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Analysis of Cadmium (Cd) Heavy Metal Levels in Groundwater around Lapindo Mudflow, Sidoarjo Regency

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ABSTRACT

Background & Objective: Metal pollution in Lapindo mudflow is a cause of pollution because the mud contains various heavy metals, including cadmium (Cd). *Cadmium* is a heavy metal with high toxicity and is included in non-essential heavy metals. Hence, the presence of heavy metal cadmium (Cd) needs to be known for sure because too high levels can harm health and the surrounding environment. This study aims to determine cadmium (Cd) heavy metal levels in groundwater around Lapindo Mudflow, Sidoarjo Regency.
Method: The research conducted in this study employed a descriptive design methodology. To ensure accuracy and precision in selecting the participants, purposive sampling was utilized, with a dual examination process consisting of 4 distinct points. The end result was a sample size of 8 participants that were selected with great care.
Results: The findings indicated that after examining 8 samples, it was observed that all of the samples retained their compliance with the SNI standards. The results showed a 100% compliance rate.
Conclusion: Based on the results of the study, it can be inferred that the average concentration of 0.5075 × 10-4 mg/L falls within the acceptable range as per the Indonesian National Standard (SNI), which specifies the acceptable range of 0.5 - 10.0 mg/L or 0.0005 - 0.001 mg/L. Therefore, the study results are in compliance with the SNI's requirements.

Keywords: Pollution, lapindo mud, cadmium (Cd), groundwater.

Introduction

Groundwater is a natural resource that plays a vital role in life and can be renewed even though it takes a long time to form, ranging from tens to thousands of years. Humans use groundwater in various sectors, such as agriculture, industry, and tourism (Sejato & Saputra, 2022). If groundwater is damaged in quantity and quality, the recovery process also takes a long time and requires complex technology. It also does not guarantee that the quantity and quality can return to its original condition (Nugroho et al., 2019).
Based on health standards written in the Regulation of the Minister of Health of the Republic of Indonesia (PERMENKES RI) No. 429/MENKES/PER/IV/2010 concerning drinking water supervision procedures. Drinking water is water whose treatment

uses health requirements or without a treatment process. It can be drunk directly and used for daily purposes, which must meet physical, chemical, and biological requirements. In reality, available groundwater only sometimes meets health standards. Especially for people whose water source comes from well water close to the source of waste, the water will be more easily contaminated by contaminants or pollutants (Gufran & Mawardi, 2019; Sari, 2019).

One source of water pollution threat comes from the Lapindo mudflow; the leakage of natural gas drilling caused this event due to negligence committed by PT Lapindo Brantas, which has not been stopped until now. The mudflow caused land and building settlements to contain polluting substances such as phenol and heavy metals, including Hg, Cr, Cd, and Pb. Later, the mud was collected by the Sidoarjo Mud Management Agency (BPLS) (Irmayani et al., 2022; Permadnoni, 2018).

As the volume of sludge increases daily, the embankment cannot accommodate the sludge, so it must be discharged to the sea through the river. Sludge flowing into water bodies continuously can increase the concentration of heavy metals. Furthermore, the water flowing into the river will enter and move into the soil through the soil's gaps and rocks' pores. This factor causes groundwater around Lapindo Mud to be contaminated with heavy metals.

Heavy metals are dangerous pollutants because they are toxic if present in large quantities and affect various aspects, both biologically and ecologically (Azizah & Maslahat, 2021). Lapindo mud contains 25.67% silica, 1.17% sodium, 1.75% magnesium, 13.27% aluminum, 0.91% chlorine, 1.93% potassium, 1.54% calcium, 7.89% iron, 0.3% cadmium, 0.4% copper, and 0.73% lead (Putri et al., 2019).

Based on the results of the initial test of Lapindo Mud quality conducted by BAPEDAL of East Java Province, some metal contents were Zn (0.45 ppm), Ni (0.22 ppm), and Pb (0.23 ppm). The results of further research conducted by Kamarian in 2009 showed Lapindo mud contains several chemicals such as hydrocarbon gas, H2S gas, CO2 gas, and CO, as well as heavy metals such as Cr (14.377 ppm), Cd (0.0271 ppm), which have exceeded the threshold of Kep. Menkes. No. 907/2002 regarding the maximum level of heavy metals in water, Cd of 0.003 ppm (Armijn & Soegianto, 2020).

Cadmium, a heavy metal, is toxic to the body, even at low levels. The toxic effects of Cd are influenced by the length of exposure and the levels during exposure, so if exposed to high levels for a long time, the toxic effects are more significant. Cadmium is a dangerous type of heavy metal because it is non-degradable by living organisms. Organs such as kidneys and liver are the target of Cd poisoning. Cd content of as much as 200 μg (wet weight) in the kidney cortex causes kidney failure and leads to death. Other diseases, such as lumbago caused by Cd poisoning, also occur in Japan, and bone damage continues due to the softening and restatement of bones. In addition, Cd is also classified as a carcinogenic agent by the International Agency for Research on Cancer (ICRP) (Pulungan & Wahyuni, 2021).

Objective

The primary objective of this research was to investigate the possible existence of the heavy metal cadmium (Cd) in the groundwater surrounding the Lapindo mudflow located in Sidoarjo Regency. The presence of cadmium in the groundwater could have significant implications for the environment and public health, and therefore, it is essential to determine its prevalence in the area.

Method

This type of research uses descriptive research intending to analyze the levels of heavy metal cadmium (Cd) in groundwater around Lapindo Mudflow, Sidoarjo Regency, which the surrounding community uses for daily needs. The population in this study is groundwater from wells with a distance of 250 m to 750 m and a total of 4 points located around Lapindo Mud, Sidoarjo Regency.

The samples in this study were groundwater from wells with a distance of 250 m to 750 m located around Lapindo Mudflow, Sidoarjo Regency, at a total of 4 points, with a repetition of 2 times, so that the total number of samples was eight samples. The sampling technique used in this study was purposive sampling. The data obtained from the measurement results with the Atomic Absorption Spectrophotometer (AAS) in the form of sample solution levels and standard solutions converted in mg/L units to obtain cadmium (Cd) levels, then the data were analyzed descriptively and tabulated in tabular form.

The instrument in this study was a Thermo Scientific iCE3000 Atomic Absorption Spectrophotometer (AAS) with a wavelength of 288.8 nm.

The examination was conducted at the Balai Besar Laboratorium Kesehatan (BBLK) Surabaya. The location of groundwater research from wells was conducted near Lapindo Mudflow, Sidoarjo Regency. The research was conducted from December to June 2023, while the inspection was conducted in May 2023.

Results

The results of research analyzing the levels of heavy metal cadmium (Cd) in groundwater around Lapindo conducted at the Balai Besar Laboratorium Kesehatan (BBLK) Surabaya on May 21 - May 30, 2023, as many as 4 points with the examination carried out in duplicate so that the total sample is eight samples. The examination was carried out using an Atomic Absorption Spectrophotometer (AAS) with a wavelength of 288.8 nm; the following results were obtained:

TABLE 1. Results of Cadmium (Cd) Heavy Metal Examination in Groundwater Around Lapindo

No	Sample Kode	Result (mg/L)
1.	U1	$0,91 \times 10^{-4}$
2.	B1	$0,58 \times 10^{-4}$
3.	T1	$0,24 \times 10^{-4}$
4	S1	$0,23 \times 10^{-4}$
5.	U2	$1,15 \times 10^{-4}$
6.	B2	$0,53 \times 10^{-4}$
7.	T2	$0,21 \times 10^{-4}$
8	S2	$0,21 \times 10^{-4}$
Total		$4,06 \times 10^{-4}$
Range		$0,5075 \times 10^{-4}$

Discussion

There was an incident that included environmental pollution, namely the Lapindo mudflow. This event was caused by leaking natural gas drilling caused by negligence by PT Lapindo Brantas. The structure of Lapindo mud consists of 70% water and 30% solids (Hidayati et al., 2017). In addition, Lapindo mud contains chemicals such as phenol and heavy metals, including Hg, Cr, Cd, and Pb, among others (Irmayani et al., 2022)

One of the metal contents, cadmium (Cd), has high toxicity after mercury (Hg). Cadmium (Cd) is also included in non-essential heavy metals, where its presence in the body is still unknown, so the presence of cadmium metal needs to be known for sure in waters because too high levels are bad for health and the environment. Cadmium metal has a low boiling point and is easily concentrated when it enters the atmosphere. Water can be polluted by sediment and mining waste containing cadmium metal (Nurhaini, 2021).

The content of heavy metals in water is naturally low; the high and low content of heavy metals is caused by the amount of waste entering the waters; the more that enters, the greater the heavy metal content in the waters. In addition, the season also affects the heavy metal content, where the rainy season tends to be lower because it is diluted with rainwater—physical and chemical parameters influence cadmium (Cd) heavy metal levels in the water. High pH causes heavy metal compounds like oxides or hydroxides to settle to the bottom, while heavy metal compounds are dissolved if the pH is low. Temperature is a factor that affects heavy metal levels in the water, and high temperatures can increase the toxicity of heavy metals. Salinity also affects the cadmium content in the water because the higher the salinity, the lower the concentration of heavy metals in the water because high salinity causes an increase in the formation of chloride ions, which can reduce the concentration of heavy metals in the water (Wardani et al., 2018).

The mitigation of Lapindo mud tends to emphasize the physical and material aspects and does not consider the mitigation aspect of the mud. It is known that Lapindo mud contains various heavy metals that can interfere with the health of the body, so to reduce heavy metal levels, phytoremediation techniques are carried out by utilizing kale plants (Dwi et al., 2020). In addition, there are also bioremediation techniques using indigenous microbes such as *Pseudomonas pseudomallei* and *Bacillus niabensis* that can neutralize polluted soil and water into substances that are no longer harmful to the environment. (Agustina & Lisdiana, 2023). So, it has been known that the time needed to handle Lapindo mud using various techniques can reduce heavy metal levels, especially heavy metal cadmium (Cd).

Based on the explanation above, the results of the study of cadmium (Cd) heavy metal levels in groundwater around Lapindo with a total of 8 samples found that all samples still meet the requirements following the Indonesian National Standard (SNI), which is 0.5 - 10.0 μg/L or 0.0005 - 0.001 mg/L. This is influenced by the importance of measuring pH and temperature levels when taking water samples because, in general, the characteristics of each water type include pH, temperature, and salinity.

Conclusion

Based on the results of the research that has been done, it can be concluded that the levels of heavy metal cadmium (Cd) in groundwater around Lapindo, with an average of 0.5075 × 10-4 mg/L still meet the requirements following the Indonesian National Standard (SNI) which is 0.5 - 10.0 g/L or 0.0005 - 0.001 mg/L.

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Conflict of Interest

There were no conflicts of interest involved in the preparation of this research and article.

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