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Research Article

MEASUREMENT OF WOOD DUST PARTICLE SIZE BY OPTICAL MICROSCOPY TECHNIQUE AND LONG-TERM EFFECT ON SAWMILL WORKERS: A RANDOM STUDY

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ABSTRACT

Objective: Sawmill workers are exposed to wood dust particles of different sizes, and they cause different respiratory effects depending on the size, physical, and chemical nature of the dust particle and also it is related to the duration of exposure.

Introduction: Many studies are done in concern with respiratory effects of wood dust exposure and its toxicity on sawmill workers. Only few studies have been done regarding measurement of particle size. Hence, this study has been undertaken. To measure the size of wood dust particle of sawmills to which the workers are exposed to and also to study significance to the duration of exposure to different sizes of wood dust and effect on long-term exposure.

Methods: Random samples collected from three different places of different sawmills where there is maximum production and exposure of wood dust. The samples were analyzed and particle was measured using optical microscopy technique. 50 healthy participants from these mills were assessed for chest expansion in cm and compared against years of wood dust exposure.

Results and Conclusion: Overall, it is observed that percentage distribution of size of wood dust particles: 45.9% <0.1 µm, 23.3% 2.5-10, 22.3% 0.1-2.5 µm, and 8.5% >10 µm. It may be concluded that occupational hazards are directly proportional to the size of the particle and duration of exposure to wood dust particles. Chest expansion in cm was also found reduced with the increase in the years of exposure to wood dust.

Keywords: Sawmill workers, Wood dust, Optical microscopy, Chest expansion.

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INTRODUCTION

People working in wood industry are frequently exposed to the wood dust, which is one of the leading causes of industrial hazard. Studies reported that across the European Union around 3.6 million workers are exposed to wood dust [1]. In industries, both hardwood and softwood are manufactured. The division among the both types of wood is based on species of tree but not based on hardness of wood. Softwood includes the species gymnosperm or conifers, and whereas, hardwood includes the species temperate angiosperms. During the recent years, utilization of tropical hardwood is increased. These types of woods are majorly belonging to species angiosperms; sometimes it also includes gymnosperms species that thrive in tropical climate [2].

The wood dust particles have various ranges of particle sizes. Occupational health dusts are classified into inhalable, respirable, and thoracic based on the dimension of their aerodynamic equivalent diameter (AED). The AED of a particle is the diameter of a unit density sphere that would have the identical settling velocity as the particle. According to this definition, the inhalable fraction (b100 µm AED) can be breathed into nose or mouth, the thoracic fraction (b25 µm AED) can penetrate head airways and enter lung airways, and the respirable fraction (b10 µm AED) can penetrate beyond terminal bronchioles to gas exchange region [3]. As stated above, compared to large particles that can easily settle out, small particles will become airborne and pose more serious issues.

Repeated exposure to airborne wood dust particles has long been associated with an increased risk of many adverse health effects, such as asthma, chronic bronchitis, emphysema and even irritant dermatitis, contact urticaria, and allergic contact dermatitis [4]. Both allergic and non-allergic events are reported with exposure to hard and softwoods [4,5]. According to IARC classification, hardwood is responsible for human carcinogenicity. They arrived the conclusion based on epidemiological evidence showing a correlation between sinonasal cancer occurrences in hardwood exposed workers [4]. To date, the underlying mechanism and pathways involved in toxicity and carcinogenicity mediated by wood dust remain to be addressed. Several *in vitro* studies were focused on the inflammatory response modulated by hard and softwood dust exposure. Although hardwood is considered more harmful than softwood, none of these studies showed significant differences between toxicities of hardwood and softwood dusts [6-8].

It is difficult to determine the exact correlation between, risks associated with exposure to airborne dust in occupational workers. This goal is complex and multifactorial since workers are usually exposed to several wood dust species simultaneously with different dust concentrations and dimensions. Epidemiological data alone are not sufficient for assessing risk in wood workers. For better understanding, the risks in woodworkers determination of size of dusts are more helpful.

Moreover, the dimensional characterization of dust may be necessary to obtain homogeneous samples of diverse soft-, hard-, and tropical-hardwoods for the evaluation of the *in vitro* cytotoxicity in order [9].

In recent years, there have been several studies regarding respiratory effects of wood dust toxicity in exposed workers. The dust of various woods and other organic dusts have been studied in relation to their health effects. Wood dust is the third organic dust such as cotton and grain dust, and its exposure can lead to substantial health hazards [10,11].

According to William Bullock, physical and chemical nature of wood suggested that particle size was between 40 and 200 µm/m^3. 90% of the dust particle was <1 µm. The size was determined optically after collection by Konimeter. Chemical nature of the substances ranges from hydrocarbons to polycyclic compounds, and effects were dependent on duration of exposure [12].

Occupational hazards are well known in wood related industries. Numerous varieties of woods are known to be potentially poisonous and biologically active. All the studies conducted on workers exposed to western cedar wood, sheesham, and mango.

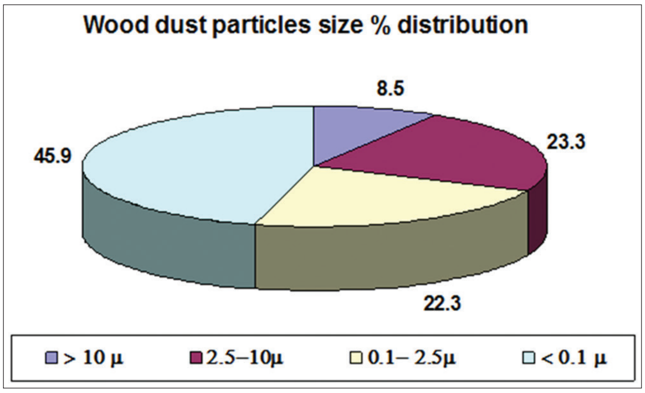

Fig. 1: Average percentage distribution of wood dust particle size in all 3 Petri dishes

Fig. 2: Photograph of Petri dish 1 with saw dust collection and microphotograph of same showing predominant larger (>10 µ) sized saw dust particles (dry amount, ×100)

Table 1: Distribution of subjects according to duration of exposure

Duration of exposure (years)	Number of subjects
0-5	19
6-10	15
11-15	7
16-20	6
21-25	3
Total	50

Carpenters, wood machinists, sawmill workers, wood polishers, cabinet makers, and furniture manufacturers are exposed to wood dust frequently.

The usual broad classification of hard and softwoods seems to be inadequate predictors of health effects as daily exposure to the mixed type of woods. There are reports on various health hazards associated with wood dust exposure from various parts of the world. Effects of wood dust on respiration are known since long time. The varieties wood dusts causing a number of symptoms are also known. However, many at times different pictures can be seen due to cutting of different mixed variety of woods [13].

A variety of respiratory disorders such as woodworkers asthma, suberosis, wood trimmer's disease, pneumonitis, chronic obstructive pulmonary disease, and pulmonary diseases like farmer's lung have been attributed due to the inhalation of wood dust [14].

The present study is undertaken to compare the chest expansion of mill workers against years of exposure of wood dust and also to measure the size of wood dust particle and compare with the standards.

METHODS

This study was undertaken from different sawmills situated in and around the Bijapur city. There are about 20 sawmills present in the locality. From these mills, 50 healthy workers were randomly selected and included in the study group (Table 1).

Inclusion criteria

Healthy male participants are included in the study based on their clinical examination and history.

Exclusion criteria

Patients with any known cardiopulmonary disorders, endocrine disorders, congenital defects, and smokers were excluded from the study.

Parameters studied

The anthropometric parameters such as age (years), weight (kg), height (cm), and chest expansion (cm) were recorded in these participants (Table 2).

Chest expansion (cm) in these participants against the years of wood dust exposure is compared statistically (Table 3).

Measurement of wood particle size

To measure the wood particle size, the wood dust particles were collected neatly and carefully in three Petri dishes from the sawmills. The Petri dishes were kept in sawmills (lids open) at locations of highest wood dust production and exposure. The Petri dishes were kept for 8 hrs (during working hours: 10 am-6 pm). During this period, the wood trimming machines and sawmill workers were busy at their work. Then, these Petri dishes were neatly collected with lids at 6 pm on the same day, and the wood dust particle size was measured using optical microscopy technique (Figs 1-4).

Statistical analysis

All the data were presented as mean±standard deviation. The significance of the difference in parameters between groups was analyzed by Student t-test, Z-test, and Chi-square test using SPSS-22 version.

Table 2: Mean values of various anthropometric and physiological parameters in subjects exposed to wood dust (n=50)

Subjects	Anthropometric parameters			Physiological parameters			
Study group (n=50)	Mean age (in years)	Mean weight (in kg)	Mean height (in cm)	Mean SBP (in mmHg)	Mean DBP (in mmHg)	Mean pulse rate (bpm)	Mean chest expansion (in cm)
	31.94±9.69	61.18±6.11	164.18±7.62	125.12±13.49	80.8±7.40	79.94±8.5	2.44±1.11

SBP: Systolic blood pressure, DBP: Diastolic blood pressure

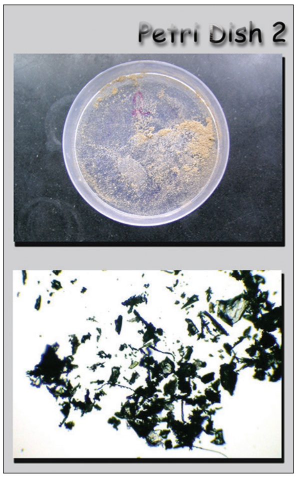

Fig. 3: Photograph of Petri dish 2 with saw dust collection and microphotograph of same showing predominant intermediate (2.5-10 µ) sized saw dust particles (dry amount, ×100)

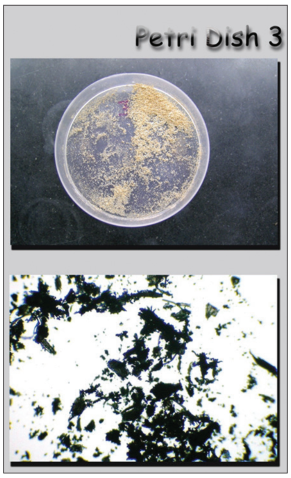

Fig. 4: Photograph of Petri dish 3 with saw dust collection and microphotograph of same showing predominant smaller (<2.5 µ) sized saw dust particles (dry amount, ×100)

RESULTS

It is seen that as the years of exposure increases, decrease in the magnitude of chest expansion is markedly noticed in the subjects (Table 3).

It is observed that Petri dish one has got 46 particles of size ranging between 2.5 and 10 µm. Petri dish two has got 63 particles of size <0.1 µm and Petri dish three has got 59 particles of size <0.1 µm. Overall, it is observed that percentage distribution 45.9% <0.1 µm, 23.3% 2.5-10 µm, 22.3% 0.1-2.5 µm, and 8.5% >10 µm (Table 4).

DISCUSSION

William Bullock *et al.,* 1994 [12], in their study measured wood particle size optically after collection by Konimeter. The size of the particle was between 40 and 200 µm/m^3, and 90% of the dust particle was <0.1 µm in size. Chemical nature of the particle ranges from hydrocarbons to polycyclic compounds, and effects were dependent on the duration of the exposure to wood dust particle.

Rango *et al.* (2002) [15] studied extensively among 540 male workers in small-scale wood industries exposed to wood dust and compared the prevalence of respiratory symptoms with the control group. It was found that there was a definite association between the increased prevalence

Table 3: Chest expansion (cm) versus duration of exposure (years)

Duration of exposure (years)	Chest expansion (cm)		
	Number of patients under		
	0-2	2-4	4-6
15-25	1	7	5
25-35	2	14	2
35-45	7	5	0
45-55	7	0	0

Y^2=30.997, p<0.001, Association is present

Table 4: Different sizes and distribution of wood dust particles in 3 different Petri dishes kept in sawmills

Sample	Size			
	>10	2.5-10	0.1-2.5	<0.1
Petri dish 1	14	46	17	23
	13	26	39	22
Petri dish 2	5	16	20	59
	4	15	18	63
Petri dish 3	8	17	16	59
	7	20	24	49

of respiratory symptoms and exposure to dust on its duration and size of dust particle.

Narala *et al.* (2003)[16] studied the effects of wood dust on the redox status and cell death in mouse macrophages and human leucocytes *in vitro*. In their study, results indicate that type of wood dust (tree species) and possibly particle size have a significant impact, on the function and viability of phagocytic cells. Studies cited above already clearly indicate a certain relationship between wood dust exposure and respiratory function of workers in sawmills. However, very few studies reported regarding the pulmonary function status of the sawmill workers vis-à-vis the size of wood particles and duration of exposure.

Harper *et al.*, 2002 [17], described a method where wood dust particles are collected by sampler and they are removed, suspended, and deposited on a mixed cellulose filter and examined by optical microscopy and determined the particle's aerodynamic diameters. In this study, he found that this method is particularly appropriate to wood dust particles. He studied over 200 wood dust samples in three different wood dust industries.

In our study, it is observed that chest expansion is reduced significantly as the duration of exposure is increased. Our previous studies have also shown that wood dust exposure results in changes in maximum expiratory pressure in sawmill workers [18] and decrease in dynamic lung functions [19].

CONCLUSION

It is concluded that exposure to wood dust in sawmill workers may lead to the development of several respiratory disorders. The development of these occupational hazards in workers is directly proportional to size and duration of exposure to dust particles.

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