collection was transparent

Code availability: Not applicable

Authors' contributions

OVO: Conceptualized the study in collaboration with IFA. Drafted the objectives of the study, co-drafted the research protocol, reviewed transcripts, wrote the first draft of the qualitative paper and is the corresponding author.

OVO: Conceptualized the study, wrote first draft of the study protocol in collaboration with IFA and OIU. Recruited and trained field Assistants, conducted the interviews and focus group discussions. Wrote the introduction of this paper and reviewed the results section and gave approval for the publication of this paper.

OIU: Reviewed the research protocol with IFA and made extensive correction and redirection of the data collection process. Reviewed the transcripts and results. Reviewed and co-wrote the methods section and gave approval for the publication of this paper.
OVO: Conducted literature review that was used in writing the introduction and discussion part of the manuscript. Participated in transcription of tapes, and gave approval for the publication of this paper
OIU: Reviewed research protocol, participated in data collection and co-wrote the discussion part of the paper and gave approval for the publication of this paper.

References

1. Agbana B. E. (2014). Occupational Hazards, Safety Measure and Lung Function of Sawmill Workers in Kwara State, North-Central, Nigeria. (Unpublished Master Degree Thesis in the Department of Epidemiology and Community Health), *University of Ilorin Teaching Hospital, Ilorin Kwara State.*
2. Agu A. P, Ume okonkwo C.D, Nnabu R. C, Odunsany O.O. (2016). Health Problems among Sawmill Workers in Abakaliki and Work Place Risk Assessment. *Journal of Community Medicine, Primary healthcare,* 28(2):1-10.
3. Aigbirior J, Ehondor O. T, Egbagbe E. E, Erhabor G. E. (2019). Dust exposure and respiratory status of workers in the wood processing industry in Benin City, Nigeria. *European Respiratory Journal,* 54:PA2822.
4. Faremi F. A, Ogunfowokan A. A, Mbada C, Olatubi M. I, Ogungbemi A. V. (2018). Occupational hazards Awareness and Safety Practices among Nigerian Sawmill Workers. *International Journal of medical Science and Public Health*, 3:1224-128
5. (2018). International Labour Organization. Occupational Health Services in Developing Countries: *Occupational Health Safety and Health Series,* 3(7):189.
6. Labreche F, Duguay P, Ostiguy C, Bouche A, Roberge B, Peters C.E. (2015). Estimating Occupational Exposure to Carcinogens in Quebec. *American Journal of Industrial Medicine.*
7. Nafisa Y. W, Dawud F. A, Sulaiman I, Salisu A I, Tukur M. A. (2020). Influence of Varying Degree of Wood Dust Exposure on Pulmonary Function and Respiratory Symptoms among Wood Workers in Kano, North Western Nigeria. *Nigerian Journal of Physiological Science,* 35(2):161-165.
8. Njinaka I, Uhumwangho O, Edema O, Dawodu O. A. (2011). A Comparison Study of Conjunctiva Disorders in Technical and Administrative Sawmill Workers in Nigeria. *Malaysian Journal of Medical Sciences,* 18(3):43-48.
9. Okuma S, Orhorhoro E. K, Olorunleke A. (2020). Safety analysis and implementation for safer design of wood processing machines; a case study of Southern Nigeria. *International Journal of Current Research in Science Engineering and technology,* 2(9).
10. Osuchukwu N. C, Osuchukwu E. C, Eko J. E, Otareh O. O. (2015). Occupational Exposure to Wood Dust in Calabar Municipality, Cross River State, Nigeria. *International Journal of Science and Research,* 4(1):23-29.
11. Raimi M. O, Olalekan A. Z, Odipe O. E, Samson T. K, Sunday A. B, et al. (2020). Impact of Sawmill Industry on Ambient Air Quality: A Case Study of Ilorin Metropolis, Kwara State, Nigeria. *Energy and Earth Science,* 3(1):1.
12. Raimi M. O, Sawyer H.O, Isah H. M. (2020). Health Risk Exposure to Cypermethin: A case Study of Kano State, Nigeria. *Journal of Agriculture. 7th International Conference on Public Health care and Epidemiology, Tokyo, Japan.*
13. Siew S. S, Kauppine P, Heikkila P, Pukkala E. (2017). Occupational Exposure to Wood Dust and Formaldehyde and Risk of Nasal, Nasopharyngeal and Lung Cancer among Finnishmen. *Journal of Cancer Management Resources,* 4(1):223-232.
14. Timothy A. A, Enabulele C. E, Olalekan R. M. (2018). Assessment of Air Quality Indices and its Health Impacts on Ilorin Metropolis, Kwara State, Nigeria. *Science Park Journal of Scientific Research and Impact,* 4(1):45-52.
15. Tobin E, Ediagboya T. (2015). Occupational Exposure to Wood dust and Respiratory Health Status of Sawmill workers in South-South, Nigeria. *Journal of Pollution Effects and Control,* 4(1):1230-1242.
16. Tobin E. A, Ediagbonya T. F, Okojie O. H, Asogun D. A. (2016). Occupational Exposure to Wood dust and Respiratory Health Status of Sawmill Workers in South -South. *Journal of Pollution Effects and Control,* 4(1):234-242.
17. (2020). WHO. Air Pollution.
18. (2018). WHO. Global Conference on Air Pollution and Health: Improving Air quality, Combating Climate Change- Saving Lives. *World Health Organization Headquarters,* M505,09h30-17h30.
19. Workplace Health and Safety Bulletin. Health effects from exposure to wood dust.
20. (1995). World Health Organization. The right to health at work. *World Health Organization Document.* 1-3.