Respiratory Health of the Workers on Wood Processing Industries on the Province of South Sumatera

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***Abstract*—**The objective of this study was to prove the relationship between the exposure to wood dust and respiratory health problems in the form of pulmonary function impairment and symptoms of respiratory disease in the workers of Plywood and Slate Pencil industries in the province of South Sumatra, Indonesia.

The site of the study is PT. W, a manufacturer of Plywood, which is located in Indralaya, South Sumatra; and PT. X, a manufacturer of Slate Pencil, which is located in Musi Rawas, South Sumatra. The total number of workers being studied in this study is 180 people, 90 employees are taken from each the two companies. The measurement of the inhalable dust is performed by using gravimetric techniques through personal and areal sampling. The variables of the study consist of the demographic characteristics of the workers such as age, gender, height, length of employment, smoking habit, spirometry values in the three parameters of FVC, FEV_1, FEV_1/FVC. In addition to those, there are also the variables of respiratory disease symptoms such as cough and phlegm. If a subject has an indication of experiencing spirometric abnormalities, then a *Skin Prick Test* is performed. The determination of spirometric abnormalities is based on the nomogram of Indonesia.

It was found in this study that PT W. used wood of rubber trees (*Havea braziliensis*) as raw material, while PT X. used wood of *Pulai* trees (*Astonia Scolaris*) as raw material. The measurable levels of wood dust are between 0,002 to 3,650 mg/m^3. The spirometric abnormalities in the workers for the parameter of FVC was 7.3%, and that of FEV_1 was 6.2%, and that of FEV_1/FVC was 18.1%. The frequency of the workers who experienced cough was 7.3%, and the frequency of those who complained about sputum production was 8.5%. The values of spirometry of FVC, FEV_1 and FEV_1 / FVC were significantly different by sex and company. Skin Prick Test Results 6 subject are positive in the PT X.

***Keywords*—**Wood Dust, Plywood, Slate Pencil, Spirometry, Respiratory Symptoms.

I. Introduction

INDONESIA is the most important producer of various woods of tropical natural forest as raw materials for wood processing industries, such as sawmills, plywood, fiberboard and slate pencil (Department of Forestry of the Republic of Indonesia, 2002). The wood processing industries in Indonesia in the 1990s required about 80 million cubic meters of wood each year to feed sawmills, plywood, pulp and paper industries. The installed capacity of the wood processing industries in 1999 was 74 million m^3 (Department of Forestry of the Republic of Indonesia, 2002). It was known that in 2007 the total area of Indonesia's forest resource was 133.7 million ha (Indonesian Chamber of Commerce and Industry, 2010).

Currently, the potential supply of wood as raw material of wood industries derived from tropical natural forests is diminishing, both in terms of quality and volume. Therefore, the wood processing industry needs to seek a substitute of tropical natural forest timber to meet the needs of the wood raw material to ensure the sustainability of its production. With the replanting of rubber trees, in the future the wood of these rubber trees can be the substitute which has physical, mechanical, and chemical properties similar to those of natural forest timber (Boerhendhy and Agustina, 2006). The wood of rubber trees has been used as raw materials by plywood industry, while other type of wood which is the product of plantations is the wood of *Pulai* trees (*Astonia Scolaris*) which is used as raw material for slate pencil industry. The activities of the wood processing industry that produces wood dust are the cutting and the sanding activities.

The study by Malaka and Kodama (1990) found that in the plywood industry with raw material of heterogeneous wood the workers respiratory health problems were caused by formaldehyde. The study of wood dust in a sawmill in South Sumatra Province by Agustia (2011) and Aulia (2012) examined the health aspects of exposure to wood dust of the plywood, but it did not measure the levels of wood dust in the air of the workplace and did not investigate the incidence of allergy in the workers. Unlike the three previous studies, this study aimed to reveal the effects of wood dust on respiratory health problems of the workers in the wood processing industry in a more comprehensive way, including the incidence of allergy to wood dust produced by the wood of *Rubber* trees and *Pulai* trees.

The materials produced by and used in the wood processing industry that can cause occupational diseases consist of wood dust, resins, coatings, adhesives, sanding and solvent materials (HSE, 2007), as well as the chemical constituents of wood (monoterpene) Hagstrom, 2008; Hagstrom et al 2008 and Hagstrom et al 2012). In addition, some types of wood can cause allergies (Alwis, 1999 and HSE, 2003).

One of the occupational diseases resulting from wood processing industry is a respiratory disorder (Alwis, 1999; Bhatti et al, 2011). Respiratory problems may occur due to exposure to wood dust and formaldehyde (Holmstrom and

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Wilhelmsson 1988; Malaka and Kodama 1990; Frashman et al 2003), wood dust and Cyanoacrylate glue (Sripaiboonkij et al, 2009), wood dust and monoterpene (Rosenberg et al 2003; Hagstrom, 2008; Hagstrom et al, 2008; Hagstrom, et al 2012).

Wood dust, in some cases, also contains other chemicals (Alwis, 1999; Sripaiboonkij, et al, 2009; Saejiw, et al, 2009; Thetkathuek, et al 2010). The studies on the relationship between the chemicals and respiratory health have been conducted by several researchers (Malaka and Kodama 1990; Teschke, et al, 1999; Frashman, et al, 2003; Edman, et al, 2003; Hagstrom, et al, 2008; Hagstrom, 2008; Hagstrom, et al, 2012). While studies on the relationship between wood dust and lung function have been done by several other researchers (Shamssain, 1992; Alwis, 1999; Mandryk, et al 2000; Frashman, et al 2003; Osman and Pala, 2009; Jacobsen, et al. 2010a; Jacobsen, et al 2010b; Sripaiboonkij, et al2009; Thetkathuek, et al 2010). And the studies on the relationship between wood dust and allergies that affect respiratory systems have been conducted by some other researchers (Eire, et al, 2006; Kespohl, et al, 2012; Schlunssen, et al 2012).

Therefore, this study was intended to reveal an association between exposure to wood dust and the workers' respiratory health problems in the form of pulmonary function impairment and symptoms of respiratory diseases in Plywood and Slate Pencil industries in the Province of South Sumatra, Indonesia

II. Materials and Methods

Wood processing companies being studied were PT. W which produced plywood and located in Indralaya, South Sumatra and PT. X which produced Slate Pencil and located in Musi Rawas, South Sumatra. The study began in August 2013 and ended in June 2014.

The first of stage of this study was conducting a preliminary survey of work environment in order to see the layout of the plant, the production process, and to determine the location of wood dust measurement.

The population of this study were all the workers who worked in the wood processing industry, numbering 381 workers of the Plywood Manufacturer of PT. W and 271 workers in Slate Pencil Manufacturer of PT. X.

The number of samples taken for this study was calculated on the basis of sample size calculation by Lemeshow et al, 1997. Prevalence of pulmonary function impairment used in this study referred to the study by Malaka and Kodama (1990). In the previous studies the prevalence of abnormalities was between 29.4% and 53.7% (Rastogi, et al. (1989); Osman and Pala (2009); Sripaibookij, et al 2009). The sample size of this study was determined in accordance with the rate of lung function impairment prevalence of 29.4%, resulting in the total number of samples as many as 90 workers per company. So, sampling in this study was done by means of purposive sampling technique.

Dust measurement was done in two ways, namely personal dust and areal dust. The dust which was measured was inhalable dust.

Examination of lung function can be done by means of spirometry examination and interpretation using a nomogram of Indonesia. Spirometry can be used as a diagnostic tool of lung function (NIOSH 2003; Miller, et al 2005; Altalag, et al 2009). The questionnaire used was ATS-DLD 78A which was used for any signs of respiratory disease experienced by the workers who complain of cough and phlegm. If the workers had an indication of experiencing abnormal lung function, then it was followed by Skin Prick Test (SPT) with a Policy and Procedural Manual P-22-PRO on the subsample of the respondents.

Outcomes

Plywood production process consists of exfoliation process of Rubber wood at the Rotary section and veneer manufacture at the Spendless. Then veneer was dried with Hot Press Dryer for 30 minutes. Then it was sent to the Glue Spreader to do gluing with glue. After that cooling process was done at the Cold Press for 30 minutes. Then further heating was done at the Hot Press section for 30 minutes. Finally, smoothing was done by using sandpaper and then it was packaged for shipment to the customers.

As for the production process of Slate Pencil, it begins with timber cutting process of *Pulai* wood, followed by the cutting process of wood beams until they become wood sheets. The wood sheets are sorted according to their quality and then sent to the Vacuum section for 6 hours for coloring, and then followed by drying process for 48 hours by using a Drying Kiln tool. After that the wood sheets are sanded on their surfaces and sides to get a certain size. Finally they are sorted according to their sizes and packaged for shipment to the customers.

The activities of Plywood and Slate Pencil production process which produce wood dust are the Cutting and the Sanding activities.

TABLE I
DEMOGRAPHIC CHARACTERISTICS OF THE SUBJECTS OF THE STUDY

Variable	*Company* (n = 177)		
	W (n=87)	X (n=90)	n=177
- Age (year); mean ±SD	26.0 (7.1)	32.0 (7.9)	30.3 (7.7)
- Gender; n (%)			
Female	23 (26.4)	40 (44.4)	63 (35.6)
Male	64 (73.6)	50 (55.6)	114(64.4)
- Body Height (cm); mean ±SD	159.4(8.1)	154.9(7.9)	157.1(8.3)
- Length of Working Time (years); mean ±SD	3.7 (1.8)	10.8 (7.5)	7.3 (6.6)
- Smoking; n (%)			
No	58 (66.7)	55 (66,7)	113 (63.8)
Yes	29 (33.3)	35 (38.9)	64 (36.2)
- Personal Dust (mg/m^3); mean ±SD	0.2 (0.5)	0.1 (0.3)	0.3 (0.4)
- Areal Dust (mg/m^3); mean ±SD	0.5 (0.4)	0.1 (0.2)	0.4 (0.4)
- Coughing; n (%)			
No	78 (89.7)	85 (94.4)	163 (92.1)
Yes	9 (10.3)	5 (5.6)	14 (7.9)
- Phlegm; n (%)			
No	79 (90.8)	83 (92.2)	162 (91.5)
Yes	8 (9.2)	5 (7.8)	15 (8.5)
- *Skin Prick Test Positive* ; n (%)	0	6	6
- Abnormality			
- Spirometry (FVC); n (%)			
Normal	85 (97.7)	79 (87.8)	164 (92.7)
Abnormal	2 (2.3)	11 (12.2)	13 (7.3)
- Abnormality Spirometry (FEV_1); n (%)			
Normal	84 (96.6)	82 (91.1)	166 (93.8)
Abnormal	3 (3.4)	8 (8.9)	11 (6.2)
- Abnormality Spirometry (FEV_1/FVC); n (%)			
Normal	76 (87.4)	69 (76.7)	145 (81.9)
Abnormal	11 (12.6)	21 (23.3)	32 (18.1)
- FVC (liter); mean ±SD	3.8 (0.8)	3.5 (1.0)	3.7 (0.9)
- FEV_1 (liter); mean ±SD	3.4 (0.7)	3.0 (0.9)	3.2 (0.9)
- FEV_1/FVC; mean ±SD	93.8(10.7)	86.3(11.9)	87.4(11.6)

Notes: PT.W uses raw material of wood obtained from Rubber trees to produce *Plywood*, whereas PT. X uses raw material of wood obtained from *Pulai* trees to produce *Slate Pencil.*

III. DISCUSSION

Demographics of Respondents

Table 1 shows the distribution of continuous data of subject demographics. The ages of the subjects are ($\bar{x}$±SD) 30.29 ± 7.69 years, with the lowest age of 19 years and the highest age of 54 years. The length of time the subject has worked is ($\bar{x}$±SD) 7.34 ± 6.55 years, with the shortest period of work is 1 year old and the longest period of work is 24 years old. Body height is ($\bar{x}$ ± SD) 157.07 ± 8.25 cm, with the shortest body height is 137 cm and the tallest body height is 176 cm. The gender of the subjects is as follows: there are 114 men, 64 of them are in PT. W and 50 of them are in PT. X. There are 63 women, 23 of them are in PT. W and 40 of them are in the PT. X. The number of subjects who have worked for less than 5 years is 108 workers, 71 of them are in PT. W and 37 of them are in PT. X. The number of workers who have worked for more than five years is 69 people, 16 of them are in PT. W and 53 of them are in PT. X.

Wood Dust Concentration

Table 1 presents the data on the results of the measurements of the Personal Dust in the air of the working environment that is ($\bar{x}$ ± SD) 0.25 ± 0.39 mg/m^3, with a range of Personal Dust from 0.002 to 3.650 mg/m^3. The multiplication of the Length of Time of Work by Personal Dust is ($\bar{x}$ ± SD) 1.70 ± 3.82 year/mg/m^3, with a range from 0.01 to 44.82 years/ mg/m^3. The Areal Dust in the air of the working environment is ($\bar{x}$ ± SD) of 0.42 ± 0.42 mg/ m^3. The multiplication of the Length of Time of Work by Areal Dust is ($\bar{x}$ ± SD) of 2.06 ± 2.22 years/mg/m^3. In the previous studies the results of the measurement of the inhalable wood dust are as follows: In the study by Alwis (1999) the concentration of wood dust was ($\bar{x}$ ± SD) 2.14 ± 3.59 mg/m^3, Milkelsen, et al (2002) was 0.95 ± 2.08 mg/m^3, Malaka and Kodama (1990) was 1.35 mg/m^3.

Respiratory Health

Table 1 presents the results of spirometry measurements of the 177 subjects as follows: the spirometry value of FVC is ($\bar{x}$

± SD) of 3.67 ± 0.92 liters, the spirometry value of FEV_1 is (x̄ ± SD) was 3.20 ± 0.86 liters, the spirometry value of FEV_1/FVC is (x̄ ± SD) 87.40 ± 11.57%. In the previous studies by Alwis (1999), of the 168 subjects, the value of FVC was (x̄ ± SD) 4.40 ± 0.68 liters, the value of FEV_1 was (x̄ ± SD) 6.34 ± 0.30 liters. The results of previous studies by Malaka and Kodama (1990) of 93 subjects exposed, the value of FVC was (x̄ ± SD) 3.28 ± 0.44 liters, the value of FEV_1 was (x̄ ± SD) 2.78 ± 0.41 liters and the value of FEV_1/FVC was (x̄ ± SD) 84.7 ± 6.5%. The results of previous study by Aulia (2011) of 87 subjects the value of FVC was (x̄ ± SD) 22 ± 0.8 liters, the value of FEV_1 was (x̄ ± SD) 3.91 ± 0.7 liters, the value of FEV_1/FVC (x̄ ± SD) 93.16 ± 7.5%.

Symptoms of Respiratory Diseases

Table 1 shows that the total number of subjects with cough is 14 people, of which 9 workers are from PT. W and 5 workers from PT. X. The number of subjects who complained of phlegm is 15 workers, of which 8 workers belong to PT. W and 7 workers belong to PT. X. The number of subjects who smoked is 64 workers, of which 29 workers belong to PT. W and 35 workers belong to PT. X.

The results of previous studies by Malaka and Kodama (1990) revealed that 53% of the exposed workers had cough and 44% complained of phlegm. While the study by Aulia (2011) revealed that 43 subjects (49.4%) complained of coughing and 33 subjects (37.9%) complained of phlegm.

The frequency of incidence of cough and phlegm at the site of the study was smaller than that of the previous studies, while smoking habit was more prevalent in the study.

The data in Table 1 show the results of spirometric examination in the subjects, of the total samples there are 32 people (18.1%) who have abnormal spirometry. The spirometric abnormalities are the result of the length of time the subjects worked in a working environment that is exposed to wood dust (> 5 years), so it has physical impact on the subjects. Furthermore, the results of allergy tests by performing Skin Prick Test on the subjects who worked in PT X that uses raw material of wood of *Pulai* trees, it was found that there were 6 workers who showed positive results. While at PT W that uses raw material of wood from Rubber trees, there was no worker with Skin Prick Test positive. This suggests that the use of wood of *Pulai* trees has greater risk of inflicting allergy on the workers who are exposed to its wood dust.

The results are consistent with the results of the previous studies by Alwis (1999) and IARC (1995), which state that wood dust can cause allergies. But the fact that the exposure to wood dust of *Pulai* trees has higher risk of causing allergy is something new. The data indicate that the incidence of abnormal spirometry mostly occur in PT. X that uses wood of *Pulai* trees.

IV. Conclusions

The workers' exposure to wood dust has caused respiratory health problems. The wood of *Pulai* tree (*Astonia Scolaris*) has a higher risk of spirometric abnormalities based on allergies than the wood of Rubber trees (*Havea Braziliensis*). The frequency of spirometric abnormality values and the symptoms of respiratory diseases of the workers at PT. W are smaller than those in the PT. X.

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