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ELEVATED BLOOD LEAD LEVELS IN WOMEN OF REPRODUCTIVE AGE DUE TO LEADS EXPOSURE FROM CONTAMINATED WATER

PENINGKATAN KADAR TIMBAL DARAH WANITA USIA SUBUR YANG MENGONSUMSI AIR TERKONTAMINASI TIMBAL

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A B S T R A C T

Background: *Water quality can decrease due to population growth, domestic waste handling, climate, and human activities. Most of the people in Cimahi use well water for drinking and eating. However, using well water with high lead levels for consumption can adversely affect on the lead levels in the women's blood of childbearing age.* ***Purpose:*** *This study investigates the relationship between lead levels in well water and the corresponding levels found in women's blood in the Leuwigajah area of Cimahi.* ***Method:*** *Research samples were collected from both well water and the women's blood of childbearing age (15 - 49 years) who consume well water for drinking and cooking. Subsequently, sample preparation was conducted, and the samples were analyzed using an atomic absorption spectrophotometer. The Spearman correlation test was employed to analyze the data and establish any potential correlations.* ***Result:*** *The lead content in water ranged from 0.055 ppm to 0.089 ppm, exceeding the requirements for lead in clean water. Meanwhile, lead levels in the blood ranged from 1.5 ug/dL to 78.2 ug/dL, with 6.7% falling within the normal category, 40% in the tolerable category, 30% in the excess category, and 23.3% in the high category. The statistical results show a significant relationship between lead levels in well water and the blood, with a correlation value of 37.9%. The correlation value indicates a weak positive relationship.* ***Conclusion:*** *There is a relationship between lead levels in well water and women's blood.*

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A B S T R A K

Latar belakang: Kualitas air dapat menurun karena pertumbuhan penduduk, penanganan limbah domestik, iklim, dan aktivitas manusia. Sebagian besar masyarakat Cimahi menggunakan air sumur untuk minum dan makan. Penggunaan air sumur untuk dikonsumsi dengan kadar timbal yang tinggi dapat mempengaruhi kadar timbal dalam darah wanita usia subur. Kadar timbal yang tinggi pada wanita dapat menyebabkan anemia, gangguan tulang, gangguan neurotransmitter, kesehatan mental, dan reproduksi. **Tujuan:** Menentukan hubungan kadar timbal dalam air sumur dengan kadar timbal dalam darah wanita di Daerah Leuwigajah Kota Cimahi. **Metode:** Sampel penelitian diambil dari air sumur dan darah wanita usia subur (15 - 49 tahun) yang mengonsumsi air sumur sebagai sumber air minum dan membuat makanan. Sampel diproses dan dianalisis menggunakan metode spektrofotometer serapan atom. Uji korelasi *Spearman* kemudian digunakan untuk menganalisis data dan membangun korelasi potensial. **Hasil:** Kadar timbal dalam air sebesar 0,055 ppm sampai 0,089 ppm yang berarti melebihi batas maksimum kandungan timbal dalam air bersih. Sementara itu, kadar timbal dalam darah berkisar antara 1,5 ug/dL hingga 78,2 ug/dL, dengan 6,7% dalam kategori normal, 40% dalam kategori dapat ditoleransi, 30% dalam kategori kelebihan, dan 23,3% dalam kategori tinggi. Hasil statistik menunjukkan adanya hubungan yang signifikan antara kadar timbal dalam air sumur dengan darah, dengan nilai korelasi sebesar 37,9%. Nilai korelasi menunjukkan hubungan positif yang lemah. **Kesimpulan:** Ada hubungan antara kadar timbal dalam air sumur dengan darah wanita.

Kata kunci:
Air terkontaminasi, Timbal, Kadar timbal dalam darah, Kadar timbal dalam air, Wanita usia subur

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INTRODUCTION

There has been a steady increase in population growth in Cimahi City, and about 8% of the residents expressed concerns about water pollution. The city's inability to treat wastewater and industrial waste from factories leads to a decline in the quality of its groundwater and rivers. Four rivers in particular, Cisangkan, Cibabat, Cibaligo, and Cibereum Rivers, which flow through the city, are contaminated with industrial waste, contributing to a heavily polluted large river called Citarum River. The Leuwigajah industrial sector, situated in the Cibaligo watershed, has been particularly affected by the adverse impacts of industrial activities (Ministry of Environment and Forestry, 2020).

Heavy metals such as lead (Pb), cadmium (Cd), copper (Cu), chromium (Cr), arsenic (As), and zinc (Zn) can usually be found in industrial waste products (Mitra *et al*., 2022). The river near the Cimahi Industry II area has been indicated to be polluted by mercury, with an average mercury level of 1.894 ppb (Nursidika *et al*., 2019). Additionally, it has been revealed that the lead level in the Cibaligo River exceeds the allowed limits (>0.005 mg/L) (Anggraini and Wardhani, 2021). Community settlements near a polluted river can accidentally be exposed to heavy metal contamination through well water, which absorbs those harmful toxic components. According to research conducted by Nursidika *et al*. (2018), industry wastewater could penetrate the soil and contaminate nearby sewage in the Leuwigajah region, resulting in high lead concentrations of 0.0345 mg/L in the morning and 0.1132 mg/L in the afternoon.

Most of the residents living in Cimahi City obtain their water from wells, with only a small percentage of the population opting to consume water from the *Regional Drinking Water Company* (PDAM) (Ministry of Environment and Forestry, 2020). Daily consumption of well water that is lead-contaminated with a level exceeding 0.05 mg/L can harm women of childbearing age. The lead level in human's blood should be less than 10 µg/dL (CDC, 2021; Putra, 2020). Due to physiological differences, hormonal balance, metabolism, and physical variations in body size, women are more vulnerable to lead exposure than men, contributing to their increased susceptibility (Kumar, 2018). Furthermore, women's bones release lead into the bloodstream slower than men's, resulting in prolonged elevation of blood lead levels even after high exposure has ceased, reflecting the endogenous lead source (Vigeh *et al*., 2011).

Women with blood lead levels of 10 µg/dL may face potential complications such as premature birth, low birth weight, infertility, miscarriage, neurological defects in early childhood, and maternal hypertension. In women of childbearing age, lead levels in the range of 10 – 15 µg/dL can directly affect fetal development. Notably, lead exposure has been linked to infertility in both men and women, and even at low exposure levels, this heavy metal can have harmful effects (León *et al*., 2020).

Based on the information provided, it is indeed essential to conduct screening for lead levels in the women's blood of childbearing age who use water from wells that may be contaminated by polluted rivers in the Cimahi area. The purpose of this study would be to screen for lead levels in the blood of these women and investigate any potential relationship between lead levels in well water and lead levels in the women's blood residing in Leuwigajah who use wells as their water source. This research aims to assess the potential risks of lead exposure and its impact on the health of women of childbearing age in the area.

MATERIAL AND METHOD

Correlational research was conducted in this study to investigate the potential connection between two variables, lead levels in well water and lead levels in the women's blood residing in the Leuwigajah neighborhood of Cimahi City. The tools used in this study were disposable syringes, glassware, micropipettes, a microwave digester, *Atomic Absorption Spectrophotometer* (AAS), and a Vessel Tetra fluoroethylene modified (TFM). Furthermore, the materials used are well water samples, containers for water samples, blood samples, 30% H_2O_2, 65% HNO_3, $Pb(NO_3)_2$, HCl, and distilled water.

Sample collection and preparation

The experimental protocol was approved by the Research Ethics Committee of the Faculty of Science and Health Technology, Jenderal Achmad Yani University, Indonesia (No.05/KEPK/FITKES-UNJANI/VII/2022). In this study, the sample must meet specific criteria for inclusion and exclusion. Inclusion criteria are women of childbearing age (15 - 49 years) who consume well water for drinking and cooking and have resided in the Leuwigajah area for over five years. Exclusion criteria were women who smoked or were ill at the time of the research. The research began with taking samples (venous blood) from the respondents according to *Standard Operating Procedures* (SOP) for phlebotomy.

The blood sample was then digested by placing it in a TFM vessel and adding 8.0 mL of 65% HNO_3 and 2.0 mL of 30% H_2O_2. The digestion was carried out in a microwave digester for 15 minutes. The results of the destruction were followed by examination with an *Atomic Absorption Spectrophotometer* (AAS).

The well water samples used by women of childbearing age for daily consumption are collected in a container that meets the requirements. The containers used are made of glass or *polyethylene* plastic (PE), securely sealed, clean, free of contaminants, resistant to breakage, and inert. The container as used for taking drinking water samples was initially washed with a metal and phosphate-free detergent.

Data analysis

The process of determining lead levels commences with creating a standard containing concentrations of 100 ppm $Pb(NO_3)_2$ along with various concentrations of 0.05 ppb, 0.2 ppb, 0.4 ppb, 0.8 ppb, 1.6 ppb, and 3.2 ppb. These standards, along with blood samples obtained through destruction and well water samples, were analyzed using the AAS flame (FAAS) method. Put the digested blood sample into a sample cup, typically made of graphite, and place it into the instrument. The wavelength used for lead is 283.3 nm. The concentration of lead in the blood sample is determined using a calibration curve. The statistical data processing involved employing univariate tests and the Spearman correlation test using SPSS. These analyses examined the relationship between lead levels in well water and lead levels in the blood samples

RESULT

In this study, the examination of lead levels involved collecting five samples of well water, commonly used for drinking, eating, bathing, etc. by several families in Leuwigajah, Cimahi. Additionally, 30 blood samples were taken from women as respondents. Before the research began, informed consent sheets and questionnaire sheets were provided to the respondents to obtain their consent to participate in the study. Each well water sample represented six female blood samples. The sampling method used in this study was purposive sampling, which involved selecting samples that met the inclusion and exclusion criteria.

The analysis of lead levels in both well water and the women's blood in Leuwigajah, Cimahi City, was conducted using AAS. The final volume of the water sample was 5.004 mL, which is not considered a dilution, as the calculated volume of 5.000 mL of water resulted in 0.9992. The dilution value had no impact on the analysis of lead content in the water. Table 1 shows that, the Pb level in well water in Leuwigajah, Cimahi City, is 0.055 ppm to 0.089 ppm. It indicates high lead levels in well water, the minimum limit for lead levels in well water is 0.05 ppm (Minister of Health Regulation, 2017).

Table 1. Statistical test results for lead levels in well water and blood

	Variable	
	Lead in water (ppm)	**Lead in blood (ppm)**
Mean	0.075	0.060
Median	0.076	0.059
SD	0.011	0.030
Min – max	0.055 - 0.089	0.055 - 0.068
95% CI	0.071- 0.079	0.059 - 0.061

The lowest lead content in well water in the area is 0.055 ppm, already exceeding the lead level in clean water, especially since the lead level in well water is the highest in the area at 0.089 ppm. Lead levels in the women's blood in Leuwigajah, Cimahi City, in 2022 are from 1.5 ug/dL to 78.2 ug/dL. Table 1 shows that the Pb level in well water in Leuwigajah, Cimahi City, in 2022 ranged from 0.055 ppm to 0.089 ppm, indicating high lead levels in well water. As per the Minister of Health Regulation (2017), the minimum limit for lead levels in well water is 0.05 ppm. The lowest lead content in well water in the area is 0.055 ppm, which already exceeds the lead level in clean water. Moreover, the highest lead content in well water in the area is 0.089 ppm.

Regarding lead levels in the women's blood in Leuwigajah, Cimahi City, in 2022, the values range from 1.5 ug/dL to 78.2 ug/dL. This indicates that there are both normal and abnormal lead levels in the women's blood in that area. According to the CDC (2021), the minimum limit for lead in the blood is less than 10 ug/dL. Therefore, some women in the area have lead levels in their blood exceeding the recommended limit.

The normality test in this study used the *Shapiro-Wilk* method for fewer than 100 samples to determine whether the data obtained were normally distributed. Based on the results, the normality test indicated that the Asymp value is Sig 0.00 <0.05, indicating that the data on Pb levels in water and data on Pb levels in the blood are not normally distributed. As the data is not normally distributed, the *Spearman* correlation test (a non-parametric test) was conducted without needing to fulfill the classical normality assumption (Table 2).

Table 2. *Spearman* correlation result

Variable	**Correlation (r)**	***p-value***
The connection between lead levels in water and lead levels in the blood.	0.379	0.019

The *Spearman* correlation test was conducted to examine the relationship between lead levels in well water and lead levels in the women's blood in the Leuwigajah area of Cimahi City. The significance level (*p-value*) was found to be 0.019, which is less than the conventional threshold of 0.05. This implies that the relationship between lead levels in well water and lead levels in the women's blood is statistically significant. The correlation analysis revealed a correlation value (r) of 0.379 (37.9%), indicating a weak relationship between the two variables.

The positive correlation suggests that as lead levels in well water increase, lead levels in the women's blood also tend to increase. In other words, the observed correlation is unlikely due to chance, supporting the notion that lead levels in well water are associated with lead levels in the women's blood in the Leuwigajah area of Cimahi City.

DISCUSSION

The results of the study described that lead levels in well water in Leuwigajah, Cimahi City, ranged from 0.055 ppm to 0.089 ppm, indicating high lead levels in the well water that exceeded the minimum limit set by Minister of Health Regulation (Minister of Health Regulation, 2017). According to the guidelines, the lead level in clean water should not exceed 0.05 ppm. Observations of the well water locations in Leuwigajah, Cimahi City, showed their proximity to industrial factories, with some utilizing coal as part of their operations. These active industrial activities may have led to releasing heavy metal waste, including lead, into the environment (Cui *et al*., 2021; Saleh and Aglan, 2018). The combustion of hydrocarbons and coal can release Pb compounds into the air, subsequently contaminating water sources. Even the presence of as little as 0.008 µg/g of lead in coal can contribute to the presence of Pb in water bodies (Gallindo Borges *et al*., 2006). Recently, lead poisoning has been on the rise, partly due to an increase in lead manufacturing and the relocation of more polluting production methods to low and middle-income countries (Gottesfeld, 2022).

The Leuwigajah area, which served as the research location, is known for housing numerous textile industries. Therefore, the textile industry is recognized for contributing to heavy metal wastes, including lead (Fenta, 2014). This waste from the textile industry can accumulate in both water and plants (Ahmed *et al*., 2021; Collin *et al*., 2022). In Leuwigajah, lead content was found in the sewage to be 0.0345 mg/L in the morning and 0.1132 mg/L in the afternoon. Furthermore, rice grown in polluted areas contained 0.66 mg/kg of lead, according to the analysis conducted by Nursidika *et al*. (2018). This significant level of lead contamination in the rice is attributed to the infiltration of manufacturing wastewater into the soil.

The combination of heavy metal waste discharged by the textile industries and the infiltration of manufacturing wastewater has led to elevated lead levels in the water and soil of the Leuwigajah area. Such contamination poses potential risks to the environment and the local community's health. The observation results indicate that the distance between well water and industrial factories in the area is 1.5 km, with an average depth of 20 meters. This proximity increases the possibility of well water being polluted by factory waste. In a study by Tumanggor *et al*. (2013), lead pollution occurred in people's dug well water, with a lead content of 0.14 mg/L found in samples from 50 meters away from the industrial site. This highlights the potential risk of contamination when wells are located closer to the pollutant source. The recommended safe distance from a chemical disposal site for a clean water source is 25 km, with a depth of over 20 meters (Ryadi, 1984). The closer the distance of the dug well to the pollutant source, the greater the risk of contamination (Marendra and Tangahu, 2020).

Regarding the analysis of lead levels in the women's blood of childbearing age, the results obtained ranged from the lowest value of 1.5 ug/dL to 78.2 ug/dL. Among the respondents, 6.7% had blood lead levels below 10 ug/dL, which is considered normal. According to the CDC (2021), blood lead levels of 10 - 25 ug/dL can still be tolerated by the body, and 40% of respondents fell within this range. Some respondents had lead levels exceeding 40 ug/dL, but they did not show physical signs of heavy metal poisoning. However, they require testing every two months and must stop exposure to lead until their lead levels decrease. The body cannot tolerate lead levels exceeding 80 ug/dL, and people exposed to lead at a level of 5 g/dL need to be closely monitored. For adults, blood lead levels should be tested until they are less than 5 g/dL if the lead level falls between 5 and 9 g/dL.

The subjects in this study were women of childbearing age (15 - 49 years) with an average age of 41 years. Gender has been found to influence blood lead levels (Joo *et al*., 2018). Women are more susceptible to lead exposure than men due to physiological differences, hormonal balance, and metabolism (Kumar, 2018; Wani *et al*., 2015). There is a relationship between age and blood lead levels, as a person gets older, the concentration of lead that accumulates in body tissues increases since lead excretion takes approximately 25 days in the blood, 40 days in soft tissues, and 25 years in bone (Schaumberg *et al*., 2004; Wani *et al*., 2015). Additionally, there is a relationship between blood lead levels and the work length or exposure duration. Individuals who are frequently exposed to lead will have high lead levels in their blood due to lead absorption (Yu *et al*., 2023.).

The statistical test results obtained a correlation value of 0.379 (37.9%), indicating a weak relationship. Blood lead levels of women are affected by contaminated water by 37.9% and other factors by 62.1%. These factors include smoking habits, the use of personal protective equipment, gender, type of job, and length of work (Rodrigues *et al*., 2010; Zardast *et al*., 2020). Lead levels in traffic police were above normal, indicating a relationship between blood lead levels and air conditions in the environment (Sebastiampillai *et al*., 2015). Observations in Leuwigajah revealed that the highway area is dense with vehicles due to its proximity to the factory area.

The correlation value is positive, and the *p-value* is $0.036 < 0.05$, suggesting a significant positive relationship between the level of lead in water and the level of blood lead. This indicates that women of childbearing age (15 - 49 years) are vulnerable to lead exposure due to high lead levels from contaminated water sources.

Elevated blood lead levels in women can be dangerous, especially for the reproductive system. Lead poisoning in the reproductive system can lead to reduced female fertility, an increase in miscarriages and stillbirths, an increase in premature births, and changes in sex drive (Undaryati *et al*., 2020). Additionally, lead poisoning can cause anemia, bone disorders, diseases related to neurotransmitters, and mental health issues (Knollmann-Ritschel and Markowitz, 2017; Mason *et al*., 2014; Meyers *et al*., 2020; Reuben *et al*., 2019).

CONCLUSION

The results of the study can be concluded that there is a positive relationship between the lead levels in well water with the blood sample of women of childbearing age in the Leuwigajah Region, Cimahi City.

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