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Research Article

THE RELATIONSHIP BETWEEN BLOOD LEAD LEVELS AND HEMOGLOBIN LEVELS IN MINING WORKERS IN MOROSI

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ABSTRACT

Background: Lead disrupts heme synthesis through various mechanisms, one of which is by interfering with the activation of the enzyme δ-aminolevulinic acid dehydratase (δ-ALAD) and ferrochelatase. Lead contamination in the blood will decrease hemoglobin levels; the higher the lead concentration in a person's body, the lower their hemoglobin levels will be. The purpose of this study is to determine the relationship between lead (Pb) levels in the blood and hemoglobin levels in miners in the nickel processing industry.
Methods: This study uses an analytical research type with a cross-sectional design employing the Atomic Absorption Spectroscopy (AAS) and Hematology Analyzer methods. The population in this study consisted of 16 respondents. The sample in this study consisted of 15 respondents. The variables of this study are miners, lead (Pb) levels, and hemoglobin (Hb) levels.
Results: The study obtained an average blood lead level of 13.81 µg/dL and an average hemoglobin level of 13.4 g/dL. The research results with the Pearson correlation statistical test between blood lead levels and hemoglobin levels showed a significance of p = 0.404 and a correlation coefficient of r = -0.233.
Conclusion: Based on this study, it is concluded that there is no relationship between blood lead levels and hemoglobin levels in nickel processing industry mine workers, with a correlation between lead (Pb) and hemoglobin of p = 0.404, which is greater than 0.05 (p > 0.05).

Keywords: Lead, Hemoglobin, Mine, worker, toxicity

INTRODUCTION

Mining is a series of activities involving the search for, extraction (excavation), processing, utilization and sale of minerals (minerals, coal, geothermal energy, oil and gas) [1]. Indonesia is one of the world's largest coal mining regions. Mining activities conducted in forest areas can damage forest ecosystems. If not managed properly, mining can cause overall environmental damage in the form of water, soil, and air pollution [2]

The impact of mining by PT. OSS and PT. VDNI in Morosi District is caused by air pollution resulting from the combustion process in nickel ore processing. This process can produce harmful chemical compounds that affect air quality. Air quality degradation occurs during nickel ore combustion, which releases toxic compounds including carbon monoxide, carbon dioxide, methane, benzene, toluene, xylene, Sulphur, arsenic, mercury, and lead. Prolonged exposure to these pollutants can adversely affect public health. One such substance is lead, where excessive exposure can pose risks of anemia and neurological and cognitive impairments [3].

One type of pollutant that has received significant attention in mining environmental management is heavy metals. Coal ash contains heavy metals and therefore requires serious attention, especially in its use as fill material in coal mining activities. Coal ash is a byproduct of coal-fired power plants (CFPPs), where it is significantly influenced by the type of combustion in the CFPP and the coal input. Coal combustion residues include fly ash and bottom ash. Based on ICP-MS testing, coal ash has high heavy metal content, one of which is lead (Pb).

Based on WHO data (2010) Excessive exposure to lead (Pb) is a significant global issue and a major environmental health risk faced by countries in both developed and developing regions. Lead is a well-known toxin with widespread health impacts, affecting the nervous, cardiovascular, gastrointestinal, and haematological systems. Young children are particularly vulnerable because they have higher exposure levels than adults and because lead affects the developing brain, potentially leading to reduced intellectual ability. Lead in the body is distributed to the brain, liver, kidneys and bones. It is stored in teeth and bones, where it accumulates over time. Lead in bones is released into the blood during pregnancy and becomes a source of exposure for the developing foetus.

Lead (Pb) is a type of heavy metal that is extremely dangerous when accumulated in certain amounts in the body, as it can cause death in living organisms. The toxicity of lead compounds (Pb) can inhibit the formation of haemoglobin (Hb) and disrupt the function of organs in the body [4]. Lead disrupts heme synthesis through various mechanisms, one of which is by interfering with the activation of the enzyme δ-aminolevulinic acid dehydratase (δ-ALAD) and ferrochelatase. Lead contamination in the blood reduces haemoglobin levels; the higher the lead levels in a person's body, the lower their haemoglobin levels. Lead (Pb) exposure is associated with its accumulation in tissues, causing disruptions in physiological processes both directly and indirectly at the molecular level [5].

In a study conducted by [6], it was found that there is a relationship between lead levels and haemoglobin levels in the blood. Out of 10 samples, 5 individuals (50%) had normal haemoglobin (Hb) levels, and 5 individuals (50%) had abnormal levels. The highest haemoglobin level was 17.8 g/dL, and the lowest haemoglobin level was

10.0 g/dL. Lead absorbed into the blood binds to red blood cells (erythrocytes) and inhibits the formation of haemoglobin. Therefore, when someone inhales lead in the air, the lead content in the blood increases, haemoglobin decreases, and anaemia occurs.

METHODS

The materials used in this study were blood samples from mine workers, alcohol 70%, nitric acid (HNO3), lead nitrate (Pb(NO3)2), plaster, and distilled water.
Method; Blood sampling of mine workers**;** Procedure for testing lead (Pb) levels using Atomic Absorption Spectroscopy (AAS)

Blood Sample Preparation

2.5 mL of blood was pipetted, 5 mL of concentrated nitric acid was added to the vessel, the vessel was placed in the microwave, the device was turned on, and microwave digestion was performed. The mixture was then cooled to 60°C. Transfer the digestion solution into a 50 mL volumetric flask, rinse the vessel three times with 5 mL of deionised water each time, then add water up to the 50 mL mark on the flask until the solution becomes clear.

Preparation of 1000 ppm Pb Stock Solution

Weigh 1.598 g of Lead Nitrate $Pb(NO_3)_2$, dissolve using 10 mL of HNO_3, transfer into a 1000 mL volumetric flask, and add distilled water until the 1000 mL mark on the volumetric flask is reached [7]

Dilution of the 100 ppm Pb Standard Solution

10 mL of the 1000 ppm Pb stock solution was pipetted into a 100 mL volumetric flask and diluted with distilled water to the 100 mL mark on the volumetric flask

Preparation of Standard Pb Solutions at 0.5, 1, 2, 4, and 8 ppm

Pipette 0.5 mL of 100 ppm Pb standard solution into a 100 mL volumetric flask, and dilute with distilled water to the 100 mL mark on the flask, resulting in a 0.5 ppm Pb standard solution; 1 mL of 100 ppm Pb standard solution is pipetted into a 100 mL volumetric flask and diluted with distilled water to the 100 mL mark, resulting in a 1 ppm Pb standard solution; 2 mL of 100 ppm Pb standard solution is pipetted into a 100 mL volumetric flask, and diluted with distilled water to the 100 mL mark on the measuring flask, resulting in a 2 ppm Pb standard solution; 4 mL of 100 ppm Pb standard solution was pipetted into a 100 mL measuring flask and diluted with distilled water to the 100 mL mark on the measuring flask, resulting in a 4 ppm Pb standard solution; 8 mL of the 100 ppm Pb standard solution was pipetted into a 100 mL volumetric flask and diluted with distilled water to the 100 mL mark, yielding an 8 ppm Pb standard solution

Preparation of Lead (Pb) Standard Curve

Each lead (Pb) standard solution (0.5, 1.2, 4, and 8 ppm) was injected into the AAS; its absorption was measured at a wavelength of 217.0 nm, and the measurement results were recorded. A calibration curve was then created to obtain the regression line equation

Measurement of Lead (Pb) Concentration Using Atomic Absorption Spectrophotometry (AAS)

10 mL sample of the digested material was pipetted and filtered; after filtering, the sample is placed on the sample rack of the

Atomic Absorption Spectrophotometer (AAS); The solution is measured for lead (Pb) analysis using Atomic Absorption Spectrophotometry (AAS) at a wavelength of 217.0 nm, and the measurement results are recorded for analysis

Procedure for checking haemoglobin levels with a Haematology Analyzer

Homogenise the blood sample in an EDTA tube; place the sample tube at the bottom of the aspiration probe needle, ensuring that the tip of the needle touches the bottom of the tube so that no air is sucked in; press the button behind the suction needle; then wait for the 'beep' sound from the device, indicating that the sample has been sucked in and the test results will appear on the screen and be printed automatically [8]

RESULTS

Univariate Analysis

Respondent characteristics based on length of employment

Table 1. Characteristics of respondents based on years of service

No	Work Period	Number (n)	Percentage %	Mean Blood Pb Levels
1	3 years	15	100	13,81 µg/dL
	Total	15	100	

Table 1 shows the research results with an average work duration of 3 years among the respondents, with a total of 15 respondents (100%) and an average blood lead level of 13.81 µg/dL. The high lead (Pb) levels in the study samples may be influenced by the duration of exposure and the length of employment. The longer the employment period, the greater the lead (Pb) exposure, resulting in higher lead (Pb) levels. Results of blood lead level tests

Table 2. Results of lead level tests using AAS

No	Lead (Pb)	Number (n)	Percentage (%)
1	Low	0	0
2	Medium	15	100
3	High	0	0
	Total	**15**	**100**

(Source: Primary Data, 2023)

Table 2 shows the results of the lead level study in 15 respondents, with an average lead level ranging from 10 to 25 µg/dL. indicating that the lead concentration in the study samples is still within the normal range for lead levels in blood, as defined by the Indonesian Ministry of Health Decision No. 1406/MENKES/IX/2002, which sets the normal range at 10–25 µg/dL. The average lead level in the blood of workers in the nickel processing industry was 13.81 µg/dL.

Hemoglobin level test results

Table 3. The results of the hemoglobin level examination using the Hematology Analyzer

	p-value	df	Interpretation of Result
Lead level in blood	0.131	15	Normal distribution
Haemoglobin level	0,152	15	Normal distribution

(Source: Primary Data, 2023)

Table 4 shows that the significance values for lead levels and haemoglobin levels obtained results of $p>0.05$, which means that the data is normally distributed. Based on the normality test results, the correlation test was performed using the Pearson correlation test.

Pearson correlation test of lead levels and haemoglobin levels

Table 5. Results of Pearson correlation test of lead levels and haemoglobin levels

	Significance	Correlation coeficient
Blood lead level and Haemoglobin level	*p*= 0,404	r=-0,233

(Source: Primary Data, 2023)

Table 5 shows that the Pearson correlation test yielded a result of p = 0.404 (>0.05), which means that there is no significant relationship (H0 accepted). The correlation coefficient (r = -0.233) indicates a negative correlation with very weak correlation strength. A negative or inverse correlation means that as the value of one variable increases, the value of the other variable decreases. As lead levels increase, hemoglobin levels decrease. The strength of the correlation in the study sample is very weak because all lead levels were moderate (normal) and most hemoglobin levels were normal.

DISCUSSION

This study was conducted to determine the relationship between lead (Pb) in the blood and hemoglobin (Hb) levels in mine workers in the nickel processing industry. Lead levels in this study were examined by analyzing heavy metals using the AAS (Atomic Absorption Spectroscopy) method. AAS is a tool used in analytical methods to determine metal and metalloid elements [9]. Hemoglobin levels in this study were measured using an automatic method with a hematology analyzer, which is used to measure and count the total number of blood cells. The principle of the hematology analyzer is to mix the blood sample with a reagent to induce a process called hemolysis.

One indicator for detecting lead poisoning is to conduct a test using a blood sample. This is because blood can determine the level of lead poisoning in the body. Lead in the blood is toxic and accumulative, and even though the amount of lead absorbed by the body is very small, its effects are extremely dangerous. Lead compounds (Pb) can cause health issues or effects, particularly on the hematopoietic system (blood formation system), such as inhibiting hemoglobin production and shortening the lifespan of red blood cells, leading to anemia. Lead exposure can also cause erythrocyte hemolysis and inhibit hemoglobin synthesis [10]

Lead can disrupt the hemoglobin synthesis system. The main components of hemoglobin are synthesized from glycine and succinyl coenzyme A (KOA) with pyridoxal as a cofactor. After several steps, they combine with iron to form heme. The enzymes involved in heme formation that are most susceptible to lead are ALAD and heme synthase. Lead compounds in the body bind to the active site of the ALAD enzyme. The binding of lead metal to ALAD disrupts or halts the reaction process. This inhibition of hemoglobin synthesis leads to abnormal hemoglobin levels, with lead blood levels influenced by age and duration of exposure [11]

High levels of lead (Pb) in research samples can be influenced by the duration of exposure and length of service. The longer the length of service, the greater the exposure to lead (Pb), resulting in higher lead (Pb) levels. Based on Table 1, a length of service of 3 years with 15 respondents had an average blood lead level of 13.81 µg/dL. According to Bada (2014), exposure to air containing lead (Pb) increases the

accumulation of lead (Pb) in the blood, and [12] states that lead (Pb) exposure can cause long-term effects. This is because lead (Pb) can enter the bloodstream through respiration and the digestive tract and inhibit heme synthesis, which reduces the production of hemoglobin (Hb) in the blood.

The results of the lead concentration analysis on miners in the nickel processing industry (table 2) show that the lead concentration in the research samples is still within the normal limits of blood lead levels based on the Decree of the Minister of Health of the Republic of Indonesia Number 1406/MENKES/IX/2002, which is 10 - 25 µg/dL, where the average blood lead level of miners in the nickel processing industry is 13.81 µg/dL. Meanwhile, in table 3, the results of the Hb (Hemoglobin) level examination on miners indicate that some respondents have hemoglobin levels in the low category (anemia), with 7 respondents (47%) and normal levels in 8 respondents (53%). Based on the available data, it is known that the lowest hemoglobin level is 10.7 g/dL and the highest is 15.9 g/dL, with an average Hb level of 13.4 g/dL. According to the research by Lubis et al. (2013), high lead concentration in the body will decrease blood hemoglobin levels, which can affect the occurrence of anemia.

Based on the results of the Pearson correlation test (table 13), it shows that the correlation between lead (Pb) levels and hemoglobin is p = 0.404, which is greater than 0.05 (p>0.05). Thus, a negative relationship with very weak strength or opposite direction is obtained, where the greater the value of one variable, the smaller the value of the other variable. Thus, it can be concluded that the higher the lead content, the lower the hemoglobin level. The strength of the correlation in the research sample is very weak because all lead levels are moderate (normal) and the majority of hemoglobin levels are normal. Therefore, there is no relationship between lead (Pb) levels and hemoglobin levels. This is also in line with the research findings of Rosita (2018), which showed that there is no significant relationship between lead (Pb) levels and hemoglobin levels in workers.

One of the factors influencing the absence of a relationship between blood lead levels and hemoglobin levels is the length of employment, in this study the average respondent had a work duration of 3 years, so the lead exposure was not too high, resulting in most blood lead levels still being within the normal range.

Based on this research, it is known that there is no relationship between blood lead levels and Hb levels. The research results also show that the average Pb and Hb levels of the respondents are normal or in accordance with the standards of the Minister of Health of the Republic of Indonesia Number 1406/MENKES/IX/2002. However, the researchers believe that there may have been a disturbance in heme biosynthesis in the respondents because the average lead level in their blood was 13.81 µg/dL (> 10 µg/dL). However, this is only an early-stage disturbance in heme biosynthesis, so no health impacts are yet visible; the disturbance can only be detected through laboratory examination.

CONCLUSION

The relationship between blood lead (Pb) levels and haemoglobin levels in mine workers in the nickel processing industry in Morosi indicates that there is no correlation between blood lead levels and haemoglobin levels, with a correlation coefficient of p = 0.404, which is greater than 0.05 (p > 0.05).

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