Journal of Environmental and Occupational Science
www.jenvos.com
DOI: 10.5455/jeos.20140512123536

Original Research

GESDAV

Wood dust particles: Environmental pollutant in Nigerian sawmill industries

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Received: March 29, 2014
Accepted: May 12, 2014
Published: May 21, 2014

ABSTRACT

Background: Wood dust is made of wood shavings from machining wood in sawmills and it becomes potential health problem when inhaled. This study assesses concentration of wood dust particulate matter resulting from wood processing in sawmills. **Methods:** It is a descriptive cross-sectional study carried out in 84 sawmills in Osun State, Nigeria in January, 2013. Samples of total suspended particulate matter of sizes 0.5 μm, 1 μm, and 5 μm were measured with GT-321 Particle Counter. Two samples were taken at 1 h interval from each sawmill sites during work hours. Air sampling was also done in 84 welder workshops to compare results. A walk through survey was conducted in 10 sawmills to assess the usage of personal protective equipment (PPE). Data were analyzed using Statistical Package for Social Sciences version 16. P value was set at <0.05. **Results:** Mean value of dust size of 0.5 μm of 305445.9 $\pm$ 104255.6 particles/m^3 at the sawmill sites was significantly ($P = 0.001$) more than the welders' workshops (134638.7 $\pm$ 10074.7 particles/m^3). Dust sizes of 1 μm and 5 μm in the sawmill sites (145332.0 $\pm$ 110201.6 and 19792.1 $\pm$ 15102.5 particles/m^3 respectively) were also significantly ($P < 0.05$) higher than dust in the welders' workshops (33485.0 $\pm$ 3549.2 and 927 $\pm$ 157.0 particles/m^3). None of the observed workers used appropriate PPE. **Conclusion:** Total Suspended Particles in sawmill environments are high and could cause pulmonary and nonpulmonary impairment. Lack of preventive measures such as use of PPE will enhance susceptibility to this hazard. Measures should therefore be undertaken to control dust in sawmills as well as provide PPE for workers.

KEY WORDS: Particle counts, personal protective equipment, sawmill industries, wood dust

INTRODUCTION

Wood dust is made of wood shavings from machining wood; it refers to the tiny sized and powdery wood waste produced by sawing of wood [1]. About 10-13% of the total volume of the wood log is reduced to wood dust in milling operations; this dust generally depends largely on the average width of the saw kern and the thickness of the timber sawed [2]. Particle sizes in the wood dust package are distributed from very fine to coarse. The wood dust is created when machines are used to cut or shape wood materials and the dust becomes a potential health problem when the wood particles from these cutting and shaping processes are inhaled. Exposure to wood dust may result in external and internal health problems which may be immediate, short term or long term [3].

Exposures to wood dust have generally been reported in sawmills, wood furniture and cabinet manufacturing industries. Exposure has also been seen in the finishing departments of plywood and particleboard mills, where wood is sawn and sanded. Exposure to wood dust also occurs among workers in joinery shops, window and door manufacturing industries, wooden boat manufacturers, pulp and paper manufacturers, construction carpentry, and logging [4].

Various epidemiological studies have linked morbidity and mortality of individuals to exposure to particulate matter [5,6]. While working to increase productivity, workers in sawmill industries breathe in wood dust [7], which is deleterious to their health. In Nigeria studies have shown the role of occupational exposure to environmental pollutants (such as wood dust) in the incidence of respiratory diseases [8-10]. High prevalence of respiratory symptoms, increased nose and eye irritations, skin symptoms, and high prevalence of allergy/sensitivity symptoms have been observed among workers exposed to wood dust compared to unexposed [9-11]. Generally respiratory health effects have been documented in workers exposed to a variety of wood dusts [12], and reduced lung function is said to be associated with increased illness and mortality [13]. Cancers have also been associated with wood dust exposure. The national institute for occupational safety and health considers both hardwood and softwood dust to be potentially carcinogenic to humans [14].

Greatest air pollution problem in the Nigerian environment is atmospheric dust that arises from many industrial processes including sawmill industries [15]. Due to fast growth recorded in the building construction sector, there has been high increase in the establishment of sawmills in different parts of the country to satisfy the growing demand for wood [16]. The first pit sawing station in Nigeria was established in 1782 and the first "modern" sawmill was established in 1909; there has however been appreciable numerical growth in the sawmilling establishment [17]. Majority of the sawmill industries are located in the wood producing rain forest areas of Nigeria. The largest concentration of sawmills are in Lagos, Ekiti, Osun, Cross River, Ondo, Oyo, Imo, Edo, Delta and Ogun States. Together, they accounted for over 90% of the saw milling activities in the country [18]. In order to put in place measures to prevent or reduce exposure to the wood dust by sawmill workers, thus preventing health problems, knowledge of the workplace airborne dust particles is necessary.

The increased sawmilling activities as well as the continuous emissions of wood dust in the wood producing areas of Nigeria over the years needs to be examined. This study therefore focuses on the assessment of the number concentration of wood dust particulate matter resulting from wood processing in sawmills.

METHODOLOGY

The study was a descriptive cross-sectional survey conducted in January 2014 in Osun State, South-Western part of Nigeria. Osun State has three senatorial districts namely Osun central, Osun west and Osun east each comprising of ten local governments (thus making 30 local governments) and one area office, located in Osun east senatorial district [19]. There are 106 registered sawmill industries distributed round the three senatorial districts.

Leslie Fischer's formula for population <10,000 was used to calculate the number of sawmills industries to be sampled and this gave an approximate of 84. The 84 sawmill industries sampled were selected using the balloting method of simple random sampling, and another 84 welders' workshops were sampled as control. Welding works are usually carried out in open spaces under sheds, likewise sawmilling works; hence welders' workshops were chosen as control due to the similar environmental condition with the sawmill industries. The welders' workshops used were at least about 1 km away to the nearest sawmill industry to ensure absence of wood dust in the welders' workshops.

Dust sampling of the sawmill and welder workshops was done with the technical assistance of the Environmental Engineering Research Laboratory, Department of Chemical Engineering, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria. Samples of total suspended particulate (TSP) matter were measured with GT-321 particle counter, a standardized handheld, portable unit measuring three number ranges of particulate matter: $PM_{0.5}$, PM_1 and PM_5. It has a sampling period of 2 min and a flow rate of 2.83 l/min. Air sampling were undertaken during work hours at the environments of interest (sawmill and welders' workshops). To measure, the equipment was placed at 1 m above the ground level overlooking the locations where continuous milling was going on in the workshops, switched on and the measured concentration read directly on its screen (particles per m^3) after particle capturing. For each particle sizes 0.5 μ, 1.0 μ, and 5.0 μ, two samples were taken at 1 h interval from each sawmill and welders' workshops per day at the peak of activities (usually between 9 am and 4 pm). Average of the two samples (particle concentration) measured per site of interest were computed (mean ± standard deviation), and the mean of all the averages in the 84 sawmill sites was compared with that of the welders' workshops (mean ± standard error of the mean). The measured concentrations were also compared with the International Standard Organization standard (ISO 14644) for airborne particulates for cleanrooms and clean zones [Table 1].

A walk through survey was also conducted in 10 sawmill sites using a check list guide to assess usage of personal protective equipment (PPE) by the workers.

Data were analyzed using Statistical Package for Social Sciences version 16. The total particle number concentrations of the air sampled were expressed as mean of means (± standard error), and the values obtained at the sawmill sites as well as the welder sites were compared using the *t*-test. Statistical significance was set at *P* value less than 0.05.

Ethical clearance for the study was obtained from the Ladoke Akintola University of Technology Teaching Hospital Ethical

Table 1: Selected airborne particulate cleanliness classes for clean rooms and zones

ISO classification number (N)	Maximum concentrations limits (particles/m^3)					
	0.1 μm	0.2 μm	0.3 μm	0.5 μm	1.0 μm	5.0 μm
Class 1	10	2				
Class 2	100	24	10	4		
Class 3	1000	237	102	35	8	
Class 4	10000	2370	1020	352	83	
Class 5	100000	23700	10200	3520	832	29
Class 6	1000000	237000	102000	35200	8320	293
Class 7				352000	83200	2930
Class 8				3520000	832000	29300
Class 9				35200000	8320000	293000

Source: ISO (2004)

Review Committee and permission was taken from the Sawmill Workers Association and Welders Association, Osun State chapter before carrying out the study.

RESULTS

Particulates of 0.5 μm, 1 μm, and 5 μm sizes were sampled from the 84 sawmills as well as 84 welders' workshops that serve as control.

The TSP dust of 0.5 μm size varied from 188532.0-446103.0 particles/m^3 with mean value of 305445.9 ± 104255.6 particles/m^3 at the sawmill sites. At the welders' workshops the TSP dust of 0.5 μm size ranged from 123570.0-145800.0 particles/m^3 with mean of 134638.7 ± 10074.7 particles/m^3. The *t*-test was used to compare the mean values and that of the sawmill sites was significantly ($P = 0.001$) higher than that of the welders' workshops.

The range of dust size of 1 μm varied from 39033.0-346410.0 particles/m^3 in the sawmill industries, and the mean value was 145332.0 ± 110201.6 particles/m^3. In the welders' workshops, the mean value of 33485.0 ± 3549.2 particles/m^3 for the 1 μm dust size was significantly lower ($P = 0.02$) compared with the sawmill sites' using the *t*-test statistic. The range of TSP of 1 μm in the welders' workshops was 28430.0-38367.0 particles/m^3, a value lower than what was obtained in the sawmill sites.

For dust size of 5 μm, mean value in the sawmill sites was 19792.1 ± 15102.5 particles/m^3 and the range was from 4131.0-4307.0 particles/m^3 while in the welders' workshop, range of dust size of 5 μm was 4131.0-4307.0 particles/m^3 and mean was 927 ± 157.0 particles/m^3. A difference which was statistically significant ($P = 0.006$) with that of the sawmill sites being higher [Table 2].

Table 3 shows the number of respondents expected to use different PPE as well as those observed to use them during the walk through survey. None of the respondents that were expected to be using face mask, ear muffs, overall clothing, boot/protective foot wear and hand gloves during the period of survey had them on. Just one worker each from three of the sawmill surveyed were using hand gloves.

Table 2: Comparing the total suspended particulate dust in the sawmill workshops and welders' workshops

Dust sizes (μm)	Values (particles/m^3)		*t*	*P* value*
	Sawmill workshops	Welders' workshops		
0.5				
Range	188532.0-446103.0	123570.0-145800.0	4.315	0.001
Mean	305445.9	134638.7		
1				
Range	39033.0-346410.0	28430.0-38367.0	2.684	0.020
Mean	145332.0	33485.0		
5				
Range	4131.0-4307.0	693.0-1098.0	3.305	0.006
Mean	19792.1	927.0		

**P* values less than 0.05 are statistically significant

DISCUSSION

With the significantly higher TSP dust in the sawmill workshops compared to the welders' workshops, sawmill workers are likely to have higher prevalence of pulmonary and nonpulmonary symptoms compared with the control. Ijadunola *et al*. [20] similarly reported higher prevalence of pulmonary and non-pulmonary symptoms among workers exposed to higher concentration of TSP compared to their controls.

ISO standard for clean rooms and zones are rated according to how much particulates matter of different sizes exist per cubic metre [Table 1], with a class one as the "cleanest" clean room, and a class nine as the "dirtiest" [21]. Average measured concentration for particulate size of 0.5 μm at the sawmill sites (305446 particles/m^3) and welders' workshops (134639 particles/m^3) in this study were both within the ISO class seven for clean zones with concentration limit of 352000 particles/m^3. However, mean particle sizes 1.0 μm and 5.0 μm measured in sawmill sites (145332 particles/m^3 and 19792 particles/m^3 respectively) were above the ISO class seven with concentration limits of 83200 particles/m^3 for 1.0 μm and 2930 particles/m^3 for 5.0 μm, while that of the welders' workshops fall within this ISO class seven values [21]. This shows that the sawmill sites are "dirtier" than the welders' workshops based on the ISO clean zones classification. Generally, particles below the size of 100 μm diameter referred to as inhalable dust are termed "Hazardous Dust Particles" because they can enter the nose and mouth during normal breathing and cause pulmonary symptoms [22].

It was observed during the walk through survey that very little attention was paid to the use of PPE in all the sawmill visited. In

Table 3: Observed respondents' use of personal protective equipment in the 10 sawmills visited

Personal protective equipment*	Sawmill sites visited									
	A	B	C	D	E	F	G	H	I	J
Facemask										
Numbers expected to use	15	14	14	16	13	15	15	14	13	16
Numbers actually using	0	0	0	0	0	0	0	0	0	0
Overall clothing										
Numbers expected to use	8	8	7	8	6	8	7	8	7	8
Numbers actually using	0	0	0	0	0	0	0	0	0	0
Ear muffs										
Numbers expected to use	15	14	14	16	13	15	15	14	16	13
Numbers actually using	0	0	0	0	0	0	0	0	0	0
Boot/protective foot wear										
Numbers expected to use	8	8	7	8	6	8	7	8	9	8
Numbers actually using	0	0	0	0	0	0	0	0	0	0
Hand gloves										
Numbers expected to use	8	8	7	8	6	8	7	6	8	6
Numbers actually using	1	0	1	1	0	0	0	0	0	0
Helmet										
Numbers expected to use	8	8	7	8	6	8	7	8	8	7
Numbers actually using	0	0	0	0	0	0	0	0	0	0
Goggle										
Numbers expected to use	4	4	4	4	4	4	4	4	4	4
Numbers actually using	2	0	0	0	0	0	0	0	0	0

*Numbers expected to use personal protective equipments (PPE) is based on the numbers of respondents whose work/activity require such PPE during the walk through survey spite of the high concentration of TSP in the sawmill sites, none of the workers used face masks. None also used overall clothing, ear muffs, boot/protective foot wear and helmet. A couple of workers used goggle in one of the mills and very few used gloves. Osagbemi *et al.*'s study revealed very low usages of PPE among sawmill workers due to various reasons [23]. Bamidele has also reported non-use of PPE due to non-availability [24]. Employers are responsible for providing PPE appropriate for the risk involved and the conditions where it will be used to workers, to maintain and replace PPE as necessary, to provide information, training and instruction for employees therefore enabling them to make proper effective use of PPE [25]. This is very important as employees may not know as much as the employer the health effects of hazardous materials peculiar to their work.

CONCLUSION

Total suspended particles in sawmill environments are high and they could cause various degrees of pulmonary impairment. In the sawmills the TSP particles of 1-5 μm sizes which when inhaled can cause respiratory problems are higher than the ISO class seven particulates maximum concentration limit for clean zones. It is therefore very important that engineering measures be put in place in the sawmill so that wood dust emitted could be controlled and passed through diverted channels. Employers should also provide workers with PPE and ensure their application in order to reduce exposure to wood dust and other hazards in sawmill industries. Without proper preventive measures in place, the lung function indices of sawmill workers will continually decrease.

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Source of Support: Nil, Conflict of Interest: None declared.