Advances in Health Sciences Research, volume 25

2nd Sriwijaya International Conference of Public Health (SICPH 2019)

Respiratory Health of Workers Exposed to Wood Dust in Pulp Industry Sumatera Selatan

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Abstract* — *In pulp processing industry, exposure to wood dust is one of the main health risks for workers. Data and information on health problems associated with the risk of exposure to wood dust are still minimal recorded in published literature. This study aims to analyze the relationship between exposure to wood dust and lung function disorders and respiratory disease symptoms in pulp industry workers in South Sumatra. 80 workers are in the Wood Handling Process Unit in the Debarking, Chipping and Screening areas of PT. X South Sumatra chosen randomly determined spirometric values and exposure to wood dust. Inhalable wood dust exposure was carried out with Gravimetric technique of 20 measurement point samples spread over all three areas in the Wood Handling Process Unit. Respiratory health was measured through spirometry and the Standardized Respiratory Questionnaire from the American Thoracic Society (ATS). The age of the workers varies between 20-53 years (29.87 ± 7.13), height varies between 152-185 cm (167.80 ± 6.33), work period varies between 1-4 years (1.85 ± 0.85), dust exposure varies between 0.21-1.43 ppm (0.76 ± 0.36). Spirometry results showed that spirometry abnormalities in PVC parameters were 30%, FEV1 17.5%, FEV1 / FVC 7.5%, overall 56.3% of the samples had abnormal spirometry values. Workers who experience breathing problems shortness of breath, coughing and phlegm by 77.5%. Subsequent analysis showed that dust exposure and years of service in the company were predictors of spirometric values. The frequency of respiratory symptoms such as shortness of breath, coughing and sputum are related to dust levels, work location, and smoking.

Keywords:* *wood dust, Wood Handling Process Unit, spirometry, respiratory disorders

I. INTRODUCTION

Pulp is a material for making paper. At present Indonesia is 9th ranked in the world's pulp and paper producer with market share of 2.4% and 2.2% of the world per year. The development of the pulp and paper industry in Indonesia continues to increase from year to year, but has not been able to meet all the domestic needs and export demand that continues to increase. Confederation of European Paper Industries (CEPI) projected world pulp consumption in 2015 to be 233 million / ton with a growth of 1.8% per year, while paper amounted to 458 million / ton with a growth of around 2.9% per year, indicating that the demand for pulp and paper the world is still quite large and Indonesia has the opportunity to play a role in the world pulp and paper market.[1] Wood plants that are often used as raw materials for making pulp are *Acacia sp* and *Eucalyptus sp*.[2]

In wood processing industry, exposure to wood dust is one of the main potential health threats for workers. Epidemiological studies have shown that exposure to wood dust is associated with nasal and sinonasal cancer. So that the International Agency for Research on Cancer (IARC) classifies wood dust as a group 1 (carcinogen) to humans.[3]

The standard concentration of wood dust on work environment in general is 1 mg / m3 for hardwood and softwood for workers who work 8 hours a day (ACGIH, 2018). For the standard in Indonesia, the standard is 1 mg / m3 for hardwood species and 5 mg / m3 for softwood species.[4]

South Sumatra has one of Asia's largest pulp producing industries. PT.X produces around 2,800,000 tons / year of pulp. PT. X has 1681 local employees and 102 foreign employees. Work schedule is divided into two types, shift work schedule and non-shift work schedule. Shift work schedule is for Field Operators and DCS Operators, divided into 3 shifts every day, namely: shift 1 (morning) with work time is 07:00 - 15:00 WIB, shift 2 (afternoon) with work time is 15 : 00 -

17:00 WIB, shift 3 (night) with work time is 23:00 - 07:00 WIB. For non-shift workers have normal working as more industries develop, the number of workers becomes more and the health of workers is very important for productivity.hours which is 8 working hours per day, which is from 07: 00-11: 00 followed by 13: 00-17: 00, plus overtime according to the work requirements.

Part of production are process preparation of raw materials (woodyard and chip preparation), cooking, washing and screening, oxygen delignification, bleaching and drying and forming pulp (pulp drying and finishing). On part of preparation of raw materials (woodyard and chip preparation) in the Wood Handling Process unit consists of a process of debarking, chipping and screening of wood chips. Debarking process is removing the bark that will be used by using a drum debarker unit. Waste generated in the form of bark (bark) is sent to the remaining wood storage (hog pile) to be used as fuel for power plants. Chipping process is hardened wood that will be passed by a conveyor belt to the chipper unit to be cut into uniform sized wood chips (2 x 3 x 0.2 cm).

Waste generated from this process in the form of wood sawdust sawdust is sent to the hog pile to be used as fuel for power plants and the screening process is a process carried out to obtain wood chips that have the desired size and then the wood chips are stored into a pile of wood chips (chip pile) before cooking in the digester unit. Wood chips that do not meet the size (oversized chip) will be chipped again, while the results of a smooth screening (fines) will be stored in the hog pile with bark and saw dust to be used as fuel for power plants. In this unit workers are directly exposed to bark dust (bark), wood chips, sawdust, and fine dust (fines) produced by these three processes, so it is necessary to analyze the health risks of worker breathing using a lung physiology test indicator in the form of spirometry and a questionnaire to see symptoms of respiratory health problems.

This study is to analyze the relationship between exposure to wood dust with the incidence of respiratory health problems of spirometry pulmonary disorders and the emergence of symptoms such as shortness of breath, coughing and phlegm.

II. METHOD

This study uses a cross sectional design with an analytical survey of 80 workers in the Wood Handling Process unit in the Chipping, Debarking & Screening area with the same characteristics Process unit in the Chipping, Debarking & Screening area with the same characteristics. The selection of workers by purposive sampling technique for workers who are exposed to dust in these three areas. Dust measurements were carried out at 20 points representing three areas and the dust examined was inhalabe dust using an IOM Dust Sampler according to the American Conference of Governmental Industrial Hygienist (ACGIH) standards. Furthermore, to measure pulmonary function (spirometry) according to the National Instute of Occupational Safety and Health (NIOSH) standards using a digital spirometer with three important parameters for epidemiological studies, namely FVC, FEV1, FEV1 / FVC. Respiratory symptoms were obtained using a DLD-78 A standardized symptomic respiratory questionnaire from the American Thoracic Society (ATS) in 1987 and spirometry interpretations used normal values for Indonesians.

III. RESULT

TABLE I
Frequency Distribution of Worker Characteristics, Concentration of Wood Dust and Worker's Spirometry

Variabel	n	Mean	Median	SD	Min-Max
Age (yr)	80	29,87	27	7,13	20-53
Height (cm)	80	167,80	167,50	6,33	152-185
Lenght of service (yr)	80	1,85	2	0,85	1-4
Areal Dust *Inhalable* (mg/m^3)	20	0,76	0,72	0,36	0,21-1,43
FVC (L)	80	3,30	3,32	0,64	1,91-4,65
FEV1 (L)	80	3,11	3,16	0,59	1,06-4,40
FEV1/FVC (%)	80	94,40	96	6,98	55-105

In table I it can be seen that the average age of the worker is 29 years with the youngest age is 20 years and the oldest age is 53 years. The average height of workers is 167 cm with the lowest height of 152 cm and the highest height of 185 cm. The average lenght of service is 1 year with the shortest lenght of service of 1 year and the longest lenght of service is 4 years. While the average areal dust inhalable content is 0.76 mg / m3 with a minimum dust content value of 0.21 mg / m3 and a maximum dust content value of 1.43 mg / m3. The average FVC value is 3.30 L, with the lowest value 1.91 L and the highest value 4.65 L. While the average FEV1 value is 3.11 L, with the lowest value 1.06 L and the highest value 4.40 L. And the average FEV1 / FVC value is 94.40%, with the lowest value of 55% and the highest value of 105%. From the

distribution of available data it appears that the median is close to the mean which means the distribution of each variable approaches normality.

TABLE II
Variable Frequency Distribution of Research Data Categories

Variable	Categorical		n	%
Work Location	1	WHP	16	20
	2	Debarkin	19	23,8
	3	Chipping	19	23,8
	4	Screenin	26	32,5
Dust & TLVs Levels	1	Under	60	75
	2	Below	20	25
Respiratory Disorders:	1	Yes	3	3,8
	2	No	77	96,3
Caugh	1	Yes	42	52,5
	2	No	38	47,5
Phlegm	1	Yes	5	6,3
	2	No	75	93,8
Smoke	1	Yes	55	68,8
	2	No	25	31,2
Spirometry Value : FVC	1	Normal	56	70
	2	Abnorma	24	30
Spirometry Value : FEV1	1	Normal	66	82,5
	2	Abnorma	14	17,5
Spirometry Value : FEV1/FVC	1	Normal	74	92,5
	2	Abnorma	6	7,5
Spirometry Abnormalities (Overall Samples)	1	Normal	35	43,8
	2	Abnorma l	45	56,3

In table II it can be seen that the distribution of characteristics based on work location, 16 people (20%) work in the WHP area, 19 people (23.8%) work in the Debarking area, 19 people (19.8%) work in the Chipping area, and 26 people (32.5%) work in the Screening area. Workers exposed to area dust (inhalable) below the Threshold Value (TLV) of 60 people (75%) and workers who are exposed to area dust content (inhalable) above the Threshold Value (TLV) of 20 people (25%). The TLV used here is the 2011 NAV, because it was still valid at the time the study was conducted. The current applicable TLV is Permenakertrans No 05 th 2018 where the number relating to wood dust does not change. Workers who experienced shortness of breath were 3 people (3.8%) and those who did not experience shortness of breath were 77 people (96.3%). Workers who experienced cough as many as 42 (52.5%) and who did not experience cough as many as 38 people (47.5%). Workers who experienced phlegm were 5 people (6.3%) and those who did not experienced phlegm were 75 people (93.8%). Workers who have a smoking habit are 55 people (68.8%) and workers who do not have a smoking habit are 25 people (31.3%). The table shows that there are
55 FVC abnormalities (70%) having normal FVC values,
and the remaining 24 people (30%) have abnormal FVC values. Workers who experienced FEV1 abnormalities, there were 66 people (82.5%) had normal FEV1 values, the remaining 14 people (17.5%) had abnormal FEV1 values. Abnormalities of FEV1 / FVC in workers, there are 74 people (92.5%) have normal FEV1 / FVC values and the remaining 6 people (7.5%) have abnormal FEV1 / FVC values. Total spirometry abnormalities in all workers studied were: 35 people (43.8%) had normal values and the remaining 45 people (56.3%) had abnormal values. The standard values used are the normal values of the Indonesian Pneumobile Project (PPI) spirometry based on recommendations from the American Thoracic Society / ATS 1987.

TABLE III
Relationship between Work Location and Cough

Work Location	Caugh				Total	P Value
	Yes		No			
	n	%	n	%		
WHP	0	0	16	100	16	0,004
Debarking	4	21,1	15	78,9	19	
Chipping	5	26,3	14	73,7	19	
Screening	11	42,3	16	57,7	26	

Table III shows that of the 16 people working in the Wood Handling Process (WHP) area, no workers (0%) were exposed to dust above TLV and all workers (100%) were exposed to dust below TLV rate. Of the 19 people working in the Debarking area, dust exposed workers were above TLV of 4 (21.1%), while workers exposed to dust were below TLV of 15 (78.9%). Of the 19 people working in the Chipping area, workers exposed to dust were above TLV of 5 (26.3%), while workers exposed to dust were below TLV by 14 (73.7%). Of the 26 people working in the Screening area, workers exposed to dust above TLV were 11 (42.3%), while workers exposed to dust below TLV were 16 (57.7%). There was a difference with p-value = 0.004 ($\alpha = 0.05$).

TABLE IV
Relationship between Dust Concentration and Cough

Dust Concentration	Caugh				Total	P Value
	Yes		No			
	n	%	n	%		
Above TLVs	17	85	3	15	20	0,001
Below TLVs	25	41,7	35	58,3	60	

Note : TLVs = ***Threshold Limit Values***

Table IV shows that out of a total of 42 workers who experienced coughing, workers exposed to dust levels above TLV were 17 people (85%), while workers who were exposed to dust levels below TLV were 25 people (41.7%). Of 38 workers who did not experience coughing, workers exposed to dust levels above TLV were 3 people (15%), while workers who were exposed to dust levels below TLV were 35 people (58.3%). There is a difference with p-value = 0.001 (α = 0.05).

TABLE V
The relationship between smoking and cough

Smoking	Caugh				Total	P Value
	Yes		No			
	n	%	n	%		
Yes	35	63,6	20	36,4	55	0,004
No	7	28	18	72	25	

Table V shows that out of a total of 55 workers, there were 35 people who smoke and cough (63.6%), while those who smoked but did not cough as many as 20 people (36.4%). From a total of 25 workers who did not have the habit of smoking but experienced coughing as many as 7 people (28%), while those who did not have the habit of smoking and did not experience coughing as many as 19 people (76%). There is a difference with p-value = 0.004 (α = 0.05).

TABLE VI. Final Modeling Analysis of Multiple Linear Regression FVC and FEV1

	Variable	*P*	R^2
FVC	Age	0,000	0,538
	Height	0,000	
	Lenght of service	0,019	
	Dust Concentration	0,000	
	Konstanta	0,220	
FEV1	Age	0,000	0,500
	Height	0,000	
	Lenght of service	0,019	
	Dust Concentration	0,000	
	Konstanta	0,697	

Table VI, from 6 (six) independent variables that entered into the multivariate modeling, there were 4 (four) variables that had a P value <0.05 while the other 2 (two) variables had a P value of> 0.05. Of the 6 (six) independent variables, the modeling is continued by issuing one by one variable that has the largest p value. This is done to see whether the variable to be excluded has an influence on other variables, by looking at changes in OR when modeling continues.

The final modeling of Multivariate analysis shows that,
Age, Height, Lenght of Service and Dust Concentration variables are the most dominant variables that can cause abnormal FVC and FEV1. The results of the interpretation are the variables Age, Height, Length of Service and Dust Concentration significantly associated with abnormal FVC and FEV1, where the OR value is already controlled (adjusted) by other variables in the model. While the dust TLV and smoking variables are confounding variables.

It was found that multivariate analysis showed Nagelker's R Square value of 0.495. This shows that the contribution of the independent variable Work Period, NAV Dust and Cigarette to the cough dependent variable was
49.5%. The results of logistic regression analysis showed
that the variables most influential on dust were years of service, NAV dust, and cigarettes.

TABLE VII
Final Modeling of Logistic Regression in Cough

Independent Variable	Coefisien	*p value*	OR	Nagelkerke R square
Work Period	-1,045	0,003	0,352	0,495
Dust Concentration	1,752	0,022	5,765	
Smoke	-1,081	0,103	0,339	
Konstanta	-0,723			

IV. DISCUSSION

In table III there is a difference with p-value = 0.046 (α = 0.05). Statistical results show that work location variables have a significant relationship that affects workers coughing.It can be seen that the workers who experience the most cough are at the work site with the highest levels of dust, the work location of Screening.

In table IV there is a difference with p-value = 0.001 (α = 0.05). Statistical results show that there is a significant relationship between area dust levels and cough variables. It is seen that more workers are exposed to dust above NAV who experience cough compared to workers who are exposed to dust under NAV. In table V There is a difference with p-value = 0.004 (α = 0.05). Statistical results show that smoking habits have a significant relationship with the incidence of cough. It appears that workers who have a smoking habit cough more than those who do not have a smoking habit.

This research was conducted to determine the Health Risk of Respiratory Workers Exposed to Wood Dust in the Wood Handling Process Unit of

PT.X Pulp Industry in 2018. There were 3 people (3.8%) workers who experienced shortness of breath and who experienced quite a lot of cough that is 42 people (52.5%). This should be consulted to the clinic, in addition to conducting treatment also to look for the possibility of tuberculosis in workers. Workplace environmental factors provide a very large role can reduce the quality of pulmonary physiology, namely the presence of high dust pollution, ventilation and hygiene of the workplace that is not good. Some types of dust can reduce the quality of lung function including silica dust, wood dust and chemical dust. Pollutants in the workplace environment can reduce lung function, thus making the lungs more vulnerable. Low lung resistance can occur with Tuberculosis, so workers will suffer from TB.[5] Tuberculosis is a direct infectious disease caused by TB bacteria (Mycobacterium Tuberculosis), most TB germs attack the lungs, but can also affect other organs.[6] TB among workers is not uncommon, so in previous studies namely Malacca and Kodama (1990) and Zaman (2015) conducted further research by doing Chest X-Ray to diagnose pneumonia, emphysema and other lung disorders. However, how the role of TB in causing respiratory disease has not been revealed because in this study did not conduct further tests for TB.[7]

Respiratory spirometry is a screening test that measures several aspects of respiratory and pulmonary physiology. Byusing spirometry which records the amount of air inhaled and expelled as well as the amount of air flowing in and out of the lungs. Spirogram records the results of spirometry by performing maximal expiration after maximal inspiration. From the results of spirometry checks conducted on Pulp Industry Wood Handling Process Unit workers who use raw materials of Acacia mangium, Acacia crassicarpa, and Eucalyptus pellita, the total frequency of workers whose spirometrics are abnormal is 43.8%, which means that almost half of the there are also more workers who have the habit of smoking. The cough condition in Pulp Industry workers is exacerbated by smoking habits.

V. CONCLUSION

A study was carried out on 80 people exposed to Acacia and Eucalyptus wood dust in the Pulp Industry. Inhalable dust varies between 0.21-1.43 ppm (0.76 ± 0.36), there is a significant relationship between dust content and service life on spirometry parameters and there is a significant relationship between wood dust, work period, work location, smoking to respiratory symptoms such as shortness of breath, coughing and phlegm.

workers are exposed dust has abnormal spirometry results. Workers who have an abnormal FVC value of 30%, an abnormal FEV1 value of 17.5% and a FEV1 / FVC value of 7.5%. From Zaman's research (2015), the results of abnormalities in lung function of workers exposed to dust in the Plywood Industry that uses Rubber Wood (Hevea braziliensis) and Slate Pencil raw materials that use Pulai wood (Alstonia scholaris) as raw material in South Sumatra Province are 19.5 %, workers who have an abnormal FVC value of 4.1%, an abnormal FEV1 value of 3% and a FEV1 / FVC value of 15.4%. Similar to Faisya's research (2017), the results of abnormal lung function of workers exposed to rubber dust in the production section of Palembang City Crumb Rubber Industry were 23.7%, workers who had abnormal FVC values of 9.6%, abnormal FEV1 values of 23 7% and FEV1 / FVC value of 14.1%. And the results of research by Zulviani (2017) the results of abnormal pulmonary function of workers in the carpet or flake industry by 13.3%, workers who have an abnormal FVC value of 2.2%, abnormal FEV1 values of 1.1% and FEV1 / FVC values by 10%.

In Pulp Industry Wood Handling Process Unit workers, workers who coughed by 52.5% and workers who had a smoking habit of 68.8%. In the Zaman study (2015) in the Plywood and Slate Pencil Industry, workers who experienced a cough of 7.1% and who had a smoking habit of 36.1%. Whereas in Faisya's research (2017) on the Crumb Rubber Industry, workers who experienced coughing amounted to 27.6%, and workers who had smoking habits amounted to 22.4%. As well as in Zulviani's research (2017) on the carpet manufacturing industry, workers who experienced a cough of 21.1% and workers who had a smoking habit of 22.2%.[8] That is, the workers at PT.X's Wood Handling Process Unit have more cough workers compared to previous studies, and

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