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CORRELATION BETWEEN LEAD LEVELS AND BLOOD PROFILES IN RICE FARMERS

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ABSTRACT
Pesticides contain Pb in their composition, while farmers often come into direct contact with pesticides without realizing the potential health risks involved. . This study aimed to determine correlation between blood lead (Pb) levels and hematological profiles in rice farmers in Tlingsing Village, Cawas District, Klaten Regency. Design research used a cross-sectional approach using purposive sampling on 24 respondents who had been working for more than two years. Data were obtained through questionnaires and laboratory tests, including blood Pb levels using the GFAAS (Graphite Furnace Atomic Absorption Spectrophotometry) method and complete blood tests using a Hematology Analyzer. Correlation analysis used Spearman's rho test at a significance level of 95% ($\alpha = 0.05$). According to the Centers for Disease Control and Prevention (CDC), blood Pb levels can be categorized as low if they are <1 µg/dL and high if they are >80 µg/dL. The results showed that all respondents had blood Pb levels below the CDC threshold (<10 µg/dL). There was an increase in erythrocytes in 4.2% of respondents, hematocrit in 12%, and a decrease in platelets in 4% of respondents. The correlation test showed no significant relationship between Pb levels and hemoglobin ($p = 0.801$), hematocrit ($p = 0.657$), leukocytes ($p = 0.580$), platelets ($p = 0.463$), or erythrocytes ($p = 0.900$). Lead exposure in farmers was still at a level (<10 µg/dL) that was not significant correlation for the hematological profile.

Keywords: blood; farmers; hematology; pb; pesticides

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INTRODUCTION

Pesticides are chemicals used in agriculture to control weeds, insect pests, and other harmful organisms (Tudi et al., 2021). Pesticides are generally formulated in various forms such as emulsifiable concentrate (EC), suspension concentrate (SC), and wettable powder (WP). Some formulations, especially liquid-based ones such as EC, are known to contain organic compounds called VOCs (Volatile Organic Compounds) such as toluene, benzene, and xylene. Pesticides also contain heavy metals such as Cr, As, Cd, Hg, Pb, Cu, and Zn (He et al., 2024; Ye Xuezhu, 2022). The content of these heavy metals in the formulations of several types of pesticides includes Cr, As, Cd, Hg, and Pb, with an average Pb formulation of 3 .43 mg/kg (Ye Xuezhu, 2022). Pb is a type of toxic heavy metal that is often found in the environment, mainly as a result of human activities (He et al., 2024). Pb in the environment comes from industry, fossil fuel combustion, batteries, and pesticide use (Alengebawy et al., 2021; Balali-Mood et al., 2021; Putros & Khadim, 2024; Raj & Das, 2023). Pb can enter the body in several ways, such as through mouth and nose respiration, absorption through the skin, and ingestion because hands that touch the mouth or pass through food will be absorbed in the stomach and intestines (Huang et al., 2024). Pb absorption through the skin then enters the body after continuous exposure for 12 hours. Pb circulates in the bloodstream and can interfere with oxygen circulation(Santosa et al., 2022). Workers' awareness of the dangers of pesticides is not yet optimal. Workers work with their hands without PPE (Personal Protective Equipment) when using pesticides, and the use of PPE is not effective in protecting against

pesticide exposure when mixing, making, or spraying (Desouky et al., 2023).
Ecologically, some farmers may be exposed to Pb from sources other than pesticides, such as irrigation water and rice grains containing Pb, albeit at low levels(Lu et al., 2024). In this case, cumulative exposure may have long-term effects that are not yet detectable hematologically. Additionally, the half-life of Pb in body tissues, particularly bones, can reach decades, making Pb bioaccumulative (WHO/CSIR India Review 2022). Therefore, even if current blood levels are within safe limits, long-term cumulative exposure should still be monitored as a potential hematological or systemic risk in the future. Pb is mobile, biologically active, and can move between parts of the body, accumulating in soft tissues (such as the intestines, lungs, liver, spleen, kidneys, and central nervous system) and bones. Pb is excreted through the liver (bile) and kidneys (glomerular filtration and transtubular flow). The half- life of Pb in the blood is approximately 35 days, but it can be stored in bones for up to about 30 years (Ramírez Ortega et al., 2021). The human body can have systemic effects, especially on the hematopoietic system. The main mechanism of Pb toxicity is the disruption of heme biosynthesis, which is an important stage in the formation of hemoglobin. Pb inhibits the activity of two key enzymes in the heme biosynthesis pathway, namely ferrochelatase and δ-aminolevulinic acid dehydratase (ALAD). This inhibition causes a decrease in heme production, resulting in reduced hemoglobin levels (Okechukwu Ohiagu et al., 2022). Exposure to Pb leads to a decrease in the number of erythrocytes due to disruption of the erythropoiesis process. One way to detect this disruption in erythrocyte production is through a hematocrit test, which measures the volume of red blood cells in the blood volume. Hematocrit values may decrease due to a reduction in the number and size of erythrocytes (red blood cells). This is evidenced by a decrease in MCV (mean corpuscular volume) and MCHC (mean corpuscular hemoglobin concentration) values (Dongre et al., 2011; Okechukwu Ohiagu et al., 2022). Lead exposure has been shown to increase platelet count (PLT) but decrease functional indicators such as mean platelet volume (MPV) and platelet distribution width (PDW). This indicates that lead may interfere with platelet activation and maturation, possibly through inflammatory pathways such as IL- 6 and oxidative stress.

These effects are amplified when there is simultaneous exposure to heavy metals such as arsenic and cadmium (Zheng et al., 2024). Research in Khartoum State, Sudan. This study evaluated the effect of gasoline exposure in Khartoum State, Sudan on hematological parameters in gas station workers. It showed that chronic exposure to gasoline fumes containing Pb can cause significant changes in blood parameters. Hemoglobin levels were found to be significantly higher in the exposed group than in the control group. No significant differences were found in other parameters such as hematocrit, erythrocyte count, red blood cell volume, mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), or white blood cell and platelet counts. These findings indicate that increased HGB levels are the body's compensatory response to tissue hypoxia due to the toxic effects of Pb, while other hematological parameters remain within normal limits (Qafisheh et al., 2021). Research shows that lead exposure in individuals with levels (<5 µg/dL) is associated with decreased neural activity in the prefrontal cortex. Chronic exposure is also associated with oxidative stress, neuronal loss, and an increased risk of mental disorders such as depression and anxiety (Ramírez Ortega et al., 2021). Low-level Pb exposure affects the reproductive system, reducing sperm count and quality and causing hormonal disorders in men. Pb can be released from the bones into the blood, cross the placenta, and interfere with fetal development. This can increase the risk of miscarriage and premature birth. Pb also contributes to cardiovascular disorders at low levels (Mandal et al., 2023).

This study aims to determine the relationship between blood lead levels and blood profiles in rice farmers. The results of this study are expected to provide a more comprehensive scientific contribution to understanding the health effects of heavy metal exposure. This study can also add to knowledge in the field of clinical toxicology and serve as a basis for preventive and promotive occupational health efforts among farmers.

METHOD

This study used an analytical method with a cross-sectional research design. The research population consisted of rice farmers in Tlingsing Village, Cawas District, Klaten Regency who had been actively working for at least 2 years. The sampling technique used was purposive sampling. This study has obtained ethical approval from Muhammadiyah University Purwokerto with registration number KEPK/UMP/125/VIII/2025. The data used in this study were primary data from questionnaires and primary data from blood lead level tests and blood profiles of 6 cc of farmers' blood using EDTA vacuum tubes. Blood lead level tests were conducted at the Yogyakarta Health and Calibration Laboratory (BLKK) using 3 cc samples with a GFAAS instrument, and 3 cc blood samples were used for blood profile tests conducted at Moewardi Hospital using a Hematology Analyzer. Blood lead levels and blood profiles were analyzed using bivariate tests to examine correlation with a 95% confidence interval (p= 0.05).

RESULT

The respondents were 24 rice farmers aged 42-70 years old who had been working as rice farmers for more than 2 years. The complete characteristics of the respondents can be seen in the following diagram.

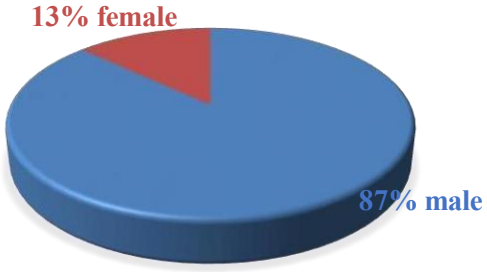


Figure 1. Diagram of the number of respondents

The number of respondents (figure 1) in this study was 24 rice farmers, with 13% female and 87% male.

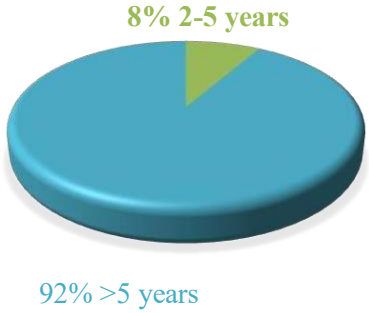


Figure 2. Diagram of length of employment

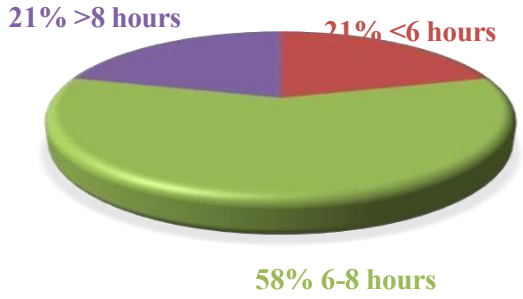


Figure 3. Diagram of duration of work

In the diagram above, the criteria for respondents were rice farmers with a length of service of 8% (2-5 years) and 92% (>5 years), and a length of service per day of 21% (>8 hours), (<6 hours), and 58% (6-8 hours).

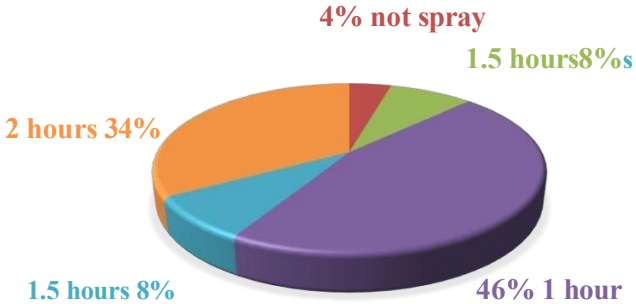


Figure 4. Duration of spraying

The duration of spraying can be seen from the table: 4% (*No spraying*), 8% (30 minutes), 8% (1.5 hours), 34% (2 hours), 46% (1 hour).

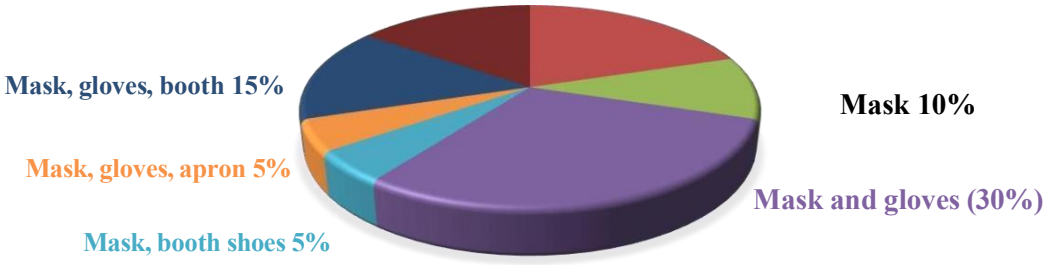


Figure 5. Diagram of PPE usage

Based on the results of research on the use of Personal Protective Equipment (PPE), it is known that most respondents use masks and gloves (30%). As many as 15% of respondents use masks, gloves, and boots, while another 15% add protective aprons as additional equipment. Only 10% of respondents used masks alone, and 5% of respondents used a combination of masks, gloves, and aprons. Meanwhile, 5% of respondents only used boots without other equipment. However, there were still 20% of respondents who did not use PPE at all while working.

Table 1.
Blood Profile Parameters

		f	%
Blood lead level (CDC, 2011)	Below standard (<10 µg/dL)	24	100
	Above standard (>10 µg/dL)	0	0
Blood profile reference range (CDC 2005)	Low value (< 3.0 × 10^9/L)	0	0
	Normal range (3.0 – 11.7 × 10^9/L)	24	100
White blood cells (WBC)**	High value (>11.7 × 10^9/L)	0	0
Red blood cells (RBC)**	Low value (< 3.7 × 10^{12}/L)	0	0
	Normal range (3.7–5.8 × 10^{12}/L)	23	95.8
	High value (> 5.8 × 10^{12}/L)	1	4.2
Hematocrit (HCT)**	Low value (< 0.325 L/L)	0	0
	Normal range (0.325–0.495 L/L)	21	87.5
	High value (> 0.495 L/L)	3	12.5
Hemoglobin (Hb)**	Low value (< 109 g/L)	0	0
	Normal range (109–173 g/L)	24	100
	High value (>173 g/L)	0	0
Platelets (PLC)**	Low value (< 200 × 10^9/L)	1	4.2
	Normal value (200–400 × 10^9/L)	23	95.8
	High value (>400 × 10^9/L)	0	0

Table 1 shows the distribution of blood Pb levels and blood profiles based on the 2005 and 2011 CDC references. Blood Pb levels showed that all respondents (100%) had results (<10 µg/dL). Leukocyte values from 24 respondents (100%) showed normal results, erythrocyte values from 23 respondents showed normal results (95.8%) and 1 respondent showed results above normal (4.2%), hematocrit values from 21 respondents showed normal results (87.5%) and 3 respondents showed results above normal (12.5%), hemoglobin values from 24 respondents showed normal results (100%), and platelet values from 23 respondents showed normal results (95.8%) and 1 respondent showed values below normal (4.2%). The normality test determines the appropriate statistical test. In this study, the normality test used the *Shapiro-Wilk* method because the sample size was < 50. The normality test results showed that Pb levels in all blood parameters had a significance value of 0.006 (< 0.05), indicating that the Pb level data were not normally distributed. hemoglobin levels (p = 0.793), hematocrit (p = 0.064), leukocytes (p= 0.083), and platelets (p = 0.251) showed p values > 0.05, indicating normal distribution. Erythrocyte levels (p = 0.007) had p values < 0.05, indicating abnormal distribution. For each pair of variables, one or both variables were not normally distributed (especially Pb levels, which were entirely non-normal), so the correlation analysis used was the non-parametric *Spearman's rho* test.

Table 2.
Correlation of Lead Levels with *Blood Profile*

		Hb	Ht	Leu	Eri	Thromb
Lead level	Sig. (two-tailed)	0.801	0.657	0.580	0.900	0.443
	N	24	24	24	24	24

The significance values of the *Spearman's rho* correlation test results between Pb levels and each blood parameter are as follows: hemoglobin (p = 0.801), hematocrit (p = 0.657), leukocytes (p = 0.580), platelets (p = 0.463), and erythrocytes (p = 0.900). The significance values are greater than 0.05 (p > 0.05). This indicates that there is no statistically significant relationship between Pb levels and each blood parameter.Lead levels are related to heavy metal exposure in the body, but there was no significant correlation between lead levels and blood parameters such as hemoglobin, hematocrit, leukocytes, platelets, and erythrocytes in the group of respondents in this study. These results indicate that lead exposure within the limits found in the study samples did not have a direct effect on blood parameters.

DISCUSSION

In this study, the Pb levels in the blood of rice farmer respondents were below the CDC safe level (< 10 µg/dL), and there was no significant correlation with hematological parameters such as hemoglobin, hematocrit, leukocytes, erythrocytes, or platelets. These findings are in line with a study in Bihar, India, which reported that the majority of children and pregnant women had BLL ≥ 5 µg/dL without a significant direct impact on hemoglobin (Lu et al., 2024). This is consistent with a study conducted by (Ansari et al., 2020)on children in Patna who lived near a used battery processing site. Although the correlation was not significant, there was an increase in erythrocytes in 4.2% of respondents, hematocrit in 12%, and a decrease in platelets in 4% of respondents. Similar conditions have been observed in Pb exposure, causing eryptosis activation (programmed erythrocyte death) and affecting the distribution of red blood cells and platelets (Obeagu et al., 2024; Wani et al., 2015). Wani et al., (2015) In addition to the mechanism of Pb toxicity that affects heme biosynthesis and triggers oxidative stress, dehydration in farmers while working in the fields may also contribute to changes in hematological parameters. Dehydration causes a decrease in plasma volume, thereby increasing the concentration of blood cells relative to body fluids. This condition is called hemoconcentration, which causes hematocrit and erythrocyte counts to appear to increase even though the absolute number of cells has not changed. A similar thing can also occur in platelets, where dehydration increases plasma viscosity and accelerates platelet aggregation. Research by Kratz et al. (2006) on Boston Marathon participants showed an increase in hematocrit and platelet count after the race that was consistent with body fluid loss, accompanied by a decrease in mean platelet component (MPC) and an increase in platelet clumps. The relationship found in this study is likely the result of a combination of the subclinical effects of Pb and the dehydration factor due to working in a hot environment. Dehydration enhances the effects of hemoconcentration, causing hematocrit and erythrocytes to increase, and also promotes an increase in platelets. This factor needs to be considered in interpreting the results, as not all hematological changes solely reflect Pb toxicity, but also physiological conditions due to heat exposure and fluid loss (Kratz et al., 2006).

The findings of a relationship with hematocrit and erythrocytes support this mechanism, in which even low exposure to Pb can cause changes in red blood cell components. In addition, the relationship with platelets can be explained through the inflammatory mechanism. Exposure to Pb has been shown to increase platelet count but decrease function indicators such as MPV (Mean Platelet Volume) and PDW (Platelet Distribution Width). This condition indicates a disturbance in platelet activation and maturation, which may occur through the interleukin-6 (IL-6) inflammatory pathway and oxidative stress (Zheng et al., 2024). This is consistent with the results of a study that found variations in platelet counts in some respondents. Pb can also affect leukocytes as the main component of the immune system. In this study, all respondents showed leukocyte values within the

normal range. However, a number of studies confirm that Pb exposure has a more dominant effect on leukocyte function than on their total number, for example by reducing phagocytosis, inhibiting lymphocyte proliferation, and altering the production of important cytokines such as IL-2 and IFN-γ (Pukanha et al., 2020; Kalahasthi et al., 2022). The main mechanism occurs through oxidative stress and protective enzyme disruption, so that leukocytes remain normal in number but their function is not optimal (Ilesanmi et al., 2022). This condition explains why in most individuals leukocyte levels appear normal, even though subclinically the immune system may be weakened. Additionally, the human immune response varies between individuals, influenced by factors such as age, genetics, nutritional status, and other health conditions, so this variation can mask differences in leukocyte counts in groups with the same exposure. Therefore, normal leukocyte results do not indicate freedom from risk but rather highlight the limitations of routine hematological examinations in detecting the immunotoxic effects of Pb, reinforcing the need for functional biomarker or cytokine testing in further research.

Research conducted by Rahimpoor on 100 Pb miners in Iran in 2020 showed a significant effect of Pb exposure on hematological parameters and kidney function. The assessment was conducted using blood lead (Pb) level tests and complete blood count (CBC) parameters. The results showed that hemoglobin (HGB) and hematocrit (HCT) levels in the Pb-exposed group decreased significantly compared to the unexposed group. The average HGB level in the exposed group was 15.54 g/dL and HCT was 47.14%, while in the control group, the levels were 15.82 g/dL and 47.69%, respectively. There was a significant difference in both parameters with a p-value < 0.05. This indicates a negative correlation between Pb levels and decreased HGB and HCT levels due to disruption of heme synthesis (Rahimpoor et al., 2020). A study of 34 gas station workers in Sulaimaniya City showed that exposure to leaded gasoline vapor was correlated with changes in hematological parameters. The results showed that blood lead levels (BLL) in workers were significantly higher than in the control group (6.2 ± 5 µg/dL vs. 2.1 ± 6.4 µg/dL; $p = 0.017$). Smoking workers had higher BLL (10.6 ± 3.9 µg/dL) than non- smokers (4.8 ± 5.7 µg/dL; $p = 0.003$). Hematology results showed that only hemoglobin (HGB) levels were significantly increased in the worker group (15.9 g/dL vs. 15.1 g/dL; $p = 0.01$), while other parameters such as hematocrit (HCT), red blood cell count (RBC), MCH, MCHC, PLT, and WBC showed no significant differences ($p > 0.05$). This indicates that chronic exposure to leaded gasoline fumes can increase hemoglobin levels, but does not show significant differences in other blood parameters (Mohammed, 2014).

The results of this study also show that the majority of respondents have used PPE when performing activities that pose a risk of Pb exposure, although the types and completeness of the PPE vary. A total of 83.3% of respondents used masks, 60% used gloves, 35% used boots, and only 15% wore protective aprons, while 16.7% did not use PPE at all. The use of PPE especially masks and gloves plays an important role in reducing direct exposure to Pb through inhalation and skin contact (Desouky et al., 2023; Okoffo et al., 2016). This may be one of the factors explaining why the blood Pb levels of all respondents were below the CDC threshold and no significant correlation was found with hematological parameters. Work characteristics also influenced these results. The majority of respondents had worked as rice farmers for more than 5 years (91.7%), with daily working hours between 6–8 hours (58.3%) and an average duration of activities with risk of Pb exposure of 1–2 hours per session. In theory, this duration of exposure could increase the risk of Pb accumulation through inhalation and skin contact. However, studies on workshop workers show that personal hygiene practices such as washing hands and showering after work can significantly reduce blood Pb levels, even with long working hours and high exposure (Abebe et al., 2024). Overall, the results of the study indicate that there are currently no significant hematological disorders due to Pb exposure, but the emergence of subclinical indications in some respondents, such as an increase in the proportion of erythrocytes and mild thrombocytes, suggests the need for closer monitoring and the use of more sensitive biomarkers to detect subclinical effects early on.

CONCLUSION

This study shows that all respondents had blood Pb levels below the threshold of <10 µg/dL according to (Department of Public Health et al)and there was no significant correlation between Pb levels and blood profiles (hemoglobin, hematocrit, leukocytes, platelets, and erythrocytes). Thus, it can be concluded that Pb exposure among farmers in Tlingsing Village has not had a statistically significant hematological impact.

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