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Identification and Correlation Test of Mercury Levels in Community Urine at Traditional Gold Processing Locations

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ABSTRACT

Gold processing activities in Paya Seumantok Village, Krueng Sabee District, Aceh Jaya Regency, are known to utilize traditional mercury, posing a health threat to the workers and the local community. This study aims to identify local people's urinary mercury levels near the gold processing plant in Paya Seumantok Village and to see the relationship between mercury levels and disease symptoms exhibited by the local people. To this end, ninety-one participants were recruited from a total member of a population of 928 people, determined using Slovin's formula. The urine sample was collected using a purposive sampling technique following the procedure set by the regulation of the Minister of Health no. 43/2013. AAS Instrument was used to analyze the urinary mercury level. Sixteen out of 91 urine samples exhibited no mercury, while the rest, 75 samples, were found to contain mercury. The average urinary mercury level among local people near the site was 8.392 µg/L (SD: 6.721 g/L), while the minimum and maximum urinary mercury levels in this study were 0.19 µg/L and. 28.31 µg/L, respectively. Thirty-six samples were found to have mercury levels exceeding the acceptable threshold (7 µg/L), while thirty-nine samples had urinary mercury levels below the threshold. This study concluded that there is no relationship between urinary mercury levels and symptoms of acute and chronic diseases experienced local community and workers at the gold processing site in Paya Seumantok Village, Krueng Sabee District, Aceh Jaya Regency ($p > 0.05$).

Keywords: urine; society; gold; mercury; mine

INTRODUCTION

Long-term mercury exposure is known to cause health problems, particularly in individuals living in a mercury-contaminated environment. Mercury poisoning in people near mining sites is usually chronic. Individuals living in mercury-polluted environments are seven times as likely to have hair mercury levels higher than the threshold compared to those who only stay for a short time in the area. Clinical symptoms of mercury poisoning typically appear in 5-10 years, depending on the exposure in that environment. Mercury exposure to the human body could be examined by measuring the mercury level in body tissues like hair, blood, urine, nail, and breast milk (Rice et al., 2014).

Biomarker measurement is helpful for assessing exposure to pollutants, and one of the biomarkers usually used to assess mercury exposure is a urine sample. Urine is an excellent biomarker to determine acute exposure to inorganic mercury (Yard et al., 2012). A study involving workers of artisanal and small-scale gold mining (ASGM) sites in Asia and Africa reported that workers in Kalimantan, Indonesia had the highest mercury level in their urine (urinary mercury of 5.24 μg/L, creatinine of 1.697 μg/g). Another study conducted by Yard et al. (2012) stated that there were differences in the concentration of mercury in the urine of workers who burned amalgam and those who did not burn amalgam (Yard et al., 2012). Workers whose duty is to burn amalgam exhibited higher urinary mercury levels than workers with other duties.

Mercury is used in the process of separating gold by artisanal and small-scale gold miners in Krueng Sabee (Suhendrayatna et al., 2013). The miners put mercury and gold ore into the glass to extract the gold through the amalgamation method. After the gold is isolated from its ore as an amalgam, the mercury is vaporized by burning it with a simple oil burner. Some of the mercury used in this process is released directly into the environment. Active Gold processing units are known to contribute to 173.58 g/m^3 of mercury emission, far higher than idle gold processing units (33.35 g/m^3) and inactive processing units (2.54 g/m^3). The concentration of mercury emissions in ambient air depends on the height of the sampling point from the ground level. The mercury content was found to be greater at the height of 30–50 cm compared to a height of 100-150 cm.

Rice et al. (2014) stated that mercury exists naturally in the environment and as a contaminant due to human activities (Rice et al., 2014). The release of mercury into the environment can cause a progressive increase in the amount of natural mercury, which can enter the distribution cycle of air, soil, and water, where mercury can remain in the environment for years. Mercury poisoning due to mercury exposure could result in various toxic effects, depending on the chemical form and route of exposure. The main routes of human exposure to Methylmercury (MeHg) are mostly through eating contaminated fish, seafood, and wildlife exposed to mercury through consuming low-grade contaminated organisms. MeHg toxicity is associated with damage to the nervous system in adults and impaired neurological development in infants and children. As ingested mercury may bioaccumulate, it potentially causes a progressive increase in body burden.

The Minamata Disease in Japan is a well-known disease caused by mercury waste. Sakamoto et al. (2017) found that Methylmercury was the causative agent of Minamata disease, where mercury can easily penetrate the brain (Sakamoto et al., 2017). They also report that adult patients exhibited neurological symptoms, and fetuses were exposed to methylmercury through the placenta from the mother who consumed fish from methylmercury-contaminated waters. People exposed to Methylmercury usually reported headaches, pain when sitting and walking, and impaired mental development – symptoms similar to cerebral palsy.

Da Silva-Junior et al. (2018) examined the symptoms of illness caused by exposure to mercury among people around the Amazon river and found that vision problems had the highest prevalence (43.3%) among health problems and symptoms of Hg poisoning, followed by complaints/symptoms of memory loss (42.9%), weakness (35.1%), fatigue (34.3%), mood swings (28.7%) and difficulty in concentration (27.2%) (Silva-Junior et al., 2018).

Suhendrayatna et al. (2014) reported that gold mining operations affect workers' health, as nearly half of workers reported experiencing fatigue (41.7%), headaches (39.6%), and numb mouth (39.6%), which are symptoms of acute toxicity. Furthermore, workers reported four symptoms indicating chronic toxicity, namely muscle cramps (43.8%); headache (41.7%); Irritability (39.6%); and easily sad (33.3%) (Suhendrayatna et al., 2014).

It is well-known that about 80% of mercury vapor enters the body through inhalation, and only a small amount of elemental mercury (Hgo) enters the human body through the skin and oral contact. When the amalgam is heated, anyone around the burning site can be exposed to mercury vapor from the burning. Several studies in Indonesia have examined the decline in river quality and potential health risks related to mining activities. Subanri (2008) states that there is a significant relationship between the distance from mining to the levels of mercury contained at the mining site, the farther the distance, the lower the Hg level in the water (Subanri, 2008). In addition, Rianto (2010) stated that even though the mercury level in miners' blood exceeds the permitted limit, no visible symptoms or health problems are experienced by these mining workers. However, the presence of mercury in the worker's blood indicates that mercury compounds have entered the body and will undergo biotransformation, turn into metabolites, and some will enter target organs such as nerves, kidneys, and other target organs (Rianto et al., 2012).

Our preliminary survey found that the gold processing activities carried out in Paya Seumantok Village were still traditional and used an amalgamation technique with mercury to process the ore until it turned into sand powder and then it is mixed with mercury and squeezed using a cloth so that some of the mercury and water come out of the pores of the cloth. After that, the ore was heated and burned, and then pounded. From the environmental perspective, every stage of these gold processing activities is a potential source of pollution. At the milling stage, elemental mercury can be released from the ball mill so that it falls, contaminates the surrounding soil, and pollutes rivers. During the washing and extortion stages, liquid waste containing mercury from the results of these activities can be spilled around the gold processing area and contaminate the soil. Furthermore, during the burning stage, the mercury vapor produced from this activity can pollute the air and settle on the ground.

METHODS

Sampling method

Ninety-one participants were involved from a total member of population of 928 people, determined using Slovin's formula. The urine sample was collected using a purposive sampling technique following the procedure set by the regulation of the Minister of Health no. 43/2013.

For female participants

The following explanation was presented to the participants prior to the collection of urine samples:
- participants should wash their hands with soap and then dry them with a towel;
- take off underwear, spread the labia with one hand;
- clean the labia and vulva using sterile gauze from front to back;
- rinse with warm water and dry with another sterile gauze;
- during this process, excrete urine, and the first stream of urine is discarded. the urine stream is then stored in a container that has been provided;
- avoid urine hitting the rim of the container;
- urine collection is complete before the urine stream is exhausted; and
- the container is tightly closed and immediately sent to the laboratory.

Male participants

- participants must wash their hands with soap;
- if not circumcised, pull the foreskin back, and expel the urine, the first stream to come out is discarded, and then following stream of urine is collected in the container provided; avoid urine hitting the rim of the container; urine collection is complete before the urine stream is exhausted;
- the container is tightly closed and immediately sent to the laboratory.

Infants and children

- children or infants were previously given a drink to facilitate urination;
- clean the genitals as described above;
- urine sample was collected by:
  - the child sitting on the nurse's lap;
  - sterile plastic container or bag;
  - the baby has a urine collection bag attached to the genitals.

The sample bottles were stored into the box where the urine sample is stored not to contaminate other metals.

Sample storage

Prior to the measurement using Atomic Absorption Spectrophotometer or Mercury Analyzer, the urine samples were stored according to the standard set by the Indonesian National Standard (SNI) as follows:
- containers: plastic bottles (polyethylene) or glass bottles that have been rinsed with HNO_3 1:1;
- preservative: acidify with HNO_3 to pH 2;
- storage time: 14 days (using plastic bottle) or 30 days (using glass bottle);
- storage conditions: 4 ± 2 °C.

Ethical approval

Protocols in this research had obtained an ethical approval through letter no. 2559/IV/SP/2021 (date 10 April 2021) from the Faculty of Nursing, North Sumatera University, Medan, Indonesia. Urine sample and the disease symptom in this study was selected using a standard method following the ethic committee approval.

Mercury measurement in urine calibration curve creation

The calibration curve was made using blank, and mercury solutions in several concentrations; namely, 0 (blank) 4 ppb, 8 ppb, and 12 ppb. If the linearity of the calibration curve (r) was less than 0.995, the step was repeated until the r-value of was greater than or equal to 0.995.

Urine sample measurement

The collected urine samples were measured for mercury level. The sample was tested following SNI 6989.78-2011 regarding mercury (Hg) test method using Atomic Absorption Spectrophotometry (AAS)-steam-cold.

Statistical analysis

A correlation analysis was carried out to determine the relationship between urinary mercury level and symptoms of disease experienced by the local community and workers using the Chi Square method with the SPSS 20. This correlation test aimed to determine the relationship between urinary mercury level and symptoms of disease among local community near the gold processing site in Paya Seumantok Village, District Krueng Sabee, Aceh Jaya Regency.

Calibration

The calibration curve was created using a blank solution and a solution of mercury in various concentrations. The calibration curve is shown in Figure 1.

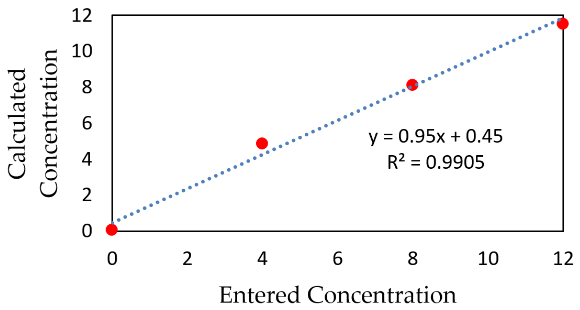

Figure 1. Calibration curve

RESULTS

Research site overview

This research was conducted in the village of Paya Seumantok, Krueng Sebee district, Aceh Jaya district; Paya Seumantok village is one of the villages in which local communities rely on gold mining activities to make a livelihood. The gold mining activities in this village have existed for decades.

Fifty-one participants (56.6%) in this study were female, while thirty-nine were male (43.3%). In terms of age group, most participants were between 17–25 years of age (28%). The second largest age group in this study was 36–45 years of age (20%), followed by 56–64 years of age (13%), 45–55 years of age (12%), 26–35 years of age (8%), and over 64 years of age (7%). Most participants were students (n = 28), followed by farmers (n = 24), and only two worked as civil servants (Table 1).

Table 1. Participants' characteristics

No.	Criteria		Total
1	Gender	Male	39
		Female	51
2	Age	12 - 16 years old	11
		17 - 25 years old	25
		26 - 35 years old	7
		36 - 45 years old	18
		46 - 55 years old	11
		56 - 64 years old	12
		> 64 year old	6
3	Occupation	Farmer	24
		Merchant	10
		Student	28
		Housewife	19
		Miner	4
		Entrepreneur	3
		Civil servant	2
4	Education	Elementary school	29
		Junior high school	25
		Senior high school	30
		Undergraduate	6
5	Residence period	5 - 11 years	2
		12 - 16 years	17
		17 - 25 years	25
		26 - 35 years	8
		36 - 45 years	12
		46 - 55 years	9
		56 - 64 years	12
		> 64 years	5
6	Home distance	30 - 100 M	27
		> 100 - 200 M	15
		> 200 - 300 M	10
		> 300 - 400 M	23
		> 400 - 500	15

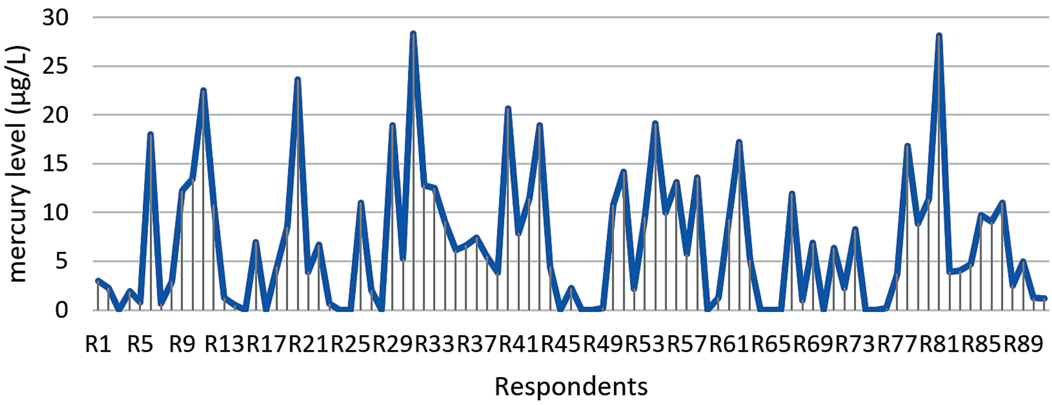

Figure 2. Urinary mercury levels (n = 91)

Table 2. The number of detected and undetected mercury in urine samples

Mercury Level	Number of respondents	%
Not detected	16	17.58
Detected	75	82.42

Most participants had a low educational background, where 29 participants had an elementary educational background, 25 participants had junior high school education, and 30 participants had senior high school education. Only six participants had higher education backgrounds. All participants were native people born and raised in Paya Seumantok Village, Krueng Sabee District, Aceh Jaya Regency. Most of them have lived in the village for 17–25 years. Twenty-seven participants lived 30–100 meters from the gold processing site, and ten participants lived 200–300 meters from the site (Table 1).

Urinary mercury level

The urinary mercury level in this study was identified using AAS instrument at Environmental Quality Analyst Laboratory, Department of Chemical Engineering, Faculty of Engineering, Universitas Syiah Kuala, Banda Aceh. Calibration curve was created prior to measuring the urine samples (n = 91). Figure 2 shows the results of the analysis of participants' urinary mercury levels.

No mercury was detected in sixteen urine samples that belongs to farmers (n = 6), housewives (n = 5), merchants (n = 3), and students (n = 2). However, no available data were able to account for the absence of mercury in their urine sample.

As displayed in Figure 3, most participants' urinary mercury level was less than 10 µg/L. Table 2 presents the urinary mercury level based on the analysis results with AAS.

Table 3 shows that the average urinary mercury level of local community near the gold processing site was 8.393 µg/L (SD: 6.721 µg/L), while the minimum and maximum urinary level detected in participants was 0.19 µg/L and 28.31 µg/L, respectively.

Correlation of urinary mercury concentration with disease symptoms

The analysis result showed a several clinical symptoms of acute toxicity among participants,

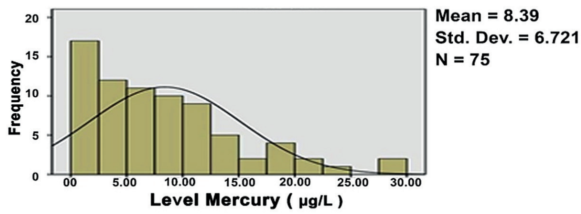

Figure 3. Distribution of urinary mercury level (n = 91)

Table 3. Urinary mercury levels (n = 75)

No.	Description	Amount (µg/L)
1	Mean	8.393
2	Median	6.867
3	Std deviation	6.721
4	Minimum rate	0.19
5	Maximum level	28.31
6	Percentile: 25%	2.94
	50%	6.86
	75%	11.82

including headache (48.6%), cough (39.6%), stomach ache (37.8%), diarrhea (29.7%), hip pain (25.6%), and loose teeth (21.6%). Somatosensory disorders experienced by participants in this study included headaches (47.7%), irritability (27.9%), insomnia (26.1%), muscle cramps (23.4%), weight loss (20.7%), and restlessness (17.1%).

The correlation analysis result demonstrated no correlation between urinary mercury level and symptoms of the acute disease reported by the participants, as shown in Tables 4 and 5. The p-value of all diseases showing acute symptoms was higher than 0.05. Table 5 displays the correlation between urinary mercury levels and symptoms of acute diseases reported by the local community in Paya Seumantok. No correlation between urinary mercury level and symptoms were found.

RESULT AND DISCUSSION

This study measured urinary mercury levels in a local community near a gold processing site. Participants were the local community in Paya Seumantok Village, Krueng Sabee District, Aceh Jaya Regency (n = 91). The study began by explaining the purpose of the study and collecting the participants' urine samples. They signed a participation consent form before participating in this study. Mercury was detected in seventy-five out of ninety-one urine samples. The average urinary mercury level was 8.392 µg/L (SD: 6.721 µg/L), with minimum and maximum detected mercury levels of 0.19 µg/L and 28.31 µg/L. The average level found in this study has exceeded the threshold set by Human Biomonitoring (HBM), i.e., 7 µg/L (Rice et al., 2014).

Recent studies have consistently shown that chronic exposure, even at low mercury concentrations, can cause cardiovascular toxicity, reproductive and developmental toxicity, neurotoxicity, nephrotoxicity, immunotoxicity, and carcinogenesis (Branco et al., 2017). The analysis result showed that the clinical symptoms of acute toxicity commonly experienced by participants were headaches (48.6%), coughs (39.6%), stomach pain (37.8%), diarrhea (29.7%), hip pain (25.2%), and lose teeth (21.6%). Meanwhile, chronic clinical symptoms included headaches (47.7%), irritability (27.9%), insomnia (26.1%), muscle cramps (23.4%), weight loss (20.7%), and restlessness (17.1%). Similar research results have also been reported related to symptoms of diseases caused by mercury exposure to communities around the Amazon River, showing that vision problems had the highest prevalence (43.3%) among health problems and symptoms of Hg poisoning,

Table 4. Correlation between urinary mercury level and acute symptoms

No			1		2		3		4		5		6		7		8		9		10	
Disease symptoms			Headache		Ulcer		Swollen gums		Dark gums		Loose teeth		Swollen tongue		Loss of smell		Asphyxiate		Chest pain		Hard to breath	
			No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Mercury level in urine	(-) NAB	n	21	34	44	11	46	9	52	3	41	14	53	2	53	2	48	7	48	7	50	5
		%	23.1	37	48.4	12	50.5	9.9	57.1	3.3	45.1	15	58.2	2.2	58.2	2.2	52.7	7.7	52.7	8	54.9	5.5
	(+) NAB	n	15	21	28	8	33	3	33	3	35	11	35	1	32	4	31	5	30	6	34	2
		%	16.5	23	30.8	8.8	36.3	3.3	36.3	3.3	38.5	12	38.5	1.1	35.2	4.4	34.1	5.5	33	7	37.4	2.2
Total respondents		n	36	55	72	19	79	12	85	6	66	25	88	3	85	6	79	12	78	13	84	7
		%	39.6	60	79.1	21	86.8	13	93.4	6.6	72.5	28	96.7	3.3	93.4	6.6	86.8	13	85.7	14	92.3	7.7
P_{value}			0.454		0.499		0.217		0.446		0.382		0.656		0.165		0.555		0.408		0.425	
No			11		12		13		14		15		16		17		18		19		20	
Disease symptoms			Cough		Mouth numb		Nauseous		Vomit		Stomach ache		Diarrhea		Cloudy urine		Bloody urine		Hip pain		Urination pain	
			No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Mercury level in urine	(-) NAB	n	32	23	53	2	40	15	45	10	31	24	37	18	49	6	51	4	38	17	50	5
		%	35.2	25	58.2	2.2	44	17	49.5	11	34.1	26	40.7	20	53.8	6.6	56	4.4	41.8	19	54.9	5.5
	(+) NAB	n	15	21	33	3	27	9	28	8	17	19	21	15	33	3	35	1	27	9	34	2
		%	16.5	23	36.3	3.3	29.7	9.9	30.8	8.8	18.7	21	23.1	17	36.3	3.3	38.5	1.1	29.7	10	37.4	2.2
Total respondents		n	47	44	86	5	67	24	73	18	48	43	58	33	82	9	86	5	65	26	84	7
		%	51.6	48	94.5	5.5	73.6	26	80.2	20	52.7	47	63.7	36	90.1	9.9	94.5	5.5	71.4	29	92.3	7.7
P_{value}			0.092		0.306		0.504		0.415		0.261		0.259		0.491		0.339		0.357		0.425	

Table 5. Correlation between urinary mercury level and acute symptoms

No			1		2		3		4		5		6	
Disease symptoms			Headache		Hearing disorders		Tremor		Muscle cramp		Erythema		Weight loss	
			No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Mercury level in urine	(-) NAB	n	21	34	48	7	47	8	38	17	54	1	41	14
		%	23.1	37.4	52.7	7.7	51.6	8.8	41.8	18.7	59.3	1.1	45.1	15.4
	(+) NAB	n	17	19	33	3	34	2	27	9	35	1	26	10
		%	18.7	20.9	36.3	3.3	37.4	2.2	29.7	9.9	38.5	1.1	28.6	11
Total respondents		n	38	53	81	10	81	10	65	26	89	2	67	24
		%	41.8	58.2	89	11	89	11	71.4	28.6	97.8	2.2	73.6	26.4
P_{value}			0.385		0.385		0.160		0.357		0.637		0.496	
No			7		8		9		10		11		12	
Disease symptoms			Anorexia		Easy to get angry		Anxious		Depression		Insomnia		Memory loss	
			No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Mercury level in urine	(-) NAB	n	53	2	38	17	44	11	49	6	35	20	54	1
		%	58.2	2.2	41.8	18.7	48.4	12.1	53.8	6.6	38.5	22	59.3	1.1
	(+) NAB	n	35	1	21	15	29	7	33	3	28	8	34	2
		%	38.5	1.1	23.1	16.5	31.9	7.7	36.3	3.3	30.8	8.8	37.4	2.2
Total respondents		n	88	3	59	32	73	18	82	9	63	28	88	3

followed by memory loss (42.9%), weakness (35.1%), fatigue (34.3%), mood swings (28.7%) and difficulty in concentration (27.2%) was most widely reported (Gibb et al., 2014).

The clinical symptoms experienced by the community around the gold processing site were almost the same as those experienced by gold processing workers, where the gold milling operation process affects the workers' health, as almost half of the workers reported experiencing acute symptoms such as fatigue (41.7%), headaches (39.6%), and mouth numbness (39.6%) (Emmanuel et al., 2018). Long-term mercury exposure is known to cause health problems, particularly in individuals living in a mercury-contaminated environment. Mercury poisoning reported in the community near mining sites is usually chronic. The toxic effects of mercury depend on the form of mercury, the route of exposure, and the duration of development (Karimuna et al., 2016). The health effects of mercury are usually evident after 5 to 10 years of exposure (Karimuna et al., 2016), and mercury toxicity has been reported to affect various organs and metabolic functions. The most frequently reported complications of mercury poisoning among workers in ASGM are neurological effects, including tremor, ataxia, memory problems, and visual disturbances (Gibb et al., 2014).

Several communities living in a small-scale gold mining village in Indonesia exhibited severe neurological symptoms and higher hair and urinary mercury levels, possibly associated with exposure to inorganic mercury in the air and consumption of mercury-contaminated fish and rice (Karimuna et al., 2016). In another study, some indigenous peoples of the Wayanad, Puleo Time-Suriname, exhibited neurological abnormalities due to mercury exposure. Through a series of neurological tests, researchers reported consistent neurotoxic effects with exposure to methyl mercury (Ekino et al., 2007).

Regarding the route of exposure, 80% of elemental mercury enters the human body through inhalation during the amalgam-burning process, and less than 3% enters through the skin (Straaten, 2000). If it enters orally, only a few are toxic. In the blood, elemental mercury is distributed throughout the body, as it easily passes through most cell membranes, the blood-brain barrier and the placenta. In blood circulation, elemental mercury can bind to many tissues, proteins, and erythrocytes (Lestarisa, 2010).

In red blood cells, elemental mercury is partially oxidized to mercury through the role of the enzyme catalase, which, when crossing the blood-brain barrier, allows the release of neurotoxic properties. The absorption of elemental mercury by the brain is reduced if the activity of the catalase enzyme in the brain is inhibited. The absorption of mercury in the brain also depends on the levels of glutathione (GSH) in the brain.

If the levels of GSH in the brain are reduced by 20%, it will cause mercury levels in the brain to increase by 66% (Aryani et al., 2013). Elemental mercury can persist for a very long time in the brain after exposure. The half-life of elemental mercury in adults is about 60 days. Elemental mercury can also be converted into Hg^{2+} and CH_3Hg1^+ in the intestine by microbial activity (Lestarisa, 2010).

While the correlation test result indicated no correlation between urinary mercury level and disease symptoms, it should be noted that the existing literature state that the health effects of mercury exposure could be identified after an individual is exposed for a long time. (Andri et al., 2011). Furthermore, the clinical symptoms of mercury poisoning would be evident after 10–15 years (Karimuna et al., 2016). Methyl mercury can penetrate the blood-brain barrier of the fetus in pregnant women and can contaminate breast milk in breastfeeding mothers. Previous reported cases, such as Minamata disease in Japan in 1932 and 1968, and in 1950, cases appeared with severe symptoms including loss of senses, ataxia, blindness, olfactory and hearing disorder, and imbalance syndrome. More serious symptoms cause convulsions, paralysis, and even death (Ekino et al., 2007), mercury can cause poisoning to the fetus and children. Mothers exposed to mercury potentially transmit the poison to the fetus and baby through breast milk, causing decreased motor function (Straaten, 2000). In other words, although this study found no correlation between urinary mercury level and the symptoms among participants, it does not necessarily mean that mercury does not adversely affect gold miners' and local community's health, as the effect may be identified after years of exposure. In an earlier study, it was reported that there was no relationship between Hg levels and multiple hematological indices, except for the correlation between Hg and leukocyte (Lestarisa, 2010).

Another study involving traditional gold miners in Wonogiri Regency reported no significant relationship between hematocrit ($p = 0.380$), erythrocytes ($p = 0.529$), mean corpuscular volume (MCV) ($p = 0.641$), mean corpuscular hemoglobin (MCH) ($p = 0.351$), platelets ($p = 0.501$), and hemoglobin ($p = 0.334$) and mercury in the blood. However, a significant relationship between mercury in the blood and leukocytes was noted ($p = 0.017$) (Aryani et al., 2013). In another study, chi-square analysis result showed that length of work/day ($p = 0.002$) and continuous use of personal protective equipment (PPE) were significantly related to mercury poisoning among unlicensed gold miners in Central Kalimantan. Symptoms of disease reported by unlicensed gold miners included fatigue, headache, shaking/shivering, and stiff joints (Lestarisa, 2010).

Based on the description above, high urinary mercury levels do not necessarily contribute to health conditions, considering that each individual has a different body condition and hence, the effect of mercury levels on each person is different.

CONCLUSIONS

This study found that 75 of 91 urine samples collected from the local community near gold processing site contains mercury. Of that number, 36 samples were found to contain mercury levels that exceeded the acceptable threshold (i.e., 7 μg/L), whereas the other 39 samples contained mercury levels below the threshold. This study concluded that there is no correlation between mercury levels and symptoms of acute and chronic diseases experienced local community and workers at the gold processing site in Paya Seumantok Village, Krueng Sabee District, Aceh Jaya Regency ($p > 0.05$). Although no correlation was noted, it is still important to monitor and test the urinary mercury level periodically. It is also necessary to socialize the hazard of heavy metal on health. Local government should regularly monitor the artisanal gold mines and equip miners with a standard operational procedure. It is also important to provide them with water and burning waste management before released to the environment. Mercury poisoning may occur in fetus and infants through breasfeeding, causing decreased motor function (Straaten, 2000). Neurological disorders including tremors, ataxia, memory loss, vision disorder are also reported (Gibb et al., 2014).

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REFERENCES

1. Andri D.H., Anies A., Suharyo H. 2011. Kadar merkuri pada rambut masyarakat di sekitar penambangan emas tanpa ijin. Media Medika Indonesiana, 45(3). 181–187.
2. Aryani L., Setiani O., Nurjazuli N. 2013. Hubungan Kadar merkuri (Hg) dengan profil darah pekerja pertambangan emas tradisional di desa jendi kecamatan selogiri kabupaten wonogiri. Jurnal Kesehatan Lingkungan Indonesia, 12(2). 144–148.
3. Branco V., Caito S., Farina M., Teixeira da Rocha J., Aschner M., Carvalho C. 2017. Biomarkers of mercury toxicity. Past, present, and future trends. Journal of Toxicology and Environmental Health, Part B. 20(3). 119–154.
4. Ekino S., Susa M., Ninomiya T., Imamura K. Kitamura T. 2007. Minamata disease revisited. an update on the acute and chronic manifestations of methyl mercury poisoning. Journal of the Neurological Sciences, 262(1–2). 131–144.
5. Emmanuel A.Y., Jerry C.S. Dzigbodi D.A. 2018. Review of environmental and health impacts of mining in Ghana. Journal of Health and Pollution, 8(17). 43–52.
6. Gibb H., O'Leary K.G. 2014. Mercury exposure and health impacts among individuals in the artisanal and small-scale gold mining community. A Comprehensive Review. Environmental Health Perspectives, 122(7). 667–672.
7. Karimuna S.R., Fachlevy A.F. 2016. Analisis perbedaan potensi risiko keterpaparan merkuri pada masyarakat di desa Tahi Ite Kecamatan Rarowatu Kabupaten Bombana Tahun 2016.
8. Lestarisa T. 2010. Faktor faktor yang berhubungan dengan keracunan merkuri (Hg) pada Penambang Emas Tanpa Ijin (Peti) Di Kecamatan Kurun, Kabupaten Gunung Mas, Kalimantan Tengah. Universitas Dipenegoro.
9. Rianto, Setiani S., Budiyono O. 2012. Analysis of factors associated with mercury poisoning of the traditional gold miner at Jendi Village, Selogiri Subdistrict, Wonogiri District. Jurnal Kesehatan Lingkungan Indonesia.
10. Rice K.M., Walker E.M., Wu M., Gillette C., Blough E.R. 2014. Environmental mercury and its toxic effects. Journal of Preventive Medicine & Public Health, 47(2). 74–83.
11. Sakamoto M., Itai T., Murata K. 2017. Effects of prenatal methylmercury exposure. from minamata disease to environmental health studies. Nihon eiseigaku zasshi. Japanese Journal of Hygiene, 72(3). 140–148.
12. Silva-Junior D., Rodrigues F.M., Oleinski R.M., Azevedo A.E.S., Monroe K.C.M.C., Dos Santos M., Da Silveira T.B., De Oliveira A.M.N., Soares M.C.F., Pereira T.D.S. 2018. Vulnerability associated with "symptoms similar to those of mercury poisoning" in communities from Xingu River, Amazon basin. Environmental Geochemistry and Health, 40(3). 1145–1154.
13. Straaten P. Van. 2000. Human exposure to mercury due to small scale gold mining in northern Tanzania. 45–53.
14. Subanri S. 2008. Kajian Beban pencemaran merkuri (Hg) terhadap air sungai menyuke dan gangguan kesehatan pada penambang sebagai akibat Penambangan Emas Tanpa Izin (Peti) Di Kecamatan Menyuke Kabupaten Landak Kalimantan Barat.
15. Suhendrayatna S.I., Elvitriana T. 2013. Mercury emissions to ambient air from activities of small scale gold mining plants in Krueng Sabee, Aceh Province, Indonesia. 8th Annual International Workshop & Expo on Sumatra Tsunami Disaster & Recovery'2013.
16. Suhendrayatna S., Hafdallah P., Lizam T.C. 2014. Mercury emissions from artisanal gold milling operation and its impact on the health of workers. Case study in Panton Luas, Aceh Selatan District in Indonesia. International Seminar "Behavioral and Earthquake Science – From Geology to Animal Perception".
17. Yard E.E., Horton J., Schier J.G., Caldwell K., Sanchez C., Lewis L., Gastañaga C. 2012. Mercury exposure among artisanal gold miners in Madre de Dios, Peru. A cross-sectional study. Journal of Medical Toxicology, 8(4). 441–448.