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Assessment of the Concentration of Mercury Metal in Sediment and Water Column, Taluduyunu River, Gorontalo Province, Indonesia

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Authors' contributions

This work was carried out in collaboration among all authors. Author Herlinda created the research design, conducted field sampling and data analysis. Author Hasim assisted with the methodology and supervised. Author SR assisted in data interpretation and preparing the draft. All authors read and approved the final manuscript.

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ABSTRACT

Mercury pollution can have a negative impact on the environment and the health of local communities. However, there is no scientific information related to the mercury content in the Taluduyuno River, which is the location of unlicensed mining activities. The purpose of this study is to analyze mercury levels in the sediment and water column of the Taluduyunu River. This information is critical in developing effective strategies to reduce mercury pollution. The sampling location was Taluduyunu River, Hulawa Village, Buntulia District, Pohuwato Regency. The number of stations was 12 from upstream to downstream. This research used a survey method, field

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measurement and laboratory analysis. The results showed that mercury content in sediment and water column was above the permitted standard with varying concentrations. The highest was at station 2 in the sediment (3.75 ppm), while in the water column (0.90 ppm). In general, the concentration pattern decreased towards the downstream stations, including the sediment and water columns. Moreover, the results also show that the mercury content in the sediment is higher than in the water column. The high mercury content in the Taluduyunu River has the potential to threaten the health of river ecosystems and humans. It is necessary to educate and socialize the dangers of mercury for ecosystems and humans by involving community leaders and law enforcement.

Keywords: Mercury pollution; sediment; water column; Taluduyunu.

1. INTRODUCTION

Mercury is a heavy metal known for its toxic effects on human health and the environment. Mercury is commonly found in various forms, including elemental, inorganic and organic compounds. The presence of Mercury in the environment is mainly caused by human activities such as industrial processes, coal combustion, and waste incineration. Mercury pollution in water bodies is a serious environmental problem. It poses serious risks to human health and aquatic ecosystems. The presence of mercury in water can be attributed to various sources such as industrial discharges, mining activities, and fossil fuel combustion (Wang et al., 2004).

Mercury once released into the environment will accumulate in the food chain through bioaccumulation and biomagnification. The implication can resulting in high mercury levels in fish and other aquatic organisms. This in turn poses a threat to human health when consumed (Pant et al*.,* 2024). Mercury pollution in water bodies not only poses a risk to human health but also has a detrimental impact on the ecosystem as a whole. High mercury content can cause reproductive problems, neurological damage, and even death in aquatic organisms.

According to (Balali-Mood et al*.,* 2021) mercury is the most dangerous of all heavy metals and has no active excretion mechanism in the human body. Mercury poisoning can have serious health effects, especially on the nervous system and kidneys. In addition, mercury pollution can disrupt ecosystem balance, leading to a decrease in biodiversity and overall ecosystem health (Cristiano et al., 2021).

According to Wahl et al*.* (2021), studies related to small-scale gold mining in several regions have been a significant source of mercury contamination in rivers. Disposal of mercury mining waste, especially from mercury mines, is also a concern. Due to high concentrations of mercury and sulfate, it can cause mercury methylation. While the other side reported by (Agustin et al*.,* 2024).

Pohuwato Regency in Gorontalo Province has several gold mining and processing sites carried out by the community, especially in Buntulia District, Paguat District, and West Popayato District. These activities often produce waste that is discharged without adequate treatment, potentially contaminating the river with metal mercury. This pollution can have a negative impact on the environment and the health of local communities. However, there is no scientific information regarding the mercury content in Taluduyuno River as the location of unlicensed mining activities.

The purpose of this study was to determine mercury levels in the sediment and water column of the Taluduyuno River. This information will be critical in developing effective strategies to reduce mercury pollution and protect the overall health of the river ecosystem.

2. MATERIALS AND METHODS

This research was conducted from September to November 2024 in Taluduyunu River, Hulawa Village, Buntulia District, Pohuwato Regency, using survey, observation, and laboratory methods. The tools used include sample bottles for water sampling, plastic bags for substrate and sediment sampling, thermometers for temperature measurement, cool box containers for temporary sample storage, aluminium foil to protect sample bottles, label paper for sample marking, tissue for cleaning tools, litmus paper for measuring pH, and global positioning system (GPS) to determine location. The materials used were water and substrate samples as research

objects. Water and sediment sampling refers to Mahmud et al. (2023). Water and sediment samples were then analyzed at the *Gorontalo Province Fisheries* Quality Development and Testing *Laboratory.* Sampling points were determined using the purposive sampling method, which focused on specific locations where there were traditional gold mining activities in the upstream, middle and downstream of as many as 12 stations. The coordinates of the sampling stations/locations are shown, and the sampling locations are presented on the map.

3. RESULTS AND DISCUSSION

The presence of mercury metal in river waters and sediments is due to anthropogenic and natural factors. One of the anthropogenic sources of mercury is the traditional mining activities carried out by the community. The following outlines the results and discussion covering the mercury content in the sediments and water column of the Taluduyunu River.

3.1 Mercury Content in Sediments

Based on the measurement of mercury in the sediment at the research location, the laboratory analysis results are presented in the Figure.

Based on Fig. 2, it shows that the mercury content in the sediment varies. The Figure also provides information that the heavy metal mercury content in the Taluduyunu River sediment is above the standard permissible. At station 1, the mercury concentration was 0.61 ppm or the lowest. Station 1 is located before massive traditional mining activities. Then, at station 2, the concentration of mercury metal is the highest at 3.75 ppm. The location of station 2 is the place of the most significant traditional mining activity along the Taluduyunu River, so the tailings are most abundant in this location. The concentration pattern towards the downstream, namely station 12, decreased significantly. This illustrates that mercury concentration in sediments is influenced by traditional mining activities carried out by the community. This is in line with the statement (Lechler et al., 2000) that one of the factors causing high mercury content in water bodies, including their sediments, is traditional mining.

3.2 Mercury Content in water

Based on mercury measurements in the water column at the research location, the results of laboratory analysis are presented in the Fig. 3.

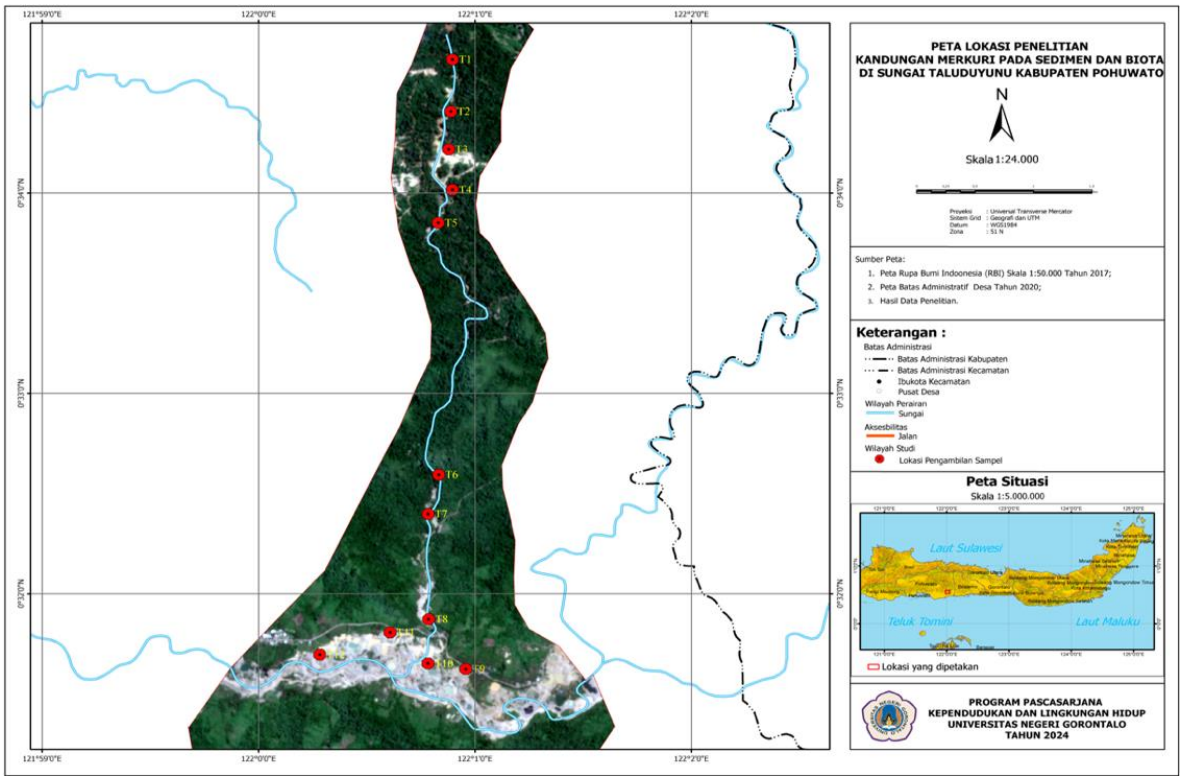

Fig. 1. Research location, red dots indicate sampling stations

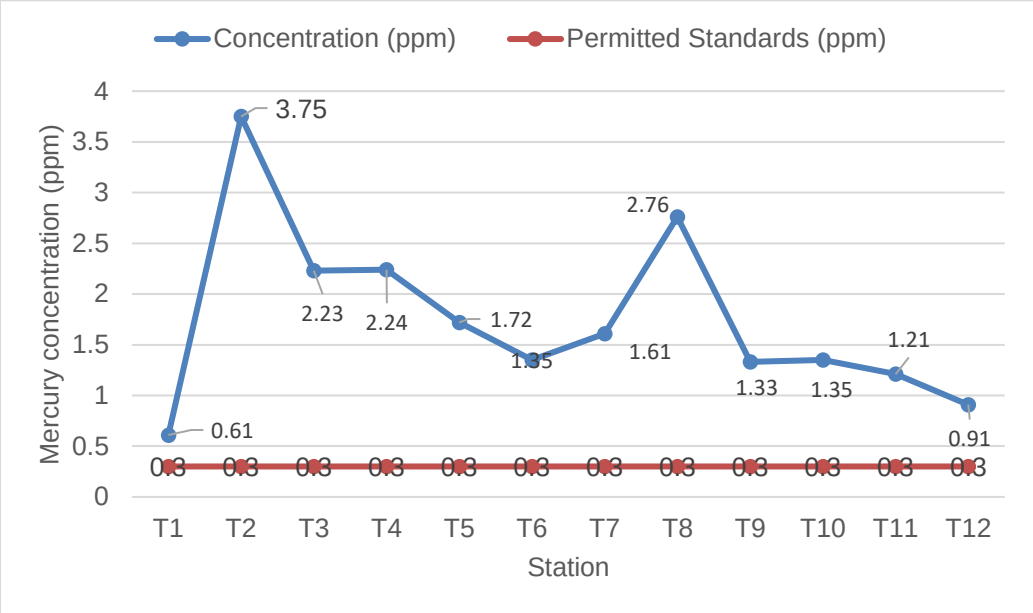

Fig. 2. Mercury concentration in sediments of Taluduyunu River
(Source: Laboratory Test Results, 2024)

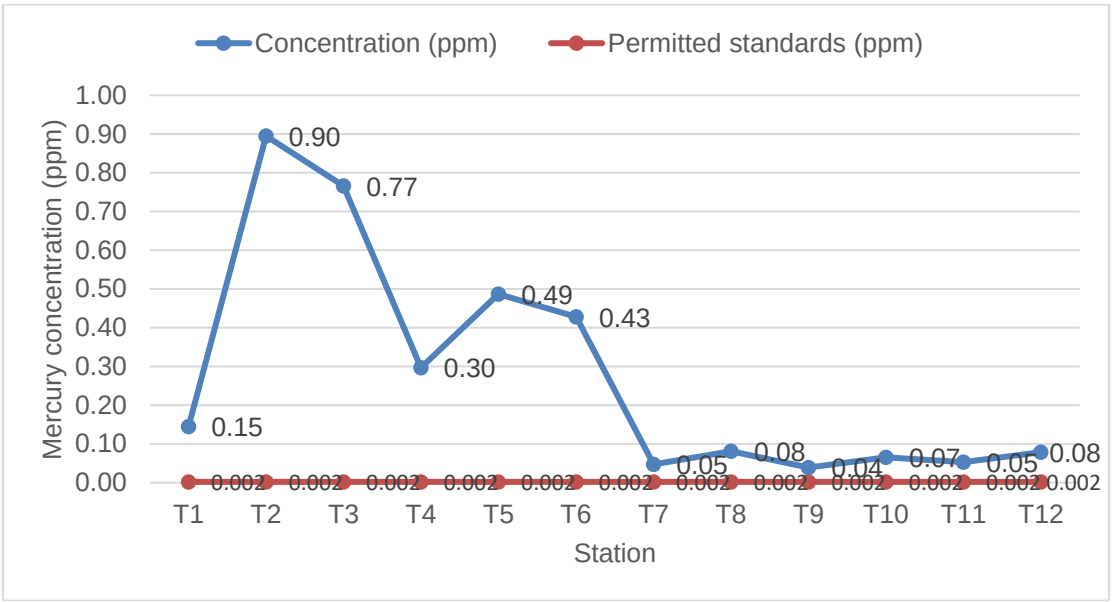

Fig. 3. Mercury concentration in Water of the Taluduyunu River
(Source: laboratory test results, 2024)

Based on Fig. 3 above, it shows that the mercury content in the water column varies. The Figure also provides information that the heavy metal mercury content in the Taluduyunu River water column is above the quality standard. At station 1, the mercury concentration is relatively low at 0.15 ppm. Station 1 was the point before massive mining activities were carried out, so the mercury content was relatively low. At station 2, the highest mercury concentration is 0.89 ppm. According to the interview, it was conveyed that at station 2, mining activities were carried out massively. Then, in general, the mercury concentration pattern decreases towards the downstream, namely station 12 at 0.08 ppm. According to (Ullrich et al., 2001; Whalin et al., 2007), the factors that cause mercury concentration to be easily lost in surface water are its high volatility and due to photochemical and bacterial aspects.

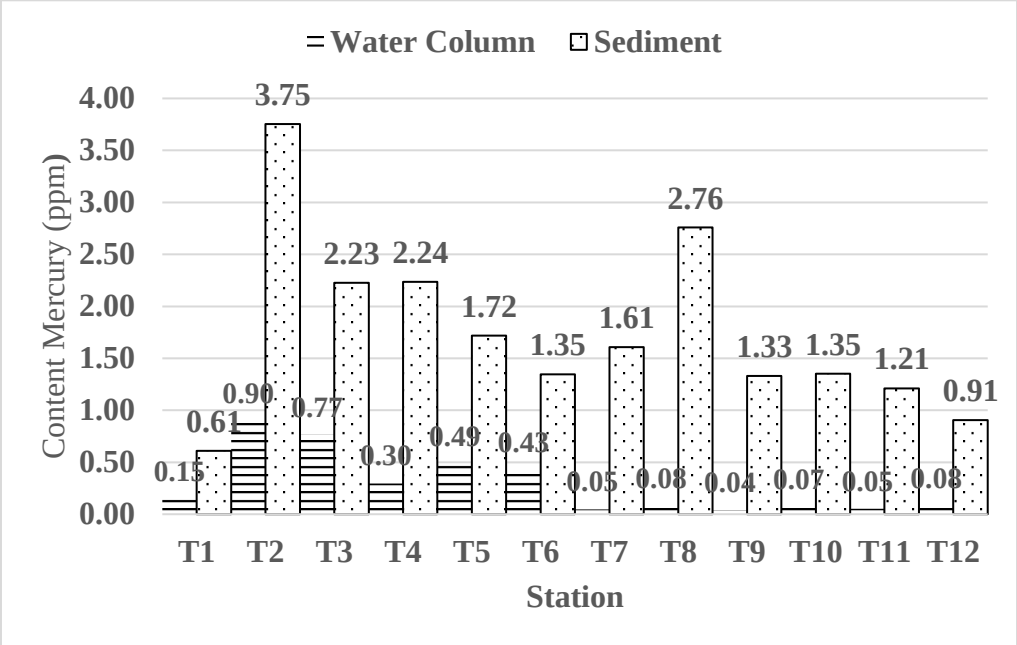

Fig. 4. Comparison of Mercury in Sediment and Water Column

Fig. 5. Traditional mining conditions on the Taluduyunu River

Based on the graph in Fig. 4, it shows that overall, the mercury content in the sediment is higher compared to the water column. According to (Ignatavičius et al., 2022), the high mercury content in sediments is due to the property of mercury to easily bind and the high organic matter content in sediments. (Ekawati et al., 2023) state that the deposition of heavy metals in water occurs due to the presence of hydroxyl and carbonate chloride anions. Heavy metals have the property of easily binding with organic materials and settling at the bottom of water bodies, thus merging with sediments, resulting in higher concentrations of heavy metals in the sediments than in the water. Based on research According to Insiani (2020) the amount of mercury used depends on the size of the drum or spindle used, but the average mercury use per drum or spindle ranges from 100 grams to 1 kilogram. The high use of mercury causes high levels of mercury to be discharged into river water bodies.

Traditional mining communities generally believe that their activities will not damage the river ecosystem, including having a negative impact

on humans. Donkor et al. (2024) highlighted that using metallic mercury in artisanal gold mining causes significant environmental pollution and adverse health effects, including transforming mercury into harmful organic compounds such as methyl-Hg, which impacts ecosystems and human health. Elwaled et al. (2024) stated that mercury contamination from artisanal gold mining poses significant health risks, especially to children, while also causing environmental problems. Tailings are identified as the primary source of mercury exposure, affecting local communities.This condition occurs because the average community engaged in traditional mining activities belongs to a group with relatively low educational levels. In addition, economic pressures drive them to make traditional mining their livelihood choice. Thus, a comprehensive approach to controlling mercury metal pollution in the Taluduyunu River includes: 1. Cultural approach through traditional leaders, religious leaders, and community leaders; 2. Social approach through non-formal education about the dangers of mercury for the survival of living beings, including humans; 3. Economic approach through life skills training to encourage the transformation of livelihoods to more sustainable practices; 4. Legal approach through effective law enforcement against activities that violate regulations.

4. CONCLUSION

The presence of mercury in the Taluduyunu river is mainly due to anthropogenic activities, especially artisanal gold mining. This activity has led to significant mercury contamination in both the water column and river sediments. The study found that mercury concentration was higher in the sediment compared to the water column. This is attributed to the nature of mercury, which binds with organic matter and settles to the bottom, thus accumulating in the sediment. Mercury concentrations varied at different stations along the river. The highest concentration was recorded at station 2, where mining activities were most intense, while the lowest was at station 12 downstream. Exposure to mercury has the potential to cause health impacts. A multidimensional approach, including cultural, social, economic, and legal, is recommended to control negative impacts.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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