Mercury content on hair as an indication of mercury exposure on gold miners in Tambang Sawah Village, Lebong Regency

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Abstract

Background: The gold mine located at Tambang Sawah Village, Lebong Regency, has been in existence since the Dutch colonial era. The mine is currently managed independently by the local populace using the amalgamation method, which causes environmental pollution and health problems to the miners and surrounding communities. Aims: This study aims to determine the effect of mercury exposure on miners. Settings and Design: The purposive sampling method was used to obtain information and research data needed on illegal gold miners. Methods and Material: Data were obtained through observation, interviews, and documentation. Statistical analysis used: The interview results were analyzed and further examined using a descriptive statistical test. Results: The result showed that the amalgamation activity is carried out from 7:00 a.m. 7:00 a.m. until 4:00 p.m. 4:00 p.m., thereby culminating in 9 hours per day. Furthermore, the highest, lowest, and average mercury level obtained from a miner's hair sample was 8.72 mg/kg, 1.42 mg/kg, and 3.06 mg/kg. Conclusions: The high levels of mercury in the hair samples of miners were influenced by the length of exposure affected by the working periods and work difficulty level.

Keywords: Mercury, Hair, Miners, Village

Key Messages:
Gold mining using an amalgamation method tends to affect the health of miners and local people adversely. Furthermore, the high mercury level in miners' hairs is due to the prolonged working hours and difficulty level.

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Introduction

TawahSawah area is a gold processing area established in the northern part of Lebong during the Dutch colonial era and managed by a Dutch company. However, the mining activities are currently carried out by many artisanal small-scale miners by taking ores from the former quarry of the colonial era, and by creating new holes to obtain gold ore. The mining treatment patterns carried out by these small-scale artisanal miners still utilize the amalgamation method, which is the binding process of gold from the ore using mercury (1). This method causes environmental pollution due to the release of tailings into the river body during panning and washing. This activity makes the river murky and polluted with mercury, which is a very dangerous and highly toxic element (1).

Mercury can enter the body through the food chain system, absorbed by the skin in daily activities such as bathing or water consumption contaminated in the element (2). Continuous exposure to mercury causes mild, severe, and chronic health problems in humans. Mild poisoning symptoms include dizziness, headaches, and fatigue, while severe mercury poisoning causes kidney damage, stiff joints, loss of peripheral vision, and nervous system disorders. Furthermore, chronic exposure to the element leads to death, as occurred in the outbreak of mercury poisoning in Minamata, Kumamoto Prefecture.

One of the ways used to detect mercury in humans is by measuring its levels in hair. The National Institute for Minamata Disease (NIMD) stated that the highest Hg levels accumulated in the human hair are approximately 250 to 300 times higher than blood mercury levels and ten times higher than methyl mercury found in urine (3).

Hair mercury levels are persistent, therefore, they cannot be erased by washing with shampoo or by dyeing, rather it decreases by 30-50% when straightened or permed. This is because the hair straightening process uses thioglycolic acid, which reduces Hg in the hair (4).

Therefore, it is necessary to determine mercury levels on human hair on Tambang Sawah villagers because the hair is the appropriate first indicator for monitoring mercury exposure in humans. According to (5), a person living in a mercury-contaminated area for a prolonged period has 7 times greater hair mercury levels than threshold compared to those that lived there for a short time. This study aims to determine the mercury levels accumulated in the Tambang Sawah villagers' hair. The results are expected to become an important information material for artisanal miners in acknowledging the impacts and dangers of carrying out daily life activities such as eating, drinking, and bathing as well as other water-using activities in the workplace. It also educates them on the
importance of using personal protective equipment and improving work methods to minimize mercury exposure in the workplace.

**Subjects and Methods**

This study was carried out at Gold Mining in Tambang Sawah Village, with hair samples obtained from 20 miners' heads. The samples were then measured to determine the value of mercury levels in the Central Laboratory of Health Laboratory Jakarta using the APHA 3112B ed 23/2017 method. According to the World Health Organization (2008), mercury's quality standard in hair is 1 ppm. For further sample tests, interviews were also conducted on the respondents with the results evaluated, analyzed, and further examined. Furthermore, a descriptive statistical test was used to determine the average, maximum, drinking value, and standard deviation of each variable.

**Results and Discussion**

Mercury can enter the body through the food chain system and the skin when carrying out daily activities such as bathing with mercury-contaminated water (2). This is similar to the research carried out by (6), which stated that mercury can enter the human body through three pathways, namely digestion, breathing, and skin absorption.

According to the World Health Organization, the mercury accumulated in the body is in the form of methyl, influenced by temperature, Cl- ion levels, organic content, pH, and mercury levels (7). Methyl mercury compounds are easily absorbed through the digestive, respiratory, skin pathways, and bloodstream before spreading to all body tissues, accumulated in the hair (8).

**Mercury Levels in People’s Hair in Tambang Sawah Gold Mining**

Mercury levels in human hair can be used as an indicator of absorption due to exposure that has lasted for several months. According to the World Health Organization (2008), the average normal level of mercury in hair is 1 ppm.

The mercury content in the hair of workers living at the gold mining area in Tambang Sawah village shows that the highest, lowest, and average levels are 8.72 mg/kg, 1.42 mg/kg, and 3.06 mg/kg. This study is in line with the research carried out by (9) on the mining in Gorontalo Province, where the average mercury levels reported were 4.04 mg/kg. A study conducted by (3) showed that hair mercury levels of Kayeli Village villagers ranged from 0.10 - 3.25 ppm, and the comparison sample was 0.42 ppm.
Methyl levels in hair

Mercury levels in the body are generally in the form of ions or inorganic compounds that do not originate from the body, rather they are from the external exposure accumulated in hair. Table 2 shows the mercury levels found in the hair of miners at Tambang Sawah Gold Mine.

Table 2: Mercury Levels in Hair Sample of the Miners

<table>
<thead>
<tr>
<th>Hair Sample</th>
<th>Mercury level (ppm)</th>
<th>Working period (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR20</td>
<td>1.42</td>
<td>4</td>
</tr>
<tr>
<td>SR10</td>
<td>1.49</td>
<td>4</td>
</tr>
<tr>
<td>SR8</td>
<td>1.54</td>
<td>4</td>
</tr>
<tr>
<td>SR15</td>
<td>1.63</td>
<td>4</td>
</tr>
<tr>
<td>SR12</td>
<td>1.83</td>
<td>5</td>
</tr>
<tr>
<td>SR14</td>
<td>2.07</td>
<td>5</td>
</tr>
<tr>
<td>SR17</td>
<td>2.49</td>
<td>5</td>
</tr>
<tr>
<td>SR6</td>
<td>2.54</td>
<td>5</td>
</tr>
<tr>
<td>SR9</td>
<td>2.91</td>
<td>5</td>
</tr>
<tr>
<td>SR4</td>
<td>4.56</td>
<td>7</td>
</tr>
<tr>
<td>SR2</td>
<td>5.58</td>
<td>8</td>
</tr>
<tr>
<td>SR7</td>
<td>8.72</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 2 shows that the high levels of mercury are affected by the length of exposure time, with the highest those that have worked for 10 years, followed by 8, 7, and 5 years, sequentially. The lowest mercury level is found in the miners that have worked for 4 years. According to data analysis, the gold miners at the Tawah Sawah area work from 6.00 a.m. to 5.00 p.m., with 1-2 hours of break, from 12.00 p.m. to 2.00 p.m. The longer the work period, the greater the Hg levels in the miner’s hair, which enters the body through the skin pores and respiratory tract. Besides the working period, the difficulty level of mining work also influences the mercury level accumulated in the hair.
Table 1 shows a positive correlation between the working period and the mercury levels accumulated in the hair, with a p-value <0.05. This result indicates a significant relationship between the mercury content variable and the working hours (p = 0.0302).

According to (10), there is varying mercury content in miners' hair samples, with the older ones having the least levels. The results showed that 23 years old miners have higher mercury levels compared to those that are 30 and above. However, older miners are advised to reduce contact with mercury to reduce exposure risk. This is because age affects one's health, body mass fraction, decreases liver and kidney function, increases fat tissue, and reduces blood flow speed, thereby prolonging the presence of toxins in the body.

Personal protective equipment (PPE)

One of the factors causing high mercury levels in the miners' hair in the Tambang Sawah area is their inability to carry out their jobs without using PPE. (11) stated that the high levels of mercury in the body of Gold Mining Workers on a small scale are one of the effects of lack of adequate Personal Protective Equipment (PPE) facilities at work, as well as the presence of poor hygiene practices. However, some of the reasons gold miners do not use PPE is due to its uncomfortable nature. Therefore, there is an urgent need to educate gold miners to use personal protective equipment (PPE).

Impact of Mercury Toxicity

The interviews results showed several types of diseases suffered by the local populace living around the mining sites, namely liver disorders (2%), headaches (65%), dizziness (20%), tremors (15%), asthma (15%), tiredness (50%), kidney disorders (5 %), abdominal pain (40%) and heel and back pain (5%). Therefore, there are already symptoms of acyclic due to mercury poisoning.

This disease is caused by the accumulation of mercury-based on the amount of toxicity in humans, which depends on the form of composition, the pathway used to enter the body, and the exposure duration. Furthermore, approximately 99% of mercury in organic forms, such as metal-mercury, is absorbed by the intestinal wall, which enters through the digestive system. This is much greater than the inorganic form (HgCl₂), which is only about 10% and through the skin tissue.

Organic mercury is soluble in fat, however, this form is less corrosive, and the ability to dissolve in fat allows it to penetrate the blood barrier, cell membranes, and placenta, thereby causing teratogenic effects and nervous disorders, such as:

a) Sensory nerve disorders, which comprise paraesthesia, decreased sensitivity and difficulty in moving fingers and toes, narrow vision, decreased hearing power, and pain in the arms and thighs.
b) Motor nerve disorders: weakness, difficulty in standing, easily fall, ataxia, tremors, slow movements, and difficulty in speaking.

c) Other disorders: mental disorders, headaches, and hypersalivation (12).

One form of inorganic mercury is Mercury chloride (HgCl₂) (13), which is very soluble in water (14). Although this element is not among the most toxic mercury compounds, it causes immunotoxic effects (15). Heavy metal mercury chloride (HgCl₂) can cause cellular or humoral immune response disorders (16). The cellular immune response used as an indicator changes the size of melanomacrophages in the liver and anterior kidney (17).

Melanomacrophages are an aggregation of macrophages, which function as the main phagocytic cells that play a role in the process of phagocytosis (18) (19). Melanomacrophages play an important role in the body's response to foreign substances, including infectious agents (20).

Based on the results of the study, it was found that the high levels of mercury in the hair samples of miners were influenced by the length of exposure and difficulty of work. The highest and lowest mercury levels from the miner's hair sample are 8.72 mg/kg, and 1.42 mg/kg, which are owned by miners with a working period of 10 and 4 years, with an average level of 3.06 mg/kg.

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References