

ARTICLE INFORMATION

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## Analysis of lead (Pb) levels in community dug well water

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### Abstract

**Background:** Most lead concentrations in the environment come from human activities. Mining activities have negative impacts on the environment, one of which is exposure to heavy metals such as lead (Pb). The hazards of lead to the human body can cause disorders of the hemopoietic system such as anemia, central and peripheral nervous system disorders, kidney damage, gastrointestinal disorders such as colic and constipation, cardiovascular system disorders, and dysfunction of the adrenal and thyroid glands.

**Purpose:** To measure the concentration of lead metal (Pb) in dug well water.

**Method:** This study used a descriptive method. Samples of dug well water from 14 locations in the area around PT Gunung Bumi Perkasa, Sukabumi Regency were collected using the Simple Random Sampling technique. The samples were then analyzed to determine the level of lead contained using Atomic Absorption Spectrophotometry (AAS) at a wavelength of 217.0 nm.

**Results:** The measurement results showed that the lead levels in the water ranged from 0.0004 to 0.0189 mg/L. Based on these data, all samples still met the quality standards for lead (Pb) levels in clean water, as regulated in Permenkes No.32 of 2017 concerning Clean Water Quality Standards, which is 0.05 mg/L.

**Conclusion:** All 14 samples of dug well water, contained lead below the threshold value for clean water quality.

**Keywords:** Atomic Absorption Spectrophotometry (AAS); Lead; Well Water.

### INTRODUCTION

Water is inseparable from the fulfillment of daily needs, including household needs for bathing, drinking, industry, agriculture, transportation, and tourism (Atmaja, 2018). To meet their water needs, people usually use groundwater, surface water, or direct rainwater. Among these sources, groundwater is the most widely used by the community because it generally has better quality (Yoga, Astuti, & Sanjaya, 2020). Environmental pollution, particularly heavy metal contamination, has become an issue that is difficult to avoid. The main sources of heavy metals are mining, smelting, industry, agricultural fertilizers, and domestic waste (Lestari & Trihadiningrum, 2019). Mining activities, such as those carried out, play an important role in supplying raw materials for construction but also pose risks of groundwater contamination (Nubatonis, Sutaji, Warsito, & Tanesib, 2021). According to the Ministry of

Environment Regulation No. 4 of 2012, the minimum distance between mining pits and residential settlements is 500 meters to reduce the risk of public health problems, particularly exposure to heavy metals such as lead (Pb). Lead is naturally present in the environment, but its concentration is mainly influenced by human activities (Tchounwou, Yedjou, Patlolla, & Sutton, 2022). Excessive lead pollution has become a global problem, with groundwater contamination also arising from agriculture and domestic waste (Obasi & Akudinobi, 2020).

The decline in groundwater quality is marked by the presence of contaminants such as chromium (Cr), lead (Pb), and copper (Cu) from industrial activities, landfills, and household waste (Cobbina, Duwiejuah, Quansah, Obiri, & Bakobie, 2025). While heavy metals are essential in trace amounts, excess concentrations lead to toxicity and health risks

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(Alloway, 2022). That millions of people die each year due to water pollution-related diseases (World Health Organization, 2022). Lead exposure can damage multiple organs, especially the nervous system, and cause developmental disorders in children (Surucu, 2021). High levels of exposure ( $>80 \mu\text{g/dL}$ ) can result in encephalopathy, while moderate exposure can reduce IQ and cause hyperactivity (Harahap & Simatupang, 2021). Other risks include reproductive dysfunction and cancer (Saleh, Panahande, Yousefi, Asghari, Oliveri Conti, Talaei, & Mohammadi, 2019).

Several studies in Indonesia and abroad reported elevated Pb levels in groundwater. Pb content in Sukabumi exceeded maximum permissible limits. Showed that Pb levels in Surakarta well water also surpassed safety standards (Handes, Permatasari, & Mahardika, 2021). Similar findings were reported in international studies, confirming the urgent need for local monitoring and management of groundwater quality (Chowdhury, Naher, Likhon, Hassan, Fariha, Hasan, & Bhuiyan, 2025).

## RESEARCH METHOD

The materials used in this research include aquadest, Whatman filter paper, lead nitrate solution  $\text{Pb}(\text{NO}_3)_2$ , nitric acid solution, sodium hydroxide, and water samples from community dug wells in the PT Gunung Bumi Perkasa area, Sukabumi Regency. The instruments used in this research include Atomic Absorption Spectrophotometry (AAS) (Thermos type AAS M5), glass funnel (Pyrex 60 mm), Erlenmeyer

flask (Pyrex 100 mL), hot plate (Thermo), volumetric flask (Pyrex 100 mL), drop pipette (Onemed  $80 \times 100 \text{ mm}$ ), and measuring pipette (Iwaki). The dug well water samples were collected house-to-house using plastic bottles previously rinsed with aquadest and dried, then wrapped with black insulation tape, labeled, and placed in a cool box to avoid contamination from other microorganisms. Each dug well water sample was collected in a volume of 600 milliliters.

The preparation of standard solution and calibration curve was carried out through several stages. First, a solution was prepared by diluting 100 mg/L of lead nitrate. From this solution, several solutions with different concentrations were prepared, namely 0.05 mg/L, 0.10 mg/L, 0.15 mg/L, 0.20 mg/L, and 0.25 mg/L. Then, each solution was added with 0.5 mL of nitric acid solution until reaching the calibration mark in the volumetric flask. Finally, the absorbance of each solution was measured at a wavelength of 217.0 nm to obtain the necessary data. The determination of lead (Pb) levels in well water samples was carried out through several steps. First, 100 mL of the water sample was placed into an Erlenmeyer flask. Then, 5 mL of nitric acid solution was added and stirred until it was evenly mixed. After that, the solution was transferred into a volumetric flask using a glass funnel. Finally, the lead content was measured using Atomic Absorption Spectrophotometry (AAS) at a wavelength of 217.0 nm to obtain accurate results.

## RESEARCH RESULTS

**Table 1. Results of Standard Lead (Pb) Solution Absorbance Measurement**

| Concentration (mg/L) | Absorbance |
|----------------------|------------|
| 0.05                 | 0.0032     |
| 0.10                 | 0.0060     |
| 0.15                 | 0.0082     |
| 0.20                 | 0.0109     |
| 0.25                 | 0.0135     |

The determination of the maximum wavelength for the measurement of standard lead solution obtained a maximum wavelength of 217.0 nm, which provides maximum absorption for the measurement of heavy metal lead (Pb) levels in solution. Subsequently, absorbance values must be measured in a series of standard solutions to obtain the linear equation  $y = ax + b$  from the standard calibration curve between concentration and absorbance of the standard solution. Then it is plotted and the  $R^2$  value is obtained, which indicates the linearity value. This curve is used to calculate the lead content in dug well water samples.

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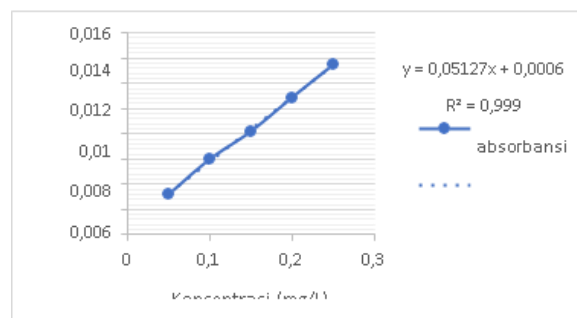


Figure 1. Calibration Curve of Standard Lead Solution

Based on Figure 1, the equation of the line from the standard curve is  $y = 0.05127x + 0.0006$ , where Y represents absorbance and X is concentration. With a correlation coefficient ( $R^2$ ) = 0.999. This  $R^2$  value indicates a strong relationship between the concentration of the standard solution and the absorbance value. This value is almost equal to the ideal value, so the resulting equation can be used to calculate and determine the concentration of heavy metal lead (Pb) in the tested samples. The data from the measurement of this standard solution is very important because it provides the basis for determining the lead concentration in the well water samples tested. By using the resulting linear regression equation, the lead concentration in the samples can be calculated accurately, thus allowing evaluation of whether the lead levels in well water meet the quality standards set by the Ministry of Health Regulation No.32 of 2017. Overall, the creation of this calibration curve is a crucial step in the analysis of heavy metal concentrations, and the results obtained show that atomic absorption spectrophotometry is an effective technique for detecting and measuring lead levels in water.

Table 2. Heavy Metal Lead (Pb) Levels in Well Water Samples

| Sample    | Lead Result (mg/L) | Quality Standard (Drinking Water) | Quality Standard (Clean Water) |
|-----------|--------------------|-----------------------------------|--------------------------------|
| Sample 1  | 0.0148             | $\leq 0.01$ mg/L                  | 0.05 mg/L                      |
| Sample 2  | 0.0157             | $\leq 0.01$ mg/L                  | 0.05 mg/L                      |
| Sample 3  | 0.0189             | $\leq 0.01$ mg/L                  | 0.05 mg/L                      |
| Sample 4  | 0.0084             | $\leq 0.01$ mg/L                  | 0.05 mg/L                      |
| Sample 5  | 0.0106             | $\leq 0.01$ mg/L                  | 0.05 mg/L                      |
| Sample 6  | -0.0010            | $\leq 0.01$ mg/L                  | 0.05 mg/L                      |
| Sample 7  | 0.0129             | $\leq 0.01$ mg/L                  | 0.05 mg/L                      |
| Sample 8  | 0.0125             | $\leq 0.01$ mg/L                  | 0.05 mg/L                      |
| Sample 9  | 0.0127             | $\leq 0.01$ mg/L                  | 0.05 mg/L                      |
| Sample 10 | -0.0024            | $\leq 0.01$ mg/L                  | 0.05 mg/L                      |
| Sample 11 | 0.0074             | $\leq 0.01$ mg/L                  | 0.05 mg/L                      |
| Sample 12 | 0.0064             | $\leq 0.01$ mg/L                  | 0.05 mg/L                      |
| Sample 13 | 0.0004             | $\leq 0.01$ mg/L                  | 0.05 mg/L                      |
| Sample 14 | 0.0035             | $\leq 0.01$ mg/L                  | 0.05 mg/L                      |

Based on Table 2, it is shown that the concentration of all samples still meets the quality standards for the requirements of heavy metal lead (Pb) concentration in the Ministry of Health Regulation No.32 of 2017 concerning Environmental Health Quality Standards and Water Health Requirements for

Hygiene Sanitation, Swimming Pools, Solus Per Aqua, and Public Baths, which is 0.05 mg/L. However, for the parameter of drinking water quality standards, it was found that samples 1, 2, 3, 5, 7, 8, and 9 did not meet the quality standard of  $\leq 0.01$  mg/L, so the well water from these households is not suitable for

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consumption as drinking water. Meanwhile, for samples 6 and 10, no lead content was found. The measured lead concentrations ranged from 0.0004 to 0.0189 mg/L. All samples met the quality standards for heavy metal lead concentration according to the Ministry of Health Regulation No.32 of 2017, namely  $\leq 0.05$  mg/L. However, the fact that 7 out of 14 samples did not meet the standards for drinking water indicates a potential health risk for the community consuming the water continuously.

Lead exposure can cause various health problems, including nervous system damage, anemia, and kidney dysfunction. Therefore, although some samples were still within safe limits for general use, it is important to carry out further monitoring and testing to ensure the safety of clean water for the community. Mitigation measures need to be taken to reduce the risk of future contamination, especially considering the impact of industrial pollution and the use of agricultural chemicals that can increase lead levels in well water. Overall, the results of this measurement emphasize the importance of monitoring well water quality in the area to protect public health and ensure that the water sources used are safe for consumption.

## DISCUSSION

The results of this study demonstrated that lead (Pb) concentrations in community dug well water around PT Gunung Bumi Perkasa varied between – 0.0024 mg/L and 0.0189 mg/L. When compared to the Indonesian Ministry of Health Regulation No. 32 of 2017, all samples were within the permissible limit for clean water quality ( $\leq 0.05$  mg/L). However, seven out of fourteen samples exceeded the drinking water quality standard of  $\leq 0.01$  mg/L. This indicates that while the water may still be suitable for hygiene and sanitation purposes, its direct consumption as drinking water poses a potential health risk (Handriyani, Habibah, & Dhyana Putri, 2020). Lead contamination in groundwater has been reported in multiple studies across Indonesia and globally, where industrial activities significantly contribute to the elevated levels of heavy metals (Ara & Usmani, 2025). PT Gunung Bumi Perkasa, being a mining-related industry, is a potential source of Pb contamination due to improper waste management and leaching of heavy metals into the surrounding soil and aquifer systems. Highlighted that communities living near mining areas are at a higher

risk of groundwater contamination (Simaremare, 2025).

The use of Atomic Absorption Spectrophotometry (AAS) at a wavelength of 217.0 nm ensured precise detection of Pb levels, with a calibration curve yielding a correlation coefficient ( $R^2$ ) of 0.999. This strong linearity indicates that the analytical method was reliable and valid for determining Pb concentrations in water samples. Such high linearity is crucial for quantitative analysis, as it confirms that absorbance values accurately reflect variations in Pb concentrations across the tested range. Thus, the methodology applied in this study aligns with international standards for heavy metal analysis (Skoog, West, Holler, & Crouch, 2016). From a toxicological perspective, lead is a persistent bioaccumulative toxin that can cause adverse health outcomes even at low concentrations. Chronic exposure to Pb through drinking water has been associated with neurological impairments, reduced cognitive development in children, renal dysfunction, and hematological disorders (World Health Organization, 2024). The detection of Pb concentrations exceeding 0.01 mg/L in several samples underscores a significant public health concern for the local community, particularly vulnerable populations such as infants and pregnant women (Frisbie, Mitchell, & Sarkar, 2025).

The results also highlight the importance of considering environmental risk assessment frameworks when evaluating groundwater quality. According to the theory of environmental exposure pathways, contaminants from industrial waste can migrate through soil layers into groundwater, influenced by factors such as soil composition, rainfall, and groundwater flow direction (Aminatun, Rakhmawati, Atun, Idrus, Simbolon, & Restele, 2024). In the case, the presence of Pb in several dug well samples suggests possible infiltration of industrial pollutants into the aquifer system, which is consistent with the hydrogeological vulnerability of shallow dug wells. When compared with other regional studies, Pb levels in Sukabumi Regency are relatively lower than those reported in mining-affected communities in West Kalimantan and South Sulawesi, where concentrations exceeded 0.05 mg/L. Nonetheless, the fact that more than 50% of the tested samples did not meet the drinking water standard remains alarming. This reinforces the idea

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that geographical differences, industrial scale, and environmental management practices strongly influence the degree of Pb contamination in groundwater (Adeyemi & Ojekunle, 2021). The discrepancy between clean water standards and drinking water standards must be emphasized. While water containing Pb concentrations of  $\leq 0.05$  mg/L may still be usable for household cleaning or agricultural irrigation, continuous ingestion of such water would accumulate Pb in the human body over time. This aligns with the bioaccumulation theory, which explains how heavy metals can persist in biological tissues due to their poor excretion rates (Ombugus, Ahulle, Adams, Shaibu, Yang, Nzeve, & Joël, 2021). Even low-level exposure should not be disregarded when assessing long-term health risks (Zamroni, Trisnaning, Prasetya, Sagala, & Putra, 2022). Community awareness and preventive strategies are critical in mitigating Pb exposure. Community-based interventions, such as periodic groundwater monitoring, installation of filtration systems (activated carbon or reverse osmosis), and education programs, can significantly reduce the risk of heavy metal exposure (Hadisoebroto, 2021). For the Sukabumi community, adopting such measures would be vital to ensure safe drinking water supply while awaiting larger-scale governmental or industrial remediation efforts (Nasir, 2020).

This study also emphasizes the regulatory aspect of water quality management. According to the precautionary principle in environmental health, immediate action should be taken once potential risks are identified, even if Pb levels are below the maximum threshold for clean water. International best practices, such as those recommended by the U.S. Environmental Protection Agency (EPA, 2018), advocate for a stricter Pb limit of 0.015 mg/L in drinking water, which further validates the necessity for Sukabumi to strengthen its local water safety regulations (Komarawidjaja, 2017). The analysis of Pb levels in dug well water reveals that while the majority of samples meet the standard for clean water, nearly half fail to meet the standard for drinking water. These findings highlight the urgent need for continuous monitoring, stricter enforcement of industrial waste management, and the implementation of community-level interventions to safeguard public health. The study contributes valuable baseline data for local policymakers and

supports the broader application of medical laboratory technology in environmental health surveillance (Adriani, 2020).

## CONCLUSION

These findings highlight the urgent need for continuous monitoring of groundwater quality in mining-affected areas, considering the potential health risks of chronic lead exposure such as neurological damage, anemia, and kidney dysfunction. Preventive measures, including periodic water testing, community education, and the provision of alternative safe drinking water sources, are essential to protect public health. Moreover, stricter environmental management and pollution control strategies should be enforced in industrial zones to minimize heavy metal contamination in groundwater resources

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