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Evaluation of mercury (Hg) control analysis in water bodies near traditional gold mines

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Abstract

Purpose: This study evaluates the mercury content in water bodies around artisanal gold mines. **Methods:** This study was conducted in water bodies in the Gledeg, Cimande, and Panaruban rivers, Paningkaban Village, Gumelar in Banyumas Regency as a sampling site for traditional gold mining wastewater by taking three sampling points at locations that are before, right, and after being polluted. Samples were then analyzed using the AAS (*Atomic Absorption Spectrophotometry*) method to measure mercury content. The data obtained were compared with applicable water and sediment quality standards, such as those set by WHO. Sample analysis was conducted at the Research Laboratory of Jenderal Soedirman University. The research time from the preliminary survey, sampling, lab test, and data analysis was conducted from May to August 2024. **Results:** The results showed that the mercury content in water bodies ranged from 0.05489 mg/L to 12.3544 mg/L, exceeding the threshold set by WHO (0.001 µg/L), PP No. 82/2001, and Kepmen LH No. 2/1988 (0.001 mg/L). **Conclusion:** This study found significant levels of mercury contamination, and further mitigation and regulatory actions are required to protect the environment and the health of local communities.

Keywords: heavy metal analysis; mercury (Hg) contamination; river water; traditional gold mining; water quality

INTRODUCTION

The demand for the precious metal gold tends to increase from year to year. The high demand and high price of gold have led some people or entrepreneurs to exploit areas suspected of containing gold legally or illegally, such as in Paningkaban Village, Gumelar District, Banyumas Regency. On the one hand, gold mining can increase the community's income, but it can have environmental and health impacts if not followed by proper waste treatment. Hg chemicals and cyanide are widely used in the amalgamation process, most of which are discharged into the environment, both soil and water, as tailings.

The amalgamation method with mercury is still the main choice because it is cheap and straightforward despite its adverse environmental impact. The uncontrolled use of mercury causes serious pollution of water and sediment, which in turn affects human health and the environment. This study focuses on mercury content in water bodies (rivers) to identify pollution because polluted rivers significantly impact environmental and public health risk factors.

Gold mining activities using mercury often impact ecosystems, especially aquatic ecosystems. This is because the waste from gold processing is generally discharged into water bodies [1]. Heavy metal mercury pollution in the Krueng Sabee River, Aceh Jaya Regency, is caused by the illegal disposal of mercury waste in the river around the gold mining site and has an impact on human health because mercury can accumulate in the body of aquatic biota whose waters are polluted with heavy metal mercury [2]. One of the negative impacts caused by PETI *(traditional gold mines)* is the occurrence of mercury pollution from the waste of the amalgamation process; in this process, mercury can be released into the environment at the washing and thinning stages [3].

METHODS

The research was conducted in Cimande River, Paningkaban Village, Gumelar Regency, Banyumas, as the sampling site of traditional gold mining wastewater, using three sampling points at the location before, right, and after pollution. Sampling was conducted in the morning, afternoon, and evening on 25 June 2024. Samples were then analyzed using the AAS method to measure mercury content. The data obtained were compared with applicable water quality standards to assess the level of mercury pollution. Sample analysis was conducted at the Research Laboratory of Universitas Jenderal Soedirman. The research time from the preliminary survey, sampling, lab test, and data analysis was conducted from May to August 2024.

The results of mercury metal analysis were analyzed using the SPSS program with the ANOVA test; after testing the normality and homogeneity of the data to qualify for this test, if it did not meet the requirements, the Kruskal Wallis test was carried out. The results were compared with the pollution quality standard.

RESULTS

Figure 1 shows the gold processing and sampling site selected to accurately observe the procedures and equipment for extracting and sampling gold. Figure 2 highlights the sample locations within Paningkaban Village, positioned explicitly at the border between RW 01 and RW 02, within RW 02 itself, and in RW 05. These locations were chosen to ensure a representative sampling across various village areas, facilitating a comprehensive analysis of gold processing impact in different residential zones.

Table 1 presents the Hg content in the studied river water. The results showed that mercury levels in water bodies ranged from 0.05489 mg/L to 12.3544 mg/L, exceeding the threshold set by WHO (0.001 μg/L), PP No. 82/2001, and Kepmen LH No. 2/1988 (0.001 mg/L). Laboratory test results for the Hg content of sample water from Cimande River as the research location obtained data in Table 1 as follows:

Table 1. Hg content in river water Gledeg, Cimande, Panaruban

No	Before Polluted (Gledeg)	Comparison with quality standards*	Polluted Area**	Comparison with quality standards*	After Polluted**	Comparison with quality standards*	Test method
1	1,443	1443	2,0126	2012,6	2,6076	2607,6	SNI 6989.78.2019
2	0,05489	54,89	2,6456	2645,6	12,3544	12354,4	SNI 6989.78.2019
3	0,8088	808,8	3,5316	3531,6	0,05489	54,89	SNI 6989.78.2019
Mean	0,76889	768,89	2,7299	2729,9	5,00563	5005,63	

Quality standards: 0.001 mg/l according to Government Regulation (PP) No. 82/2001; *Ministry of Environment Decree (Kepmen LH) No. 2/1988 (Class A and B); ** Cimande, which also flows from Gledeg

The mercury content in the water bodies of Gledeg and Cimande rivers exceeds the established quality standard. The average mercury content at the collection location before being polluted (Gledeg River) was 0.76889 mg/L (768.89 times greater than the quality standard), right after being polluted (Cimande River which also flows from Gledeg River) was 2.7299 mg/L (2729.9 times greater than the quality standard), and after being polluted (Cimande River which also flows from Panaruban River) was 5.00563 mg/L (5005.63 times greater than the quality standard), according to PP No. 82/2001 and Kepmen LH No. 2/1988.

Table 2 shows that the results were then tested for normality with SPSS and the results at the suspected location points before, just, and after being polluted. Mercury levels in water bodies and sediments are below the quality standards, 0.001 mg/kg for water bodies and 0.13 mg/kg for sediments. In contrast, mercury levels in biota samples have exceeded the quality standard value set by SNI, 0.03 mg/kg [3]. On average, each station's heavy metal mercury (Hg) contamination level has exceeded the maximum threshold of 0.001 mg/L. On average, heavy metal mercury (Hg) content in sediments at each station is higher than water, exceeding the maximum threshold of 0.2 mg/L [4].

Table 2. The laboratory test results

Test phase	Type of test	Test results	Interpretation
Normality Test	Normality Test (SPSS)	Significance values for three locations: - Before contamination: 0.0905 - Contaminated site: 0.817 - After contamination: 0.378	The data is normally distributed since all significance values are > 0.05.
Homogeneity Test	ANOVA Test	Significance value: 0.116	Since the significance value is > 0.05, the data is not homogeneous, so ANOVA cannot be used.
Kruskal-Wallis Test	Kruskal-Wallis Test	Asymp.Sig significance value: 0.211	Since the Asymp.The sig value is > 0.05. There is no significant difference between the three groups of locations (before contamination, at the contamination site, and after contamination).

Figure 1. Gold Processing and Sampling Site

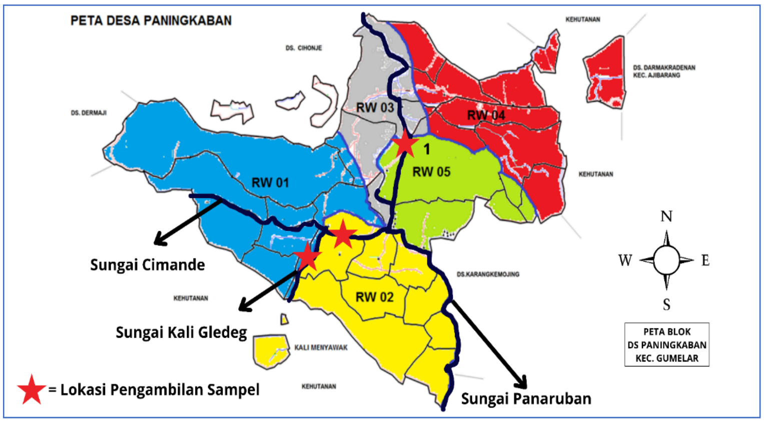

Figure 2. Village Map and Sampling Location

The research results showed that the concentration of heavy metal mercury in water in the estuaries of the Waelata River and Anahoni River was not detected at all research stations and was below the quality standard of seawater for marine biota based on the Decree of the Minister of Environment No. 51 of 2004 of 0.001 ppm. The concentration of heavy metal mercury in sediment has an average range of 0.134–0.874 ppm [5].

Long-term exposure to mercury triggers health problems in humans and is highly toxic [6]. In addition to contributing to mercury pollution, artisanal gold mining has other negative impacts on the environment (e.g., deforestation, soil degradation, erosion, river sedimentation) and communities [7].

The health impacts of mercury pollution on miners and children around small-scale gold mining are widely studied. The neurological impacts found were mainly on cranial nerves (17.1%), reflexes (5.1%), sensory (5.1%), cerebellum (3.89%), and motor nerves (1.2%). The neurological impact was characterized as follows: VIII cranial nerve abnormalities (6.87%), decreased distal vibration sensation (2.69%), palmomental reflex deficiency (2.4%), cranial nerve I (2.40%), visual acuity (2.10%), and Babinski (1.50%) [8].

DISCUSSION

Mercury levels in river water remain of particular concern in ongoing research. Continuously accumulated mercury will increase environmental pollution, adversely affect health, and be toxic to humans [9]. Locations that are former gold mining sites or gold mining sites that are no longer active can also affect mercury levels. This is based on the habit of artisanal gold miners who constantly move places because the gold mineral content in the previous location has decreased or is no longer considered profitable. Unlicensed gold mining activities are usually carried out by trial and error [10].

Heavy metal concentrations can be found in food [11]. The concentration of heavy metals in the environment will accumulate in aquatic biota. The maximum limit of contamination will affect public health [5]. Mercury contamination will significantly affect the environment and humans. Mercury pollution in Indonesian waters has become a problem due to its increasing amount [12]. Efforts to prevent the accumulation of Hg contamination are carried out by preventing the entry of heavy metals into aquatic biota [13]. Information on mercury pollution in water can cause the Minamata case and symptoms of decreased public health [14]. Mercury levels are strongly influenced by activities in the waters [15]. Mercury can be detected in water areas upstream, midstream, and downstream [16].

Gold mining in the Gumelar area has been ongoing for a long time, both by locals and migrants. The social impacts include the fact that when someone succeeds in mining, it will impact both socially and economically. However, if mining is unsuccessful, it can cause losses. This village's economic potential can still be explored from the tourism and livestock sectors, so if this potential is developed, it can anticipate suppressing mining activities. The village government and related agencies have conducted activities to increase knowledge and ways to prevent environmental damage and public health due to mining activities.

CONCLUSION

Hg concentrations in Gledeg and Cimande river water ranged from 0.05489 mg/L to 12.3544 mg/L, exceeding the threshold set by WHO (0.001 µg/L), PP No. 82/2001, and Kepmen LH No. 2/1988. Suggestions in this study include the need for stricter regulations and mitigation programs involving local communities as the key to reducing the negative impacts of mining activities that have the potential to pollute the environment and public health. Further research can be carried out to be more comprehensive in analyzing the differences in Hg contamination in areas before and after being polluted, as well as more clinical research to determine the impact of Hg heavy metal contamination on environmental and public health.

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