THE ANALYSIS OF MERCURY (HG) POLLUTION IN WATER, SEDIMENTS, AND SHRIMP AT BENDUNG LAMBUNU RIVER DUE TO CONVENTIONAL GOLD MINING ACTIVITIES IN PARIGI MOUTONG

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Abstract

This study aims to investigate mercury (Hg) pollution in water, sediments, and shrimp at Bendung Lambunu River due to conventional gold mining activities in Parigi Moutong. The study was held for four months starting from October 2019-January 2020. The study used a laboratory-based analytic-observational method with an observation of mercury (Hg) levels in the water, sediments, and shrimp at Bendung Lambunu River using ASS (Atomic Absorption Spectrophotometer) and Mercury Analyzer. The study indicates that there is no mercury in the water sample. Contrastively, the laboratory study of sediments from Bendung Lambuni River identifies mercury. The highest mercury level on the first, second, and third day that is 0.04959 mg/Kg (lower reaches), 0.05998 mg/Kg (mid-river), and 0.06705 mg/Kg (lower reaches) respectively have been categorized as hazardous as the levels have exceeded the quality standard that is 0.01 mg/Kg. Besides, the study of shrimp from Bendung Lambuni River at Laboratorium Kesehatan identifies mercury. The highest mercury (Hg) level on the first, second, and third day is 0.000128 mg/Kg (upper reaches), 0.000173 mg/Kg (lower reaches), and 0.000113 mg/Kg (lower reaches).

Keywords: *Conventional Gold Mining, Lambunu River, Mercury Pollution*

INTRODUCTION

Indonesia has regulated mining businesses in its area through the national statutory provisions. Law Number 4 of 2009 on Mineral and Coal Mining is among the provisions. Article 1 Paragraph (1) defines mining as "part or whole phases of activities carried out within the frame of mineral and coal research, management and exploitation covering general inspection, exploration, feasibility study, construction, mining, processing and purification, transportation and sales, as well as post-mining activities." Furthermore, Article 1 Paragraph (6) describes mining business as "a mineral or coal exploitation business covering phases of activities in general inspection, exploration, feasibility study, construction, mining, processing and purification, transportation and sales as well as post-mining."

A mining system that does not apply good mining concepts contributes to disasters i.e. drought, landslides, flash floods, river flow damage, and damage to assets of public interests such as damaged and destroyed roads. That situation contradicts to the Law Number 32 of 2009 on Protection and Management of Environment Article 1 Paragraph (1).

> *"Environment shall be an integral space with all the things, resources, condition, and living creatures including humans and*

their behaviors that affect the nature and the continuity of livelihood and the welfare of human beings and other living creatures." Furthermore, Article 1 Paragraph (2) mentions, "Protection and Management of Environment shall be a systematic and integrated effort to preserve the environment and prevent pollution and/or damage to the environment, of which includes planning, utilization, control, maintenance, supervision, and enforcement of laws."

Bendung Lambunu River in Parigi Moutong is one of the areas where we can find damage to the environment and general social assets due to conventional gold mining activities. Bendung Lambunu River is one of the rivers in Parigi Moutong. The community living nearby uses the river as the means of fishery activities, irrigation, transportation, and tourist destination. However, natural gold potency at Bendung Lambunu River leads to an increase in mining activities along the river. The rise of conventional gold mining is considered one of the factors polluting Bendung Lambunu River. The gold miners reportedly used hazardous substances i.e. mercury and cyanide to separate gold from sedimentary deposits (mud, sand, and water). Gold processing waste is disposed of without prior processing, polluting the environment and endangering the health of the miners and the surrounding community.

Bendung Lambunu River is one of the rivers in Parigi Moutong. The river is highly functional in terms of either agriculture or fisheries. At the upper reaches of the river are jungle and plantations managed by the surrounding community. At the upper reaches of the river, mid-river, and the lower reaches of the river are the plantation areas owned by the surrounding community. Besides, the community also uses the river to irrigate their farms. Nevertheless, in the river is conventional gold mining formerly managed by an organization and currently by the surrounding community that is not aware of its environmental impacts. Among the impacts is mercury waste that greatly affects the environment and river ecosystem.

As a result of microorganism activities, mercury (Hg) in the waste at public waters turns into toxic methyl-mercury (Me-Hg) that has a strong binding power especially in the body of aquatic animals. It leads to the accumulation of mercury through a bioaccumulation process. Furthermore, the mercury level can reach a hazardous level that threatens the life and the health of aquatic animals and humans that consume the animals (Harizal, 2006).

The use of mercury will produce hazardous waste that causes Minamata diseases i.e. the symptoms of muscle breakdown, inability to walk, speech disorders, delirium, and other (Darmono, 2001). Mercury can contaminate the human body through polluted food consumption, such as consuming aquatic animals i.e. fish, shells, and shrimp that inhabit a polluted river. Highly concentrated Me-Hg, the mercury compound found in aquatic biota tissues, is the result of biomagnification through the interaction of trophic levels in the food chain. The amount of mercury

accumulated in the waters fauna depends on the geochemical cycle existing (Fahruddin, 2010).

The waste generated by mining activities can pollute the river waters, causing health problems to the community that uses the waters. Any heavy metal exceeding the quality standard will pollute the waters once it enters the waters. Besides, it will settle in sediments that have a residence time of up to thousands of years.

The waters environment of Bendung Lambunu River allegedly gets a considerable pressure by the presence and activities of unlicensed gold mining. There are more than seven groups of miners that use heavy equipment to mine gold along Bendung Lambunu River. The activities will impact the quality of the environment, especially the quality of river waters. Heavy metal levels at the waters should thus be constantly monitored. One of the monitoring activities is a study of mercury (Hg) levels in the waters, sediments, and biota inhabiting the waters. One of the biotas that indicate pollution at the estuary is shrimp. Shrimp is one of the frequently consumed aquatic animals due to its high nutrition comprising of minerals such as calcium, phosphor, iron, and vitamins.

RESEARCH METHODOLOGY

Research Location

The study is conducted at Bendung Lambunu River, Tirtanagaya, Bolano Lambunu, Parigi Moutong. Sample analysis is conducted at *Laboratorium Penelitian dan Pengujian Terpadu* Universitas Gadjah Mada and *Balai Besar Laboratorium Kesehatan* Makassar. The study survey and data analysis were conducted in October 2019-January 2020.

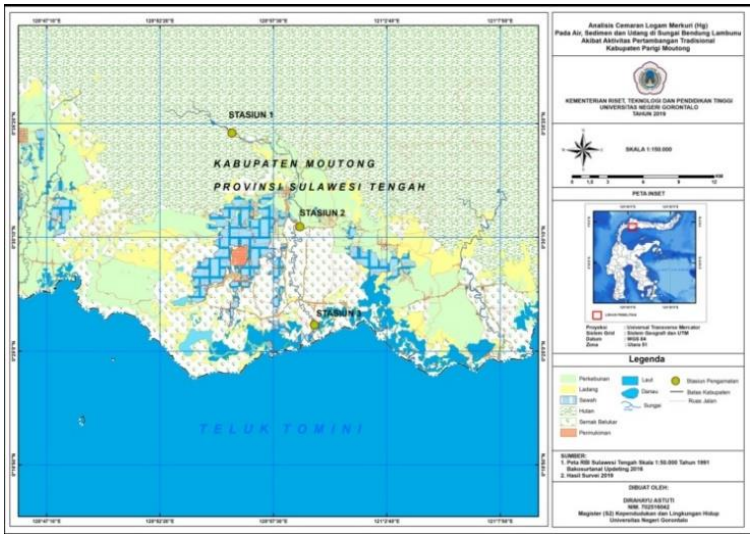

Figure 1. Map of Research Location

Research Method

The type of study is laboratory-based analytic observational with an investigation of mercury levels in shrimp, water, and sediments at Bendung Lambunu River using ASS (Atomic Absorption Spectrophotometer) and Mercury Analyzer. The study has three stages i.e. preparation, sampling, and laboratory analysis. The water sample is

directly collected at Bendung Lambunu River to observe the distribution of mercury (Hg) at the research location.

Research Procedures

Water sampling is conducted at three different locations with one water sampling at each and thus three water samples are acquired. The same treatment is conducted on sediment and shrimp sampling. As a result, we have nine samples comprising of three water samples, three sediment samples, and three shrimp samples. Sampling is repeated three times in one week, so the total number of samples is 27 consisting of nine water samples, nine sediment samples, and nine shrimp samples.

Data Analysis

The data analysis of mercury (Hg) levels at Bendung Lambunu River is indicated in the form of tables and charts. The result of the analysis of the concentration will be compared with the maximum Hg concentration in waters standardized by the Government Regulation No. 82/2001 Class II on Management of Water Quality and Control over Water Pollution. The quality standard of mercury (Hg) in water set by the Government Regulation No. 82/2001 is presented in Table 1.

Table 1. Quality Standard of Mercury (Hg) in Water

Metal	Symbol	Quality Standard
Mercury	Hg	0.001 mg/L

Source: Government Regulation No. 8/2001

The quality standard of mercury (Hg) in sediments stipulated in the Government Regulation No. 101/2014 is shown in Table 2.

Table 2. Quality Standard of Mercury (Hg) in Sediments

Metal	Symbol	Quality Standard
Mercury	Hg	0.01 mg/Kg

Source: Government Regulation No. 101/2014

The quality standard of mercury (Hg) in shrimp by SK Dirjen POM No. 03725/B/VII/89 and SNI 01-2729.1-2006 is indicated in Table 3.

Table 3. Quality Standard of Mercury (Hg) in Shrimp

Metal	Symbol	Quality Standard
Mercury	Hg	0.5 mg/Kg

Source: SK Dirjen POM No. 03725/B/VII/89 and SNI 01-2729.1-2006

FINDINGS AND DISCUSSION

Findings

1. Mercury Levels in Water

Mercury (Hg) testing at *Laboratorium Penelitan dan Pengujian Terpadu* in Universitas Gadjah Mada is presented in Table 4.

Table 4. Analysis of the Concentration of Mercury (Hg) in Water Sample I from Bendung Lambunu River

No.	Location	Unit	Result	Quality Standard	Description
1	A.S.1	mg/L	0	0.001 mg/L	Unpolluted
2	A.S.2	mg/L	0	0.001 mg/L	Unpolluted
3	A.S.3	mg/L	0	0.001 mg/L	Unpolluted

Source: Primary Data (2019)

Des: A.S.1: Water. Tuesday. 1 (Upper reaches)
A.S.2: Water. Tuesday. 2 (Mid-river)
A.S.3: Water. Tuesday. 3 (Lower reaches)

Table 4 shows that based on the laboratory testing to Sample I from the upper reaches, mid-river, and lower reaches of Bendung Lambunu River,

there is no evidence indicating mercury or low mercury level in the water. It is due to sediment deposits and changes in the form of the metal through metabolism activities in living organisms, allowing mercury (Hg) to enter the body of aquatic biota. The analysis of the concentration of mercury (Hg) in Water Sample II from Bendung Lambunu River is indicated in Table 5.

Table 5. Analysis of the Concentration of Mercury (Hg) in Water Sample II from Bendung Lambunu River

No.	Location	Unit	Result	Standard Quality	Description
1	A.R.1	mg/L	0	0,001 mg/L	Unpolluted
2	A.R.2	mg/L	0	0,001 mg/L	Unpolluted
3	A.R.3	mg/L	0	0,001 mg/L	Unpolluted

Source: Primary Data (2019)

Des: A.R.1: Water. Wednesday. 1 (Upper reaches)
A.R.2: Water. Wednesday. 2 (Mid-river)
A.R.3: Water. Wednesday. 3 (Down reaches)

As shown in Table 5, similar to the laboratory testing to Sample II from the upper reaches, mid-river, and lower reaches of Bendung Lambunu River on the first day, there is no evidence indicating mercury or low mercury level in the water. It is due to sediment deposits and changes in the form of the metal through metabolism activities in living organisms, allowing mercury (Hg) to enter the body of aquatic biota. The analysis of the concentration of mercury (Hg) in Water Sample III from Bendung Lambunu River is indicated in Table 6.

Table 6. Analysis of the Concentration of Mercury (Hg) in Water Sample III from Bendung Lambunu River

No.	Location	Unit	Result	Standard Quality	Description
1	A.J.1	mg/L	0	0,001 mg/L	Unpolluted
2	A.J.2	mg/L	0	0,001 mg/L	Unpolluted
3	A.J.3	mg/L	0	0,001 mg/L	Unpolluted

Source: Primary Data (2019)

Des: A.J.1: Water. Friday. 1 (Upper reaches)
A.J.2: Water. Friday. 2 (Mid-river)
A.J.3: Water. Friday. 3 (Lower reaches)

As shown in Table 6, similar to the laboratory testing to Sample II from the upper reaches, mid-river, and lower reaches of Bendung Lambunu River on the first and second days, there is no evidence indicating mercury or low mercury level in the water. It is due to sediment deposits and changes in the form of the metal through metabolism activities in living organisms, allowing mercury (Hg) to enter the body of aquatic biota.

The entire laboratory testing at *Laboratorium Penelitian dan Pengujian Terpadu* Universitas Gadjah Mada to the respective water sample on the first, second, and third days is indicated in Figure 2.

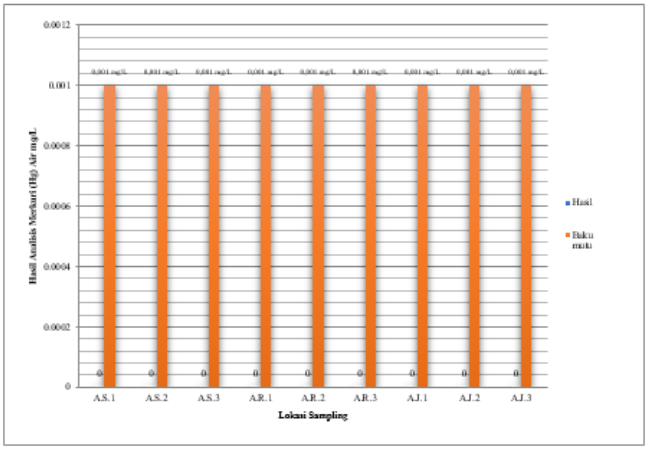

Figure 2. Analysis of the Concentration of Mercury (Hg) in the Water Samples from Bendung Lambunu River

Figure 2 shows that according to the laboratory analysis of water samples, there is no evidence indicating mercury or low mercury level in water due to sediment deposits and changes in the form of the metal through metabolism activities in living organisms, allowing mercury (Hg) to enter the body of aquatic biota. It links to an increase in the mercury level in shrimp and sediments at the research location.

2. Mercury (Hg) Levels in Sediments

The mercury (Hg) levels in sediments from Bendung Lambunu River are in the range of 0.01119-0.06705 (Table 7).

Table 7. Analysis of the Concentration of Mercury (Hg) in Sediment Sample I from Bendung Lambunu River

No.	Location	Unit	Result	Standard Quality	Description
1	S.S.1	mg/Kg	0.04044 mg/Kg	0.01 mg/Kg	Hazardous
2	S.S.2	mg/Kg	0.01119 mg/Kg	0.01 mg/Kg	Hazardous
3	S.S.3	mg/Kg	0.04959 mg/Kg	0.01 mg/Kg	Hazardous

Source: Primary Data (2019)

Des: S.S.1: Water. Monday. 1 (Upper reaches)
S.S.2: Water. Monday. 2 (Mid-river)
S.S.3: Water. Monday. 3 (Lower reaches)

Table 7 shows that based on the laboratory testing to Sample I from the upper reaches, mid-river, and lower reaches of Bendung Lambunu River, there is evidence indicating mercury in water. The mercury level in sediments from the upper reaches and lower reaches of Bendung Lambunu River is 0.04044 mg/Kg and 0.04959 mg/Kg respectively. These mercury levels are considered hazardous as they have exceeded the quality standard of 0.01 mg/Kg. Meanwhile, the mercury level in sediments from the mid-Bendung Lambunu River that is 0.01119 mg/Kg has not exceeded the quality standard. The analysis of the concentration of mercury (Hg) in Sediment Sample II from Bendung Lambunu River is presented in Table 8.

Tabel 8. Analysis of the Concentration of Mercury (Hg) in Sediment Sample II from Bendung Lambunu River

No.	Location	Unit	Result	Standard Quality	Description
1	S.R.1	mg/Kg	0.04594 mg/Kg	0.01 mg/Kg	Hazardous
2	S.R.2	mg/Kg	0.05998 mg/Kg	0.01 mg/Kg	Hazardous
3	S.R.3	mg/Kg	0.04361 mg/Kg	0.01 mg/Kg	Hazardous

Source: Primary Data (2019)

Des: S.R.1: Water. Wednesday. 1 (Upper reaches)
S.R.2: Water. Wednesday. 2 (Mid-river)
S.R.3: Water. Wednesday. 3 (Down reaches)

Table 8 shows that based on the laboratory testing to Sample II from the upper reaches, mid-river, and lower reaches of Bendung Lambunu River, there is evidence indicating mercury in water. The mercury level in sediments from the upper reaches and lower reaches of Bendung Lambunu River is 0.04594 mg/Kg and 0.04361 mg/Kg respectively. Meanwhile, the mercury level in sediments from the mid-Bendung Lambunu River is 0.05994 mg/Kg. These mercury levels are considered hazardous as they have exceeded the quality standard of 0.01 mg/Kg. The analysis of the concentration of mercury (Hg) in Sediment Sample III from Bendung Lambunu River is presented in Table 9.

Tabel 9. Analysis of the Concentration of Mercury (Hg) in Sediment Sample III from Bendung Lambunu River

No.	Location	Unit	Result	Standard Quality	Description
1	S.J.1	mg/Kg	0.02980 mg/Kg	0.01 mg/Kg	Hazardous
2	S.J.2	mg/Kg	0.01658 mg/Kg	0.01 mg/Kg	Hazardous
3	S.J.3	mg/Kg	0.06705 mg/Kg	0.01 mg/Kg	Hazardous

Source: Primary Data (2019)

Des: S.J.1: Water. Friday. 1 (Upper reaches)
S.J.2: Water. Friday. 2 (Mid-river)
S.J.3: Water. Friday. 3 (Lower reaches)

Table 9 shows that based on the laboratory testing to Sample III from the upper reaches, mid-river, and lower reaches of Bendung Lambunu River, there is evidence indicating mercury in water. The mercury level in sediments from the upper reaches and lower reaches of Bendung Lambunu River is 0.02980 mg/Kg and 0.06705 mg/Kg respectively. Meanwhile, the mercury level in sediments from the mid-Bendung Lambunu River is 0.01658 mg/Kg. These mercury levels are considered hazardous as they have exceeded the quality standard of 0.01 mg/Kg.

The entire laboratory testing at *Laboratorium Penelitian dan Pengujian Terpadu* Universitas Gadjah Mada to the respective sediment sample on the first, second, and third days is indicated in Figure 3.

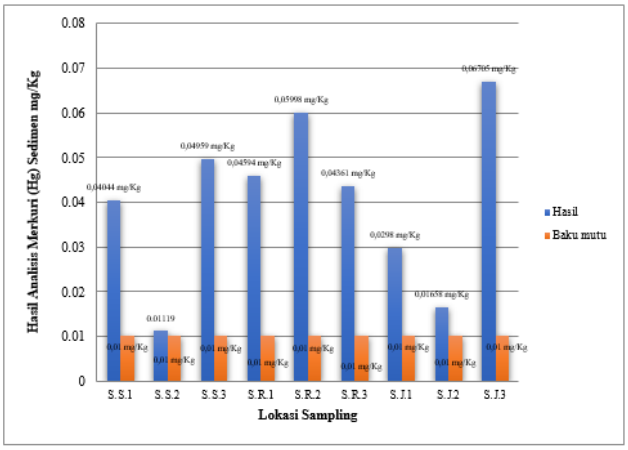

Figure 3. Analysis of the Concentration of Mercury (Hg) in the Sediment Samples from Bendung Lambunu River

Figure 3 shows that according to the laboratory analysis of sediment samples, there is evidence indicating mercury in Bendung Lambunu River. The highest mercury (Hg) level on the first and second day is in the lower reaches and in the mid-Bendung Lambunu River that is 0.04959 mg/Kg and 0.05998 mg/Kg respectively. Moreover, on the third day, the mercury (Hg) level is 0.06705 mg/Kg. These mercury levels are considered hazardous as they have exceeded the quality standard of 0.01 mg/Kg. The concentration of the pollutant has exceeded the quality standard and hence considered hazardous.

3. Mercury (Hg) Levels in Shrimp

The mercury (Hg) levels in shrimp will be presented in the form of charts. Figure 4 shows the mercury level in Shrimp Sample I identified using a Mercury Analyzer at *Balai Besar Laboratorium Kesehatan* Makassar.

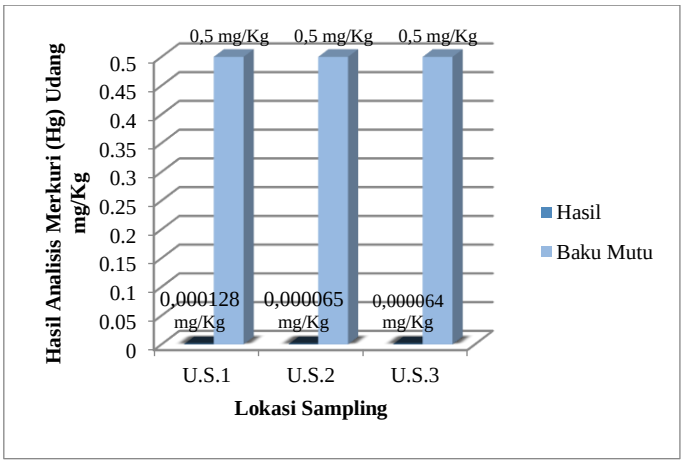

Figure 4. Mercury (Hg) in Shrimp Sample I

Des: U.S.1: Shrimp. Monday. 1 (Upper reaches)
U.S.2: Shrimp. Monday. 2 (Mid-river)
U.S.3: Shrimp. Monday. 3 (Lower reaches)

Figure 4 shows that based on the laboratory testing to Sample I from the upper reaches, mid-river, and lower reaches of Bendung Lambunu River, there is evidence indicating mercury in water. The mercury level in shrimp from

the upper reaches and lower reaches of Bendung Lambunu River is 0.000128 mg/Kg and 0.000064 mg/Kg respectively. Meanwhile, the mercury level in shrimp from the mid-Bendung Lambunu River is 0.000065 mg/Kg. These mercury levels exist due to changes in the form of the metal through metabolism activities in living organisms, allowing mercury (Hg) to enter the body of aquatic biota (shrimp). The analysis of mercury (Hg) in Shrimp Sample II is presented in Figure 5.

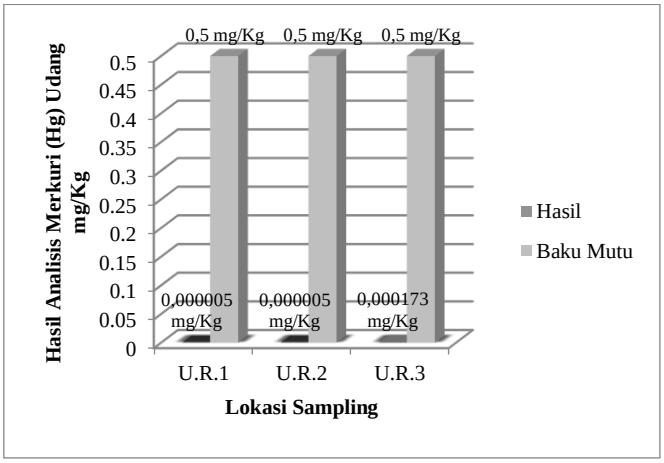

Figure 5. Mercury (Hg) in Shrimp Sample II

Des: U.R.1: Shrimp. Wednesday. 1 (Upper reaches)
U.R.2: Shrimp. Wednesday. 2 (Mid-river)
U.R.3: Shrimp. Wednesday. 3 (Lower reaches)

Figure 5 shows that based on the laboratory testing to Sample II from the upper reaches, mid-river, and lower reaches of Bendung Lambunu River, there is evidence indicating mercury in water. The mercury level in shrimp from the upper reaches and lower reaches of Bendung Lambunu River is <0.000005 mg/Kg and 0.000173 mg/Kg respectively. These mercury levels exist due to changes in the form of the metal through metabolism activities in living organisms, allowing mercury (Hg) to enter the body of aquatic biota (shrimp). The analysis of mercury (Hg) in Shrimp Sample III is presented in Figure 6.

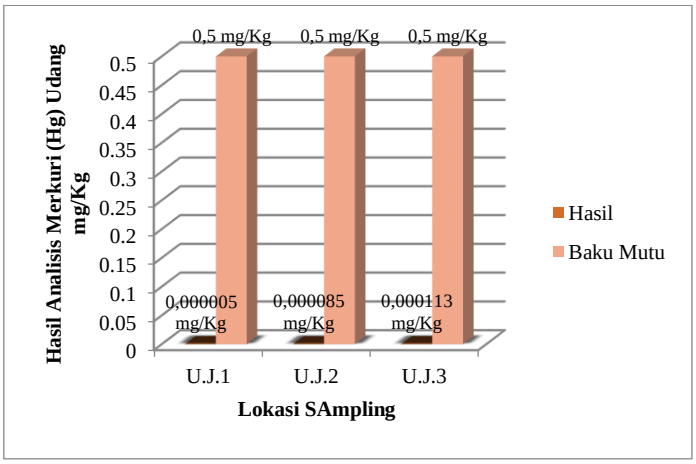

Figure 6. Mercury (Hg) in Shrimp Sample III

Des: U.J.1: Shrimp. Friday. 1 (Upper reaches)
U.J.2: Shrimp. Friday. 2 (Mid-river)
U.J.3: Shrimp. Friday. 3 (Lower reaches)

Figure 6 shows that based on the laboratory testing to Sample III from the upper reaches, mid-river, and lower reaches of Bendung Lambunu River, there is evidence indicating mercury in water. The mercury level in shrimp from the upper reaches and lower reaches of Bendung Lambunu River is 0.000005 mg/Kg and 0.000113 mg/Kg respectively. Meanwhile, the mercury level in shrimp from the mid-Bendung Lambunu River is 0.000085 mg/Kg. These mercury levels exist due to changes in the form of the metal through metabolism activities in living organisms, allowing mercury (Hg) to enter the body of aquatic biota (shrimp).

Discussion

1. Mercury (Hg) Levels in Water

Based on the laboratory testing to water samples at *Laboratorium Penelitian dan Pengujian Terpadu* Universitas Gadjah Mada, there is no evidence indicating mercury or low mercury level in the water. It is due to sediment deposits and changes in the form of the metal through metabolism activities in living organisms, allowing mercury (Hg) to enter the body of aquatic biota. It relates to an increase in mercury levels in sediments and shrimp. Heavy metal easily binds organic matters and settles to the bottom of waters and then mixes with sediments (Rolinsa, 2014). It is in line with Rochyatun (2006) that heavy metal levels in sediments are higher than that in water dye to accumulated deposits of the heavy metal and its smaller size in water due to the dilution process and the influence of current patterns.

The most significant parameter of water pollution indicated in this research is heavy metal levels because heavy metals are toxic and hazardous. It is in line with Nuraini (2015) that heavy metals cause health effects in humans. The toxic heavy metals contain will work as an enzyme barrier, breaking the metabolism process. In this research, we decide to analyze mercury (Hg) levels due to its high chemical and physical properties (the order of the toxicity of heavy metals in aquatic animals from the highest to the lowest is Hg (mercury), Cd (cadmium), Zn (Zinc), Pb (lead), and Ni (nickel) (Narasiang, 2015).

2. Mercury (Hg) Levels in Sediments

Based on the mercury (Hg) laboratory testing to sediment samples from Bendung Lambunu River at *Laboratorium Penelitian dan Pengujian Terpadu* Universitas Gadjah Mada, there is evidence indicating mercury (Hg) in the sediments. On the first day, the highest mercury (Hg) level 0.04959 mg/Kg is in the lower reaches. On the second day, the highest mercury (Hg) level 0.05998 mg/Kg is in the mid-river; while on the third day, the highest mercury (Hg) level 0. 06705 mg/Kg is from the upper reaches of Bendung Lambunu River. These mercury levels are considered hazardous as they have exceeded the quality standard of 0.01 mg/Kg. This study indicates that the sediment samples from all sampling stations have been polluted by mercury

(Hg). It is in line with our interview with the community at the mining location. They confirm that the mining location is close to the upper reaches of Bendung Lambunu River so that part of the river is evidently polluted by mercury (Hg) too. The concentration of the pollutant has exceeded the quality standard and hence considered hazardous. One of the hazardous heavy metals is mercury (Markus, 2009).

One of the pollutants, mercury enters the aquatic ecosystem through atmospheric decomposition or from externalized industrial wastes and is then biologically or chemically converted into methyl mercury (Suseno, 2007). Gold mining activities at Bendung Lambunu River with high use of mercury pollute the waters and poison aquatic animals. Heavy metals such as mercury entering sediments will affect the stability, changing carbonates to be hydroxide that forms particle binds in the waters and settles to form muds.

The mercury level in sediments indicates that the pollution level in the water body is extremely hazardous. That situation increases the concentration of pollutants in sediments. The heavy metal entering in waters will experience settlement, dilution, and dispersion and later will be absorbed by organisms living in the waters.

In this study, one of the samples is collected from the upper reaches and the mining location. Mercury identified in sediments collected at the upper reaches indicates that the upper location has also the same activities as that in the mining location.

3. Mercury (Hg) Levels in Shrimp

Based on the mercury (Hg) laboratory testing to shrimp samples from Bendung Lambunu River at *Laboratorium Penelitian dan Pengujian Terpadu* Universitas Gadjah Mada, there is evidence indicating mercury (Hg) in the shrimp. On the first day, the highest mercury (Hg) level in shrimp 0.000128 mg/Kg is in the upper reaches. On the second and third days, the highest mercury (Hg) level 0.000173 mg/Kg and 0.000113 mg/Kg respectively is in the lower reaches. It is due to changes in the form of the metal through metabolism activities in living organisms, allowing mercury (Hg) to enter the body of aquatic biota. When interviewed, the miner community operating in the location clarifies mining activities in the mining location close to the upper reaches have affected the aquatic animals live there. Shrimp that inhabits the area will be exposed to mercury (Hg) due to the dietary pattern and metabolism of the shrimp.

We identify two kinds of shrimp inhabiting Bendung Lambunu River that are *Macrobrachium rosenbergii* and *Macrobachium formosense*. Unfortunately, this study confirms mercury (Hg) levels in the two kinds of shrimp due to the dietary pattern of the biotas.

Based on the maximum heavy metal contamination determined by SK Dirjen POM No. 03725/B/SK/VII/89 and SNI 01-2729.1-2006, the shrimp has not been heavily polluted. Shrimp is animals with shells that can protect their bodies, blocking mercury to directly pollute and reducing the absorption of

mercury in shrimp. Besides, shrimp is one of the aquatic organisms that move quickly. Shrimp typically has the ability to avoid pollution. However, shrimp studied here is considered mildly contaminated as limited habitats such as rivers, lakes, and gulfs affect their self-protection from pollution (Murtini &Rachmawatie, 2007). Another factor that can affect heavy metal levels in shrimp in dietary behavior. Mercury will be accumulated in shrimp through metal absorption that enters in the digestive tract when shrimp is eating. Metal bioaccumulation in shrimp tissues through the food chain and heavy metal exploitation in waters or sediments leads to the concentration of mercury in shrimp (Novianto, 2012).

Methyl-mercury in shrimp is a serious health problem, especially in the development of the nervous system in fetuses and children. Among its neurological symptoms are mental retardation, seizures, vision and hearing loss, mute, and memory loss (Estecha *et al*., 2013).

Mercury (Hg) vapor is extremely hazardous due to its toxicity level. After inhaled, mercury (Hg) vapor will enter human blood and damage the brain tissues when reaching the brains. Furthermore, inorganic mercury compounds that dissolve in water and alcohol are toxic if coming with a large concentration. Inorganic mercury compounds i.e. dimethyl and methyl-mercury are inorganic mercury conversed using bacteria in waters through the food chain process. The compounds will enter the digestive tract and react to *thiosulfuhydrin* in protein, disturbing several enzymes, suspending necessary chemical reactions, and lastly, disturb the central nervous system (Rorong, 2002).

According to Midat (2013), one of the gold ore processing is an amalgamation in which mercury (Hg) is one of the processing materials. Mercury is a common supporting chemical material that binds gold grains as a result, gold can be easily separated from other particles. The method of gold mining and gold ore processing illegal miners use is conventional. Nevertheless, due to its conventionality, not to mention their unawareness and ignorance, the method damages the surrounding environment and pollutes the waters (Yulis, 2018).

Heavy metals are hazardous due to the bioaccumulation system, an increase in the concentration of a chemical element in a living creature's body. Heavy metals can trigger health problems in humans, depending on where the heavy metals are bound in the body. Heavy metal toxicity is an enzyme barrier, disturbing metabolism in the human body (Nuraini, 2015). Mercury in the form of metal will accumulate in kidneys and the nervous system (Edward, 2008). When mercury enters waters, it will bind with chlorine and together forms the HgCl bond. In that form, Hg will easily enter into plankton's body and be transferred to other aquatic biota's body. Humans can also be contaminated by mercury after consuming contaminated seafood such as fish, shells, and shrimp (Narasiang, 2015). Hg or mercury is categorized as the most hazardous among other the

most hazardous elements. Being exposed to a high concentration of those elements will lead to permanent brain damage as well as kidney damage (Stancheva, 2013). The operation of conventional gold mining uses mercury or Hg as the medium to bind gold. The waste that contains mercury will be disposed to waters. It is thus urgent to detect mercury levels in the river to give recommendations in terms of the use of mercury (Hg) that can harm the surrounding environment and humans to the miners.

CONCLUSION

Based on the laboratory testing to water samples from Bendung Lambunu River, there is no evidence indicating mercury or low mercury level in the water on the first, second, and third day. It is due to sediment deposits and changes in the form of the metal through metabolism activities in living organisms, allowing mercury (Hg) to enter the body of aquatic biota.

Based on the mercury (Hg) laboratory testing to sediment samples from Bendung Lambunu River at *Laboratorium Penelitian dan Pengujian Terpadu* Universitas Gadjah Mada, there is evidence indicating mercury (Hg) in the sediments. The highest mercury (Hg) level on the first, second, and third day is 0.04959 mg/Kg (lower reaches), 0.05998 mg/Kg (mid-river), and 0.06705 mg/Kg (upper reaches) respectively. These mercury levels are considered hazardous as they have exceeded the quality standard of 0.01 mg/Kg.

Based on the mercury (Hg) laboratory testing to shrimp samples from Bendung Lambunu River, there is evidence indicating mercury (Hg) in the shrimp. The highest mercury (Hg) level in shrimp on the first, second, and third day is 0.000128 mg/Kg (upper reaches), 0.000173 mg/Kg (lower reaches) and 0.000113 mg/Kg (lower reaches) respectively. We identify two kinds of shrimp inhabiting Bendung Lambunu River that are *Macrobrachium rosenbergii* and *Macrobachium formosense*.

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