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Determination of Mercury (Hg) and Lead (Pb) in Sedimen of Batanghari River in Dharmasraya Regency

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Abstract. Batanghari River is a river that crosses the Province of West Sumatra and Jambi Province, which flows through the Dharmasraya Regency area. Along this river, many illegal gold mines are found, which use mercury (Hg) as a gold-binding medium, and fuel oil containing lead (Pb) as fuel for machinery used in mining operations. This mining activity is the cause of the presence of Hg and Pb in the mining environment which is passed by the Batanghari river. The source of Pb is also from tailings, which is the remaining metal ore processing that does not meet the requirements to be taken at the time of mining. the presence of Hg and Pb metals in the aquatic environment will have an impact on the environment and interfere with the health of miners and the surrounding community, because Hg and Pb are heavy metals that are toxic. Research has been carried out on the Batanghari river sediments in January and April 2019 using the Atomic Absorption Spectrophotometer (FAAS) method to measure Pb and the Cold Vapor Atomic Absorption Spectrophotometer (CV AAS) method for Hg metal. The results showed that each metal Hg and Pb, in mg metal per Kg sediment, in the range of 0.08 mg/kg – 10.21 mg/kg, and 1.81 mg/kg – 23.10 mg/kg. Based on these data, it can be said that in January and April 2019 the metal content of Hg and Pb in the Batanghari river air was above the river water quality standard according to the Government Regulation of the Republic of Indonesia, namely 0.001-0.002 mg/L for Hg and 0.03 mg/L for Pb.

Keywords: *Mercury metal (Hg), lead metal (Pb), Batanghari river sediment.*

Abstrak. Sungai Batanghari adalah sungai yang melintasi Provinsi Sumatera Barat dan Provinsi Jambi, yang mengalir melalui wilayah Kabupaten Dharmasraya. Disepanjang sungai ini banyak ditemukan tambang emas tanpa izin, yang menggunakan logam merkuri (Hg) sebagai medium pengikat emas, dan bahan bakar minyak yang mengandung logam timbal (Pb) sebagai bahan bakar mesin-mesin yang digunakan terkait operasional pertambangan. Aktifitas pertambangan ini diduga merupakan penyebab keberadaan logam Hg dan Pb di lingkungan penambangan yang dilewati sungai Batanghari. Sumber logam Pb juga bersumber dari tailing, yaitu sisa proses pengolahan bijih logam yang tidak memenuhi syarat untuk diambil pada saat di tambang. Keberadaan logam Hg dan Pb di lingkungan perairan akan berdampak mencemari lingkungan dan menggangu kesehatan penambang dan masyarakat sekitarnya, karena logam Hg dan Pb merupakan logam berat yang bersifat beracun. Telah dilakukan penelitian pada sedimen sungai Batanghari dalam bulan Januari dan April tahun 2019 menggunakan metoda Spektrofotometer Serapan Atom Nyala (FAAS) untuk mengukur logam Pb dan metoda Spektrofotometer Serapan Atom Uap Dingin (CV AAS) untuk logam Hg. Hasil penelitian memperlihatkan bahwa masing-masing logam Hg dan Pb, dalam satuan mg logam per Kg sedimen, pada kisaran 0.08 mg/kg – 10.21 mg/kg, dan 1.81 mg/kg – 23.10 mg/kg. Berdasarkan data tersebut dapat disimpulkan bahwa pada bulan Januari dan April 2019 kandungan logam Hg dan Pb dalam air sungai Batanghari diatas baku mutu baku mutu air sungai sesuai dengan Peraturan Pemerintah Republik Indonesia yaitu 0.001-0.002 mg/L untuk Hg dan 0.03 mg/L untuk Pb.

Kata kunci: *Logam merkuri (Hg), logam timbal (Pb), sedimen sungai Batanghari*

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INTRODUCTION

Batanghari River runs through the Dharmasraya area and has many gold mining activities which are performed by the local community. Gold mining activities use mercury as a gold-binding medium to form a separate amalgam and gold from the impurities. Material that is considered by miners not to contain gold or that still contains mercury is thrown away in the river. Mercury (Hg) is a hazardous substance that is toxic and is the dominant waste from gold mining activities. Mercury (Hg) is a global pollutant due to its long-range transport from source regions to remote parts of the world (Delgado et al., 2004). Most Hg, from anthropogenic or natural sources, is exported to marine ecosystems (Kitong et al., 2012). Due to its affinity for particulate matter, Hg is readily scavenged from the water column and deposited to sediment, particularly in estuaries and coastal areas (Abass et al., 2018)

In addition to gold mining activities, there are industrial activities upstream from the rubber factory and palm oil factory. This industrial activity will produce waste whose removal flows into the river. Industrial activities and waste along the waters can have a bad impact on these waters (Suheryanto, H et al., 2013). Processing of gold ore, the use of gasoline and diesel in gold mining machines and disposal of industrial waste on the Batanghari river bank has been going on for years, so mercury and lead accumulates in sediments and floats downstream of the river along with water.

Research into the distribution of Hg and Pb heavy metals in the Batanghari river flow of the Bakauik Dharmasraya River, West Sumatra has been conducted by (Sahara & Puryanti, 2015) using atomic absorption spectrophotometry method that the heavy metal content in mercury is 5.198 mg/L and the heavy metal is Pb is 1.259 mg/L. Where the metal value exceeds the weight of Hg and Pb the threshold of the quality standard of the Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning Implementation of Environmental Protection and Management Regarding River Water Quality Standards (Pemerintah Republik Indonesia, 2021), whereby the permitted Hg content of heavy metals is (0.001-0.002 mg/L for Hg and 0.03 mg/L for Pb) (Molamohyeddin et al., 2017). Referring to the study, a study is conducted with determination of mercury (Hg) and lead metal content in the Batanghari river sediment in Dharmasraya Regency.

MATERIAL AND METHODS

Materials

Stock mercury solution (20 mg/L) was prepared by diluting a commercial mercury standard solution for AAS (1000 mg/L). Sodium tetrahydroborate solution (1%) was prepared by dissolving a tablet (0,3 g) of sodium tetrahydroborate for AAS in water before its use. Tin(II) chloride, pottasium permanganate, pottasium peroxide sulfate, sulfuric acid and nitric acid were of ultra pure analytical grade. All other chemicals were of analytical grade.

Instrumentation

The concentration of mercury was determined on a Cold Vapor Atomic Absorption Spectrofotometer (CV-AAS series GBC), AAS (varian tipe AA 420), polyethylene shovel, cooler box, filter paper Whatman no 42, hot plate (Haidolth type MR Hitechg), pH meter (Hanna HI 2211PH), glassware (Pyrex).

Procedure

Sampling site

The sampling method is done by deliberate sampling, the researcher tries to have the sample taken represent all layers of the population so that the sample has essential characteristics of the population so that it can be considered sufficiently representative (Sahara & Puryanti, 2015). Consists of 4 stations and 16 sampling points, each station being 16-20 km long, starting at the Batu Bakauik Nagari dam Kambut river Pulau Punjung District to the border of the Dharmasraya district, this area is dominated by rubber plantations, oil palm C and PETI - mining activities, use for community activities by the community and the rise of the MomongRiver (Fig. 1). Sediments taken are river surface sediments located on the riverside use a small shovel.

Figure 1. Location map of the sampling sites

Determination of mercury

The pretreatment of samples for mercury determination was done according to the Standard method. After transferring 20 mL of pretreated sample solution containing mercury (<1.0µg) into a reaction vessel, 1 mL of 10% tin(II) chloride solution was added and the mixture was shaken. A 100 µL solution 0f 1% $NaBH_4$ was added to the sample solution, followed by immediate air bubbling through the reaction vessel. The concentration of mercury was measured at 253.7 nm by CV-AAS

Determination of lead

Measurement of heavy metal content and Pb The instrument used is Atomic Absorption Spectroscopy (AAS). Where the sample was taken as much as 5 g. The sample was placed in a 100 ml glass beaker and a 20 ml HNO_3 (nitric acid) solution was added. Nitric acid is added to separate other minerals such as oil and sulfate, so that only heavy metals are read in the AAS device. The solution is heated on a hotplate until the sample volume is 5-8 mL. The solution is then placed in a 20 ml graduated flask, distilled water being added up to the limit of the graduated flask line. The sample is then transferred from the20 ml volumetric flask to a tightly closed plastic bottle and the bottles containing the sample are placed in the Atomic Absorption Spectroscopy (AAS) to read the desired content of Pb heavy metal.

RESULT AND DISCUSSION

River water sampling is done once in January 2019 and once in April 2019 Batanghari river water is classified as a strong or fast flowing river, with an average width of 50 m and a depth of 2 to 20 meters, when the water sampling itself differs from these two sampling times, namely in January, this is indicated as high drainage water with an average flow rate of 1.53 m/s, a cross section of 500 m^2, so that the water discharge (Q) of 768 m^3/s. The second sampling was carried out in April 2019, where the weather was already dominated by warm weather with an average flow of 1.37 m/s with a water discharge (Q) calculation of 685 m^3/s. According to (Sudarmaji et al., 2006) , when it rains, the amount of precipitation and water drainage can spread (thin) pollutants, so that this can influence the level of water pollution.

Determination of mercury metal

Determination of the heavy metal content in mercury in sediments was performed on 16 directly taken points. The samples taken must be analyzed immediately because mercury is volatile and easily disappears from the source. The mercury metal test was performed with AAS cold vapor and the data can be read in Table 1 at each station.

The value of the Hg concentration in sediments in the stream of the Batanghari River ranged from 0.69-1.28 mg Hg/kg of dry weight of sediment condition in January, where the highest value was found at station 2 in sample code 3A, while the Hg concentration in sediments in April varied from 0.07 - 4.18 mg Hg/kg of dry weight of sediment condition, the highest value obtained at station 1 in sample code 1B.

From the data obtained in April, when the volume of mining activity was high at stations 1C, 2C and 3B, the concentration of Hg at station 2C had the highest value of 10.21 mg/Kg compared to the others. Theoretically this can be explained as follows. Station 2C is located at a bend in the river, while stations 1C and 3B are located on a straight river (it can be seen at Figure 1), according to Mozaffari et al. (2011) the formation of sediment is influenced by river flow, where when the water speed slows down, there will be sediment deposition. A river with a gentle slope causes the water velocity to decrease so the sedimentation happened. Specific characteristics occur at a river bend, where the flow of water at the bend can cause scour on the outside of the bend, while the inside of the bend at the bend occurs continuously sedimentation (Ishak, 2015; Mozaffari et al., 2011). Thus it can be understood the high concentration of Hg at station 2C.

Table 1. Hg concentration values and the number of sources of river pollution in January and April 2019

Station	January		April		Factory
	Mercury (mg/kg)	Active gold mine	Mercury (mg/kg)	Active gold mine	
1A	1.01		1.34		
1B	1.08		4.18		1
1C	1.16	6	1.26	7	
1D	1.11		1.36		
2A	1.02	1	2.77		
2B	1.24		0.84	3	
2C	1.15		10.21	6	
2D	1.23		0.32		
3A	1.28		0.21		
3B	1.12	5	3.51	8	
3C	0.92		1.69		
3D	0.54		0.54	3	
4A	0.75		0.95	1	
4B	0.69		0.15	1	
4C	0.82	5	0.40		1
4D	0.83	1	0.08		

Unlicensed Gold Mining activity in the river influences the high Hg concentration in the river sediment. Hg in river sediments has increased from January to April. The number of active mines at each station is different because this gold mining activity itself is both non-permanent and situational, both in terms of location and time of operation. Lower rainfall in April compared to January has an impact on the Hg deposition process and increases the Hg concentration in the sediment. This is also consistent with research into the study of heavy metal contamination (Hg, Cd, and Pb) in the waters of Muara Kapuas, West Kalimantan in 2016 (Sahara & Puryanti, 2015). An increase and decrease in Hg value in the sediment will be presented in Figure 2.

The graph shows the value of the mercury concentration from the two sampling times, in general the Hg concentration increased in April compared to January, but in some samples the mercury levels decreased (Fig. 2), this is unique when testing natural samples, because natural samples were itself is taken directly without any control that can lead to uncertain changes in the measured value.

Nowadays, Indonesia still has no sediment quality guidelines, so to determine the status of sediment pollution, this is done by comparing it with international sediment quality guidelines that are applied in different countries. Based on these guidelines, the Hg concentration in the Batanghari River has exceeded the set maximum value. It is believed that unauthorized gold mining activities in the Dharmasraya Regency have an impact on the high Hg concentration at that time. Mercury that can be collected is mercury in the form of methylmercury, which can be collected by fish and is also toxic to humans (Lamborg et al., 2014; Mason et al., 2012). If the mercury level has exceeded the quality standard, this will certainly have a negative impact on the aquatic ecosystem and also on the surrounding community that uses the river.

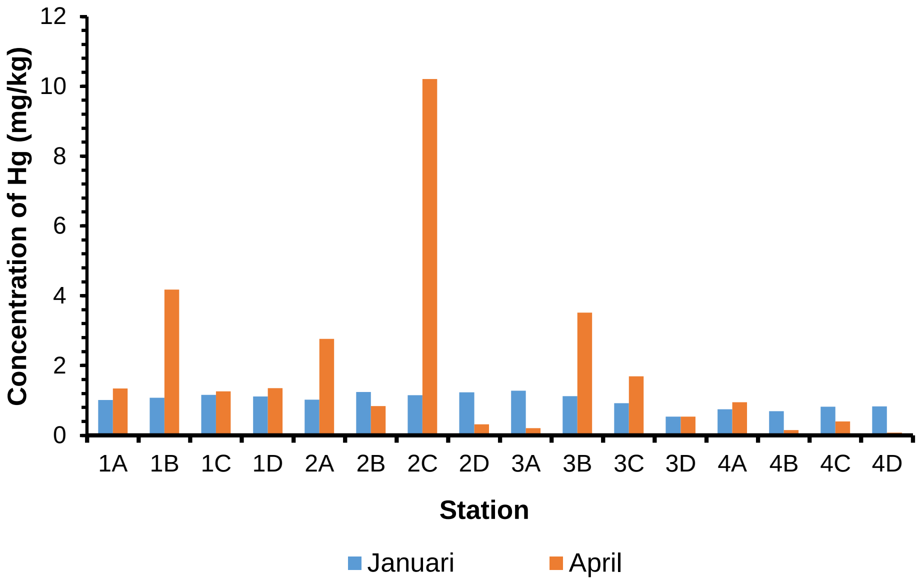

Figure. 2 Concentration of mercury in January and April

Determination of Lead Metal

Gold mining activities in rivers use motorized engines to power engines and ships that produce exhaust emissions due to poor combustion, and are also added due to insufficient maintenance or the use of poor quality petrol (such as premium and pertalite) (Anggraeny, 2019; Mason et al., 2012; Zhang et al., 2012). The results of research performed at the UNP FMIPA Research Laboratory and Kopertis Region X Padang Laboratory test parameters namely lead-heavy metal content (Pb) are shown in Table 2.

Table 2. Pb concentration values and the number of sources of river pollution in January and April 2019

Stasiun	January		April		Factory
	Lead (mg/kg)	Active gold mine	Lead (mg/kg)	Active gold mine	
1A	4.49		6.15		
1B	7.69		6.75		1
1C	5.47	6	4.95	7	
1D	4.61		8.60		
2A	1.81	1	23.10		
2B	5.34		7.85	3	
2C	13.25		11.2	6	
2D	3.91		12.35		
3A	7.95		7.10		
3B	16.43	5	11.05	8	
3C	7.70		8.30		
3D	4.15		8.35	3	
4A	8.85		9.95	1	
4B	11.25		8.45	1	
4C	9.55	5	4.75		1
4D	11.65	1	6.8		

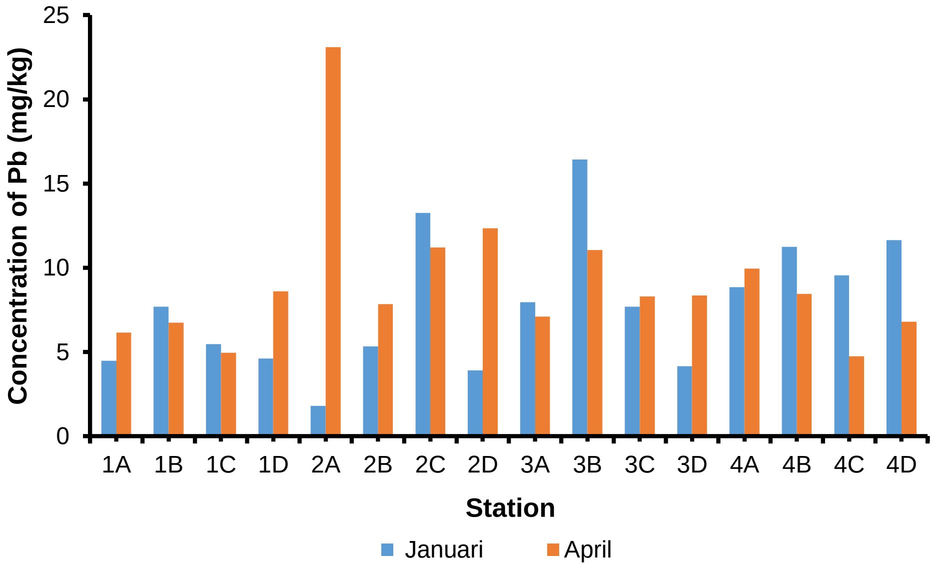

Figure 3. Concentration of lead in Januari and April

The value of the dissolved Pb concentration in the stream of the Batanghari River showed no significant difference between January and April. The value of the Pb concentration in sediments in the stream of the Batanghari River varied from 1.81 to 16.43 mg/kg dry weight in January, where the highest value at station 4 was in sample code 3B, while the Pb sediment concentration in April varied between 4.75 - 23.10 mg/kg dry weight, the highest value obtained at station 2 in the sample code 2A. Increases and reductions in Pb metal content are clearly seen in the graph that will be presented in Figure 3.

Table 2 shows that all sampling sites Pb detected heavy metals. The detected Pb metal, apart from gold mine waste indicated by the use of gasoline, and diesel, is also caused by a rubber factory that operates not far from the sampling station that also dumps its industrial waste products in the Batanghari River. PB that enters the human body can cause toxins in red blood cells, soft tissue (kidney and liver), bones and hard tissues (teeth and cartilage(Trujillo et al., 2013). Table 2 provides information that the results obtained do not exceed the quality standards established by the United States, Australia/ New Zealand and Hong Kong, which are 45.6 mg/kg, 50 mg/kg, and 70 mg/kg.

CONCLUSION

The heavy metal mercury (Hg) content in the Batanghari river water in Dharmasraya Regency in January and April is in the range of 0.08 mg/kg - 10.21 mg/kg, while the lead metal content (Pb) is about 1.81 mg/kg - 23.10 mg/kg. If the water quality of the Batnghari River can be said in terms of Hg and Pb content of heavy metals at any station in January and April 2019, the Hg content of heavy metals has exceeded the quality standards set by the United States, Australia / New Zealand and Hong Kong, which is equal to 0.15 mg/kg. While for Pb heavy metals the results obtained did not exceed the quality standards applied by the United States, Australia/ New Zealand and Hong Kong, namely equal to 46.7 mg/kg, 50 mg/kg, and 75 mg/kg.

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