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Analysis of hair trace metal levels among workers at smelter limited company

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Abstract

Background: Lead (Pb) is one of the heavy metals that has a negative effect on the health of the human body and the environment. This metal is included in the 20 dangerous and toxic heavy metals defined by the Environmental Protection Agency (EPA) in 1997. One way to detect exposure to lead (Pb) in the body is to analyze the levels of lead in hair. The impact of exposure to lead (Pb) can cause neurological disorders, kidney function, reproductive system function and nerve function.
Purpose: To analyze lead levels through hair in smelter workers at the smelting department of smelter limited company on Belitung Island, Bangka Belitung Islands Province.
Method: Quantitative with cross sectional method approach. The population in this study were workers at the smelter limited company smelting division. The object of research was 30 hair samples taken using purposive sampling method. Data analysis was processed statistically so that the research data could be concluded with univariate, bivariate and multivariate.
Results: The fisher's exact test showed a p-value of 1,000 so it could be concluded that there was no relationship between age and Pb levels in workers' hair. There is no relationship between working duration and Pb levels in workers' hair with a p-value > 1,000. That there is no significant relationship between length of service and Pb levels in the respondent's hair with a p-value of 0.469. There is a significant relationship between smoking habits, use of PPE and work environment with lead levels in hair with a p-value of 0.023.
Conclusion: There is no relationship between age, length of work and years of service with Pb levels in the respondent's hair because the p-value is > 0.05. And there is a relationship between the variables of smoking habits, use of PPE and work environment with Pb levels in hair with a p-value <0.05.

Keywords: Hair trace; Metal levels; Workers; Smelter limited company

INTRODUCTION

Belitung Island is part of the Bangka Belitung Islands Province. The economy in the Bangka Belitung Islands Province still relies on the mining sector and makes a large contribution to the Gross Regional Domestic Product (GRDP) of the Bangka Belitung Islands Province. Statistical data shows that in 2020 the contribution of metal ore mining is 8.54%, occupying the 5th position, the previous year occupying the 4th position as the largest contributor to GRDP. Mining in this area is dominated by tin mining. Central Bureau of Statistics data shows there are 9 tin mining companies on Belitung Island.

Tin ore obtained from mining is in the form of tin sand with levels ranging from 20% - 60%, then washed and separated from other minerals. After being separated, so that smelting can be carried out, the Sn content is increased to 70% - 72%. Tin is melted in a

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smelter, a furnace used to smelt tin with a boiling point of 1350oC. Furthermore, to obtain high quality tin metal with a low "lead" or lead content, a purification process is carried out using a crystallizer or electrolytic refining. In this part of the smelter workers work in shifts and it is in this process that one of the risks for workers to be exposed to Pb is in the form of fumes. These fumes are thought to enter the respiratory tract or through other organs such as the skin. After this process, high-grade tin is formed ready for export with a minimum category of 99.85%. Pb is one of the heavy metals that can have a negative effect on health and the environment.

Smelter limited company in controlling and reducing the impact of fumes has carried out various methods, namely by engineering control, namely installing large blowers towards workers during the tapping process and using personal protective equipment for workers, besides that smelter limited company also regularly conducts environmental monitoring for work environment air and air in exhaust emissions.

In 1997 the Environmental Protection Agency (EPA) in 1997, there were 20 metals declared to be hazardous and toxic materials and the heavy metal lead or lead was one of them. Pb exposure to human organs has a negative impact on health. The effects include: causing neurological disorders, disruption of kidney function, disruption of the function of the reproductive system, disruption of the hemoptytic system, and nervous system (Prasasti, Mukono, & Sudarmaji, 2006; Jaishankar, Tseten, Anbalagan, Mathew, & Beeregowda, 2014; Ashraf, Ali, Zahir, Ashraf, & Asghar, 2019).

It is possible to detect lead exposure in the body using hair. Several studies in Indonesia have been conducted to determine lead exposure through hair, including research on the Soekarno-Hatta Bandar Lampung road, namely tire patch workers (Samsuar, Kanedi, & Pebrice, 2017). Analysis of lead levels in the hair of city transport drivers in Tamalate District, Makassar City, to be precise on Jalan Andi Pangeran Pettarani, this study showed that in all study samples, lead levels were found to exceed the threshold levels, according to WHO, lead levels in hair were ≤ 12 µg/g (Alimudin & Sulfiani, 2021). Lead levels in the hair of gas station employees, the results of the study showed that length of work was a factor that influenced the amount of Pb metal content in hair. Lead levels in hair increased with length of service, the highest was found at 9-12 years of service, namely 0.8175 mg/g (Mayaserli, & Renowati, 2018). Lead that enters the worker's body comes from emissions from the work environment in the form of fumes around workers which become a hazard (Haider & Hashmi, 2014; Popović, Prokić-Cvetković, Burzić, Lukić, & Beljić, 2014).

Research on lead exposure to tin smelter workers was conducted by analyzing the blood (Lensi, 2017). However, from the research that has been done, there is no information about the analysis of lead exposure in workers at tin smelters in through hair.

RESEARCH METHOD

Quantitative with a cross sectional method approach, to analyze lead levels in workers' hair at the smelter limited company; smelting section on Belitung Island at the same time at the same location and take air measurements at the work point. Conducted from December 2022 to January 2023.

The population in this study were workers at the smelter limited company; smelting division. The object of research was 30 hair samples taken using purposive sampling method. With the criteria of permanent workers employees at smelter limited company; Furnace workers; Willing to be a respondent in this study; Aged between 20 to 50 and potentially directly exposed to lead (Pb).

Primary data was obtained from data on the results of measuring lead levels in workers' hair through examination of lead levels in accredited laboratories whose results were acceptable. Collecting data on workers' behavior and health complaints from the results of interviews and using a questionnaire.

The results of measuring the air quality of the work environment carried out for 24 hours are categorized as not at risk if ≤ 2 µg/m3, and at risk if > 2 µg/m3. The results of measuring Pb levels in the respondent's hair were categorized as good if ≤ 12 µg/g, and bad if > 12 µg/g.Data analysis was processed statistically so that the research data could be concluded with univariate, bivariate and multivariate which were described with the characteristics of the respondents.

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RESEARCH RESULTS

Table 1. Distribution of The Characteristics of The Respondents (N=30)

Variables	Results (n/%)
Age (M±SD)(Range)(Years)	(31.00±8.370)(20-54)
>30 Years	16/53.3
≤30 Years	14/46.7
Length of work in a day	
>8 Hours	30/100
≤8 Hours	0/0
Length of Time Employee (M±SD)(Range)(Years)	(5.00±2.704)(1-11)
≥5 Years	22/73.3
< 5 Years	8/26.7
Heavy Smoker	
Yes	5/16.7
No	25/83.3
Using of PPE properly	
Always	25/83.3
Occasionally	5/16.7
Work Environment	
High Risk	5/16.7
Low Risk	25/83.3
Pb Levels in Hair	
Normal Level	28/93.3
High Level	2/6.7

From table 1 above it is known that the age of the respondents is with a mean of 31.00 and a standard deviation of 8.370 and the youngest is 20 years old and the oldest is 54 years old, the majority are >30 years old as many as 16 (53.3%). All respondents have worked > 8 hours a day. The average respondent has worked for 5 years, with a standard deviation of 2,704. The most recent respondent's working period was less than 12 months and the respondent who had the longest working period was 11 years, the majority with working period ≥5 years were 22 (73.3%). However, the majority of workers work in a work environment that is not at risk, namely 25 (83.3%). The majority of respondents did not have heavy smoker (83.3%) and the majority using PPE according to the properly (83.3). Then, from the results of the analysis of Pb levels in the hair of the majority, 28 (93.3%) detected good.

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Table 2. The Factors Associated With Hair Trace Metal Levels

Variables	Pb Levels in Hair		p-value	OR (95% CI)
	Normal Level (n=28)	High Level (n=2)		
Age (n/%)				
>30 Years	15/53.6	1/50	1.000	0.867 (0.049-15.279)
≤30 Years	13/46.4	1/50		
Length of work in a day (n/%)				
> 8 Hours	28/100	2/100	>1.000	<0.000
≤ 8 Hours	0/0	0/0		
Length of Time Employee (n/%)				
< 5 Years	7/25	1/50	0.469	0.364
≥ 5 Years	21/75	1/50		
Heavy Smoker (n/%)				
Yes	3/10.7	2/100	0.023	0.600 (0.293-1.227)
No	25/89.3	0/0		
Using of PPE properly (n/%)				
Always	25/89.3	0/0	0.023	0.600 (0.293-1.227)
Occasionally	3/10.7	2/100		
Work Environment (n/%)				
High Risk	3/10.7	2/100	0.023	<0.000
Low Risk	25/89.3	0/0		

Table 2 shows that workers who are >30 years old and have good Pb levels in their hair are 53.6% and 50% are bad, while workers aged ≤30 years and have good Pb levels in their hair are 46.4% and 50% bad ones. Then the chi-square test was not suitable for use in this data, so as an alternative, the Fisher's exact test was used, which showed a p-value of 1,000 so that it could be concluded that there was no relationship between the age variable and Pb levels in hair.

It is known that workers who work longer than 8 hours and have good lead levels in their hair are 100%, while workers who work long hours ≤8 hours and have bad lead levels in their hair are 0%. Then the statistical test showed a p-value of > 1,000 so it could be concluded that there was no relationship between the variable length of work and Pb levels in hair.

It is known that respondents with a length of time employee of <5 years and having good lead levels of 25% and bad by 50%, and respondents with a length of time employee of ≥ 5 years who have good lead levels in hair are 75% while 50% are bad. The results of fisher exact analysis showed a p-value of 0.469. This value is greater than the value of α (0.05), so the decision is to fail to reject H0. It can be concluded that there is no significant relationship between length of service and Pb levels in the respondent's hair.

It is known that 10.7% of respondents have a heavy smoker and have good lead levels in hair, while the other 100% have heavy smoker and bad lead levels in hair. The results of the fisher exact analysis show a value of 0.023 which is smaller than the alpha α value (0.05), so the decision is to reject H0. It can be

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concluded that there is a significant relationship between smoking habits and lead levels in hair. The odds ratio value indicates that respondents who do not have smoking habits are 0.6 times more likely to have good Pb levels in hair. In the general population, 95% of researchers believed that smoking was a protective factor for lead levels in hair in the range 0.293-1.227.

It is known that there are 1007% of respondents who do not properly for using PPE have good Pb levels in hair. And 100% who do not properly for using PPE and have bad Pb levels in hair. The results of the fisher exact analysis show a value of 0.023 which is smaller than the alpha α value (0.05), so the decision is to reject H0. It can be concluded that there is a significant relationship between the use of PPE and lead levels in hair. The odds ratio value indicates that respondents who properly for using PPE are 0.6 times more likely to have good Pb levels in hair. In the general population, 95% of researchers believe that not properly for using PPE is a protective factor for lead levels in hair in the range of 0.293-1.227.

It is known that workers who work in a work environment are at high risk and have Pb levels in bad hair by 100%, while workers who work in a work environment are low risk and Pb levels in bad hair are 0%. Then the chi-square test was not sufficient to be used for this data, so as an alternative the fisher's exact test was used, which showed a p-value of 0.023 so that it could be concluded that there was a relationship between work environment variables and Pb levels in hair.

DISCUSSION

Demographic Characteristics

From the research data it was found that 2 people out of 30 people in their hair exceeded 7 µg/g lead levels which exceeded lead levels in hair according to the Decree of the Minister of Health of the Republic of Indonesia No. 1406/Menkes/SK/XI/2002 compared to the Biological Exposure Index (BEI) or an index for biological exposure and they work in a metal casting or printing place which is in a work unit with purification of tin impurities to reach 99.98% levels, one of the impurities derived is Pb or Lead or lead using a crystallizer which are assumed to become fumes and subsequently expose workers for quite a long time and are accumulative, the risk increases because in the casting department there is a habit of some workers not wearing masks, only using visors or face shields, so the risk of inhaling fumes will occur more. Smoking habits are also a factor causing lead exposure in hair.

This research succeeded in finding Pb levels in the air around the work environment and Pb levels in workers' hair, which means that this indicates a health risk in the workplace which has not been considered high risk so far.

Judging from the levels of Pb in the hair, it was also found that some were close to the biological exposure index threshold which also indicated that the risk of exposure also occurred to other workers.

In statistical bivariate analysis it was found that lead levels in hair which were used as bioindicators were significantly related to smoking habits, use of PPE in this case masks and work units or work locations of workers at the smelter limited company. From the behavior, it was found that workers were still negligent in using masks even though they had been provided by the company because with the naked eye there was no visible presence of smelting fumes, especially Pb at the refining or printing locations which were no less at risk in other parts of the smelting. Efforts should be made to increase knowledge in the form of education and training, safety talks, print media or all available facilities seriously regarding knowledge of hygiene, occupational sanitation, work-related diseases in the smelting department in a well programmed manner.

Suggested follow-up from this research in order to improve and prevent the adverse effects of this smelting fumes, namely; The engineering approach at the printing/refining location needs to be implemented as the use of a large fan/blower behind the workers to avoid heat is also effective in reducing the inhalation of fume to workers in the furnace section; Air monitoring point for the work environment to be added at a location near the casting/purification with 24-hour measurements, to obtain periodic data in determining the program to be implemented; Conduct integrated training/training and campaigns to provide education to workers about hygiene; Include the budget as a form of the company's seriousness in implementing the

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program and periodically rotate workers in the refining and printing sections.

Age

Based on the results of the analysis, it was found that there was no relationship between age and Pb levels in workers' hair. The increase in the level of Pb (lead) content in the human body cannot be proven proportional to the increase in age. According to research in Pekanbaru which states, the relationship between age and lead content in the body is found in the absorption of heavy metals in the body. This is because there is a metabolic function that changes based on increasing age in a person, especially field workers (Roza, Ilja & Anita, 2015). While research in Pakistan stated that contamination of workers' hair was based on age category with an average Pb content of 2.26 – 8.02 ppm (Anwar, 2005). In line with this, in a study in Northern Poland which examined the Pb contained in the hair of the surrounding population, the highest was in the 61-75 year age group of 3.88 ppm while the lowest was in the 0-15 year age group of 0.152 – 2. 07 ppm, which is based on data from the Central Bureau of Statistics in 2013, productive age or working age, namely in the age range of 15-64 years (Trojanowski, Trojanowski, Antonowicz, & Bokiniec, 2010; Central Bureau of Statistics of the Republic of Indonesia, 2013).

Working Period

The results of the study showed that there was no relationship between employee tenure and lead levels in workers. The results of the study were not in line with research in Jombang which stated that exposure to lead (Pb) in the body was affected by years of service, with years of service ≥ 4 years having higher levels of lead (Pb) (Khanifah, 2022). The results of research at CV Arba Palu City also showed a significant relationship between lead (Pb) exposure and the respondent's working period with a value of p = 0.000 (p <0.05) (Tasya, 2018). However, this research is in line with research at the Kartini gas station in Palu City which states that there is no effect of length of work on lead (Pb) levels at gas station operators (Melinda, Afni & Hamidah, 2019). The results of this study are also in line with studies in Pekanbaru City and Bengkalis City which showed no significant difference between lead levels in hair with < 3 years of service, 3-5 years of service, and > 5 years of service at traffic police at both locations (Putra, Amin & Anita, 2015).

Research in Padang explains that the longer you work, the greater the Pb metal content. The highest amount of Pb was found during the longest working period, namely 9-12 years with a metal content of Pb of 0.8175 mg/g (Mayaserli & Renowati, 2018). However, a statement from a study in Palu City explained that no matter how long the work period cannot fully determine the lead level in the body, no matter how long the work period is if the nutritional status and lifestyle are healthy can reduce the lead level in the body, and vice versa even if a person's working period is still in a new condition but if the pattern of life is not healthy it will affect the level of lead in the body, especially if someone smokes it will greatly affect the level of lead in a person's body, because cigarettes contain lead even if only a little. It is not only active smokers who can be exposed to lead but also passive smokers who are exposed to cigarette smoke in their daily environment (Melinda, Afni & Hamidah, 2019). Researchers assume that there is no relationship between work period and lead levels in workers' hair because it is supported by other factors, such as the personal protective equipment that workers wear. Even though the workers have had a long working period, it has no effect on lead exposure from the work environment because there is self-protection through PPE.

The Length of Work

Based on the results of the analysis in the study, it was found that there was no relationship between length of work and Pb levels in workers' hair. Length of exposure is defined as the exposure time of workers to Pb. However, according to research in Bandar Lampung, the duration of exposure to substances will affect the concentration of Pb entering the body (Samsuar et al., 2017). The same thing was also mentioned in the research in Kampung Rambutan, time/length of work had a significant effect on Pb levels contained in the body where workers with daily working hours of more than 8 hours had Pb levels in

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the blood that exceeded the threshold (Sofyan, Wintarsih, & Ismail, 2020).

Heavy Smoker

The results showed a relationship between heavy smoker and lead levels in hair. The results of the study are in line with a study in Magelang which showed a significant relationship between smoking duration and lead (Pb) levels in hair. duration of smoking can affect lead (Pb) levels in hair by 25.4%, the remaining 74.6% by other variables. The longer a person's smoking habit will also affect lead (Pb) levels in the hair, so to reduce the effect of long smoking on lead (Pb) levels, you can eliminate the smoking habit or stop smoking (Wulandari, Abdullah & Yulianto, 2016). Previous studies conducted research on the analysis of the heavy metal lead (Pb) on the hair of employees at public refueling stations (SPBU) using secondary data showing that the employee's hair was polluted by lead (Pb) metal not according to CDC standards, with the result that the highest lead content was 1.909 ppm (Nuriah, 2020). Other researchers stated that the older a person is, the higher the concentration of lead that accumulates in body tissues. The type of tissue also affects lead levels, these tissues include bones, liver, lungs, kidneys, spleen, heart, brain, teeth and hair (Restuaji, & Kusuma, 2022).

Smoking is a habit that can cause lead to enter the human body through several routes, namely through food and drink, air (breathing/inhalation) and seepage or penetration of the membranes or layers of the skin (Shatriadi & Zairinayati, 2017). Cigarettes contain several heavy metals such as Pb, Cd, and so on which are harmful to health. Daily cigarette consumption will increase the risk of Pb inhalation as a result of cigarette smoke (Ardillah, 2016). The presence of lead levels that exceeded the threshold rate in the hair was due to the smoking habit of each individual.

Using of PPE Properly

The results of this study indicate that there is a significant relationship between the use of PPE and lead levels in hair. The results of this study are in line with previous research which stated that there is a relationship between the use of PPE and Pb levels, that workers who wear PPE who do not properly are 1.364 times more likely to have Pb levels exceeding normal limits (Sari, Setiani & Joko, 2016). Research in Sukoharjo also explains that using workers who do not wear complete personal protective equipment such as masks, head coverings, goggles, coveralls, and boots are at greater risk of being exposed to heavy metals in pesticides that enter the body through inhalation, oral, dermal , eyes and also injection into open wounds (Silviani, Wimpy, Livana, Utami, Pradita, & Nasruminalloh, 2022). Pb metal ion levels in blood and hair are closely related to many things such as lifestyle, living conditions and the use of personal protective equipment (PPE) at work (Wiratama, Sitorus, & Kartika, 2018).

Work Environment

Based on the results of the analysis in the study, it was stated that there was a relationship between the division of the work environment and Pb levels in hair. Because workers who get a high risky work environment have a higher vulnerability to exposure to Pb compared to workers in low risk environments because the work environment is a place that has a risk of exposure to Pb so that the work environment plays a major role in the accumulation of Pb in the body. Research in Bandar Lampung states that hair contains sulfhydryl and disulfide groups which can bind trace elements such as Pb which will enter the body and be bound to the hair, so if these trace elements enter the body it will be directly bound to sulfide compounds in the hair. The negative impact of lead if exposed to the body will result in kidney damage, hypertension, menstrual disorders and anemia, as well as changes in the central nervous system, decreased IQ, and there has been evidence of changes in spermatogenesis (Samsuar et al., 2017). Other harmful effects include impairing mental function and serious damage to the nervous system, changing behavior and causing anemia (Rosmiati, 2019).

In the process of tin smelting industry activities that take place, it will have an impact on environmental pollution by heavy metals in the air, water and soil so that this can lead to risk factors for the occurrence of vulnerability to health problems for workers due to exposure to heavy metals produced by the industrial process. , including one type of lead (Leksono, Setiani,

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& Sulistiyani, 2014). Research in Klaten examined differences in blood lead (Pb) levels based on the type of work in workers, and found that the average blood lead levels in the casting, molding and finishing sections had exceeded the limits set by the Center for Disease Control and Prevention (Center for Disease Control and Prevention). CDC) namely 10 µg/dl (Lestari, Setiani & Dewanti, 2015). The higher the Pb level in the air in the work section, the higher the Pb level in the blood of the workers in that section.

RESEARCH LIMITATIONS

The limitation of this study is that it cannot confirm the lead levels obtained from the smelter process, but it does not rule out the possibility of Pb exposure also from motor vehicle fumes. In addition, the air sampling point was carried out only at 1 point where the smelter was located, so it could not differentiate the air quality per unit of work at the smelter limited company.

CONCLUSION

There is no relationship between age, length of work and years of service with Pb levels in the respondent's hair because the p-value is > 0.05. And there is a relationship between the variables of smoking habits, use of PPE and work environment with Pb levels in hair with a p-value <0.05.

SUGGESTION

Respondents need self-awareness from these workers to give up their smoking habit in order to minimize lead exposure to these workers. To pay more attention to the use of PPE, not only to get used to using it in daily work, but also to pay attention to whether its use is in accordance with work safety standards.

For smelter limited company to provide education and guidance to workers regarding personal health such as the dangers of smoking, provide complete and standard personal protective equipment and conduct regular medical tests to monitor the health of workers.

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