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ACUTE TOXICITY MERCURY CHLORIDE AGAINST TRICHOPTERA LARVA

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ABSTRACT

Mercury waste from gold mining activities that pollutes the environment is hazardous for life, including aquatic insects. The acute toxicity of mercury in LC_{50}in the larvae of Trichoptera aquatic insects, which are often used as insect bioindicators of water quality, was determined in this study. A completely randomized design with various concentrations of mercuric chloride ($HgCl_2$) was applied. A total of six concentration levels, namely: control (0.00); 0.001mg / l; 0.005 mg / l; 0.1 mg / l; 0.2 mg / l; 0.3 mg / l $HgCl_2$ were tested. Each treatment was repeated three times. At each test concentration, 20 Trichoptera larva were used. The Trichoptera larva were exposed to the mercury solution in a 250 ml beaker with a 100 ml solution volume. The Trichoptera larva mortality was observed at 30 minutes, 60 minutes, 1.5 hours, and 48 hours after exposure. The results showed that the larva' mortality had occurred in the observation 30 minutes after exposure, namely 2% mortality at a concentration of 0.005 and reaching 45% at a concentration of 0.3 mg l^{-1}. The higher the mercury content in the water, the higher the mortality of the test larvae. The concentration of 0.048 ppm is the LC_{50} value of mercuric chloride for Trichoptera larvae. This study shows that mercuric chloride is a compound with acute toxicity. Mercury exposure to the larvae can also cause physiological reactions that cause observable morphological changes. Trichoptera larvae exposed to mercury showed signs of a defect in blackening the trachea gills and spread throughout the body. At 24 hours after exposure, the larval body becomes stiff and black.

Keywords: Acute toxicity, Mercury, Trichoptera larvae.

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INTRODUCTION

Poboya gold mine is one of the small-scale gold mines that have been managed by the people. Mining activities using traditional technology and using mercury in the amalgamation process negatively impact the environment since some mercury releases and pollutes to surround area of mining (Drace et al., 2012; Odumo et al., 2014; Rehani, 2012; Zolnikov and Ortiz, 2018). Several studies show that the soil at the location of the Poboya gold mine has been contaminated with mercury, far exceeding the average threshold, which ranges from 0.057 to 8.19 ppm, even in tailings, it ranges from 84.15 ppm - 575, 16 ppm from the threshold of

0.005 ppm (Mirdat et al., 2013; Sari et al., 2016). Mercury has also polluted the waters around the Poboya gold mine (Purnawan et al., 2013).

Mercury contamination in water can decrease the diversity of aquatic organisms, including aquatic insects, due to its highly toxic nature and even reported to be acutely toxic. Acute poison is defined as a poison that works and gives death to organisms in a short time (Asy, 2012). Several studies have shown that mercury is acute toxicity in several aquatic animals such as fish (Asy, 2012; Senthamilselvan et al. 2015; Ishikawa et al., 2007) and aquatic arthropods such as water mites (Tsui and Wang, 2006).

Acute toxicity studies on aquatic organisms need to be carried out to protect aquatic organisms' lives, including aquatic insects. This study will show the sensitivity of a species by looking at lethal concentrations. This finding can then be used as the basis for long-term tests to establish the requirements necessary for aquatic insect welfare (Warnick and Bell, 2014). Therefore, this research is essential to study the acute toxicity of mercury in Trichoptera larvae.

MATERIALS AND METHODS

A completely randomized design was applied in this study. The concentrations of mercury ($HgCl_2$) in six concentration levels were assessed, namely: 0.00 (control), 0.001, 0.005, 0.1, 0.2, and 0.3 mg l^{-1} $HgCl_2$. Each treatment was repeated three times. At each test oncentration, 20 Trichoptera larva were used. The Trichoptera larva were exposed to mercury solution in a 250 ml beaker with a volume of 100 ml test solution without being fed. Trichoptera larva' mortality was observed over 30 minutes, 60 minutes, 1.5 hours, and 48 hours. Observation variables were the number of Trichoptera larvae dead and symptoms of Trichoptera larvae mortality

Data analysis includes the acute toxicity of mercuric chloride to Trichoptera larvae determined by looking at the LC_{50} value using probit analysis (Finney, 1971), while the larval mortality was calculated using the Microsoft Excel software.

RESULTS AND DISCUSSION

Result

The mortality data for Trichoptera larvae can be seen in Table 1.

Mercury is very toxic to aquatic insects. It can be seen from the mortality of the test insects in a relatively short time since exposure to mercury. The results also showed that the higher the mercury content in the water, the higher the insect mortality, as illustrated in the following graph (Figure 1). The LC_{50} was at a concentration of 0.048, with the highest value ranging from 0.121 and the lowest at 0.019. In Figure 2, the healthy larva (2a) can be compared to the death larva. The death insect showed blackening symptoms that occurred 24 hours after exposure. Moreover, the larvae became stiff (Figure 2b). Then the larva's body damaged and macerated (Figure 2c)

Table 1: Average Cumulative Mortality of Trichoptera larvae at Various Times of Observation.

Concentration of $HgCl_2$	Trichoptera larvae mortality (%) at various times of observation			
	30 MAE	60 MAE	90 MAE	120 MAE
0.000	0.00	0.00	0.00	20.00
0.001	0.00	3.00	7.00	20.00
0.005	2.00	22.00	24.00	28.00
0.1	5.00	12.00	40.00	50.00
0.2	28.00	48.00	60.00	77.00
0.3	45.00	68.00	85.00	93.00

MAE: Minutes after exposure.

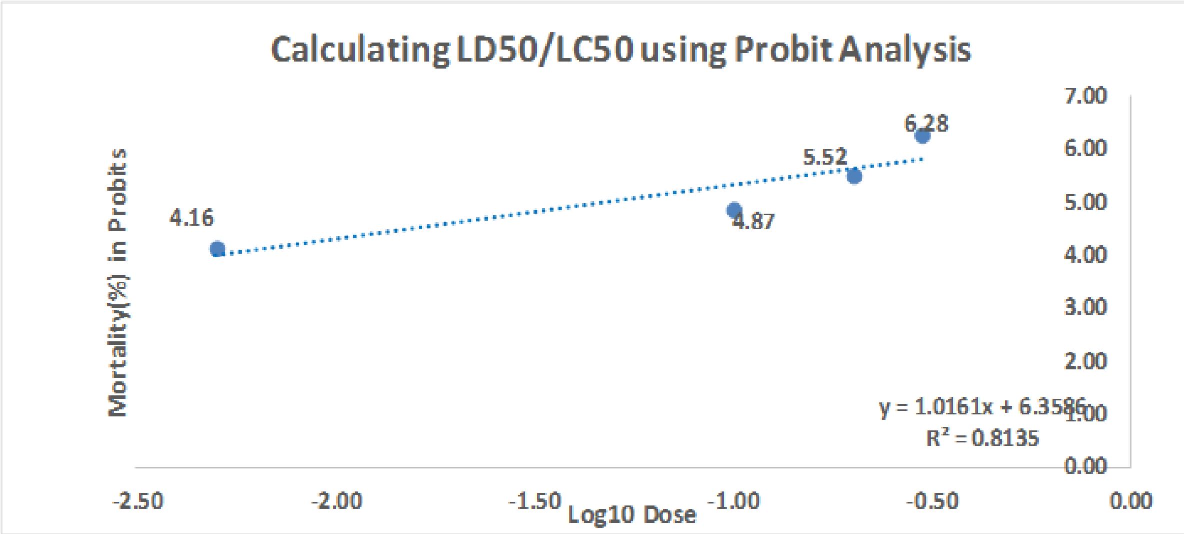

Figure 1. The LC_{50} Mercury ($HgCl_2$) on Trichoptera larvae

Figure 2. Morphology of Trichoptera larvae; A) healthy larvae; B) Trichoptera larvae that died and were exposed to mercury; C) Trichoptera larvae that died on the control.

Discussion

This study proves that mercury (in this case, mercuric chloride) is a metal that has acute toxic properties. Acute poison is defined as a poison that works and gives death to organisms in a short time (Asy, 2012). In some literature, it is stated that the nature of acute toxicity can be seen in the percent mortality of test animals observed at 24 hours after application (Tsui and Wang, 2006) and interpreted as acute toxicity. Some literature also states that acute toxicity refers to adverse effects after a single oral or dermal dose of a substance administered within 24 hours, or a 4-hour exposure. Knowledge of acute poison activity is critical to know as a long-term knowledge base to see other living communities (Warnick and Bell, 1969).

In this study, the test insect mortality occurred only 30 minutes after exposure at a concentration of 0.1 (5% mortality), even at a concentration of 0.05, although with low mortality (2% mortality). The same thing was reported by Asy (2012) in test animals *Clarias gariepinus*, which also died on observation 30 minutes after application, although with a higher concentration of 3 mg/l. Observation results show that the tested insects' mortality is higher with the higher the concentration of mercury (Figure 1). The tested insects' mortality reached 68% at a concentration of 0.3 mg / L and only 3% at a concentration of 0.01 mg / l $HgCl_2$ at observation 60 minutes after application. The observations show that shortly after being exposed to mercury at high concentrations, the test insects immediately showed a reaction in the form of sensitivity symptoms and immediately left the nest. Occasionally swim and then stay still for a moment and make movements that are not directed. This study is likely due to disruption in breathing as a direct result of mercury exposure. Heavy metal exposure in Trichoptera larvae can cause morphological abnormalities in the trachea gills, ion regulation organs, and anal papillae, which can interfere with the respiration process and ion function in individuals. This symptom is almost the same as the symptoms in tilapia exposed to mercury, namely the fish will show a physiological response, which is indicated by sudden and rapid movements, frequent rolling movements, and a few moments later, the movements become weak. Besides, fish exposed to mercury often attract air due to respiratory rate disturbances (Senthamilselvan et al., 2015)

However, when compared with the research of Warnick and Bell (2014), which concluded that the water insects of the *Ephemerella* sp. (Ephemeroptera: Ephemerellidae), *Acroneus* sp. (Plecoptera) and *Hydropsyche* sp. (Trichoptera) turned out to be insensitive to water-soluble mercury, because the results showed that these three aquatic insect species could survive up to 96 hours after application, even at a concentration of 64.0 mg / l. However, referring to Chakona (2009), it is stated that some Trichoptera species can indeed live in polluted waters, including those contaminated with heavy metals. On the contrary, some other species are susceptible. It was likely this insect species factor that caused these different results. However, several other factors can affect the sensitivity of Trichoptera larvae in an environment, namely current velocity, pH, dissolved oxygen, and food availability. Differences in water temperature, the origin of the test animal population, and body size have also been reported to affect mercury absorption in aquatic insects *Daphnia magna*, affecting mortality (Tsui and Wang, 2006).

Mercury exposure to aquatic insects can also cause physiological reactions that can lead to observable morphological changes. The report by Sudarso and Yoga (2015) states that Trichoptera larvae exposed to mercury can cause defects in the form of blackening of the trachea gills and expansion of the lumen insect intestines. In *Tilapia* sp., the darkening of the body color has also been reported after exposure to mercury (Senthamilselvan et al., 2015).

The LC_{50}probit analysis at a concentration of 0.048 ranged from 0.121 and 0.019 as the highest top the lowest, respectively, with 95% mortality. It indicated that mercury in the form of $HgCl_2$is remarkably toxic to aquatic insects. The results of this study show a similar trend to the results of other studies for aquatic arthropods. Jensen et al. (2007) reported that the LC_{50} value for *Culex quinquefasciatus* larvae (Diptera: Culicidae) ranged from 0.042, and 0.03 for the LC_{50} for *D. magna* water flea (Tsui and Wang, 2006). However, compared with the research (Warnick and Bell, 2014), which reported that water insects *Ephemerella* sp, *Acroneus* sp, and *Hydropsyche* sp. species from the order Ephemeroptera, Plecoptera, and Trichoptera were not sensitive to water-soluble mercury with an LC_{50} value of 2.0 mg / L $HgCl_2$.

Research by Jensen et al. (2006) further explained that mercuric chloride in water could affect *C. quinquefasciatus* larvae (Diptera: Culicidae). The larvae's lifespan is shorter with increasing concentrations of mercury in water, but it does not affect the behavior of females in laying eggs.

The acute toxicity test of mercuric chloride was widely treated in fish as test animals with varying LC_{50} values. Asy (2012) research on *Clarias gariepinus* fish with an LC_{50} value of 0.6 mg / L mercury. Meanwhile, in Ishikawa et al., 2007), the LC50 in *Nile tilapia* was 0.220, while the Senthamilselvan et al. (2015) study found acute toxicity in *Lates calcafier* fish with an LC_{50} value of 0.8.

CONCLUSION

The concentration of 0.048 ppm is the value of LC_{50} mercuric chloride for

Trichoptera larvae. It shows that mercuric chloride is a compound with acute toxicity.

REFERENCES

Asy, H. Acute toxicity of mercury cloride ($HgCl_2$) to african catfish, *Clarias gariepinus*. Research Journal of Chemical Sciences 2012 2(3): 2231–2606.

Drace, K., A.M. Kiefer, M.M. Veiga, M.K. Williams, B. Ascari, K.A. Knapper, K.M. Logan, V.M. Breslin, A. Skidmore, D.A. Bolt, G. Geist, L. Reidy, and J.V. Cizdziel. Mercury-free, small-scale artisanal gold mining in Mozambique: Utilization of magnets to isolate gold at clean tech mine. Journal of Cleaner Production 2012 32: 88–95. https://doi.org/10.1016/j.jclepro.2012.03.022

Ishikawa, N. M., M.J. Ranzani-Paiva, and J.V. Lombardi. Acute toxicity of mercury ($HgCl_2$) to Nile tilapia, Oreochromis niloticus. B. Inst. Pesca, São Paulo 2007 33(1): 99–104.

Mirdat, Y.S. Patadungan, and Isrun. Status logam berat merkuri (Hg) dalam tanah pada kawasan pengolahan tambang emas di kelurahan Poboya, kota Palu. e-Journal Agrotekbis 2013 1(2): 127–134.

Odumo, B. O., G. Carbonell, H.K. Angeyo, J.P. Patel, M. Torrijos, and J.A. Rodríguez. Impact of gold mining associated with mercury contamination in soil, biota sediments and tailings in Kenya. Environmental Science and Pollution Research 2014 21(21): 12426–12435. https://doi.org/10.1007/s11356-014-3190-3

Rehani, H. Direct smelting of gold concentrates as an alternative to mercury amalgamation in small-scale gold mining . Artisanal and Small Scale Miners (ASGM) Workshop on Environment, Socio-Economic and Health Impacts of Artisanal and Small Scale Mining, Februari 2012. http://balifokus.asia/balifokus/wp-content/uploads/2012/04/09_Direct_Smelting_Techniques_HR_en.pdf

Sari, M. M., T. Inoue, Y. Matsumoto, K. Yokota, and Isrun. Assessing a mercury affected area from small-scale gold mining in Poboya, Central Sulawesi, Indonesia. Environment and Ecology Research 2016 4(4): 223–230. https://doi.org/10.13189/eer.2016.040406

Senthamilselvan, D., A. Chezhian, and E. Suresh. Acute toxicity of chromium and mercury to Lates calcarifer under laboratory conditions. International Journal of Fisheries and Aquatic Studies 2015 2(4): 54-57.

Tsui, M. T. K, and W. Wang. Acute toxicity of mercury to daphnia magna under different conditions. Environ. Sci. Technol 2006 40(12): 4025-4030. https://doi.org/10.1021/es052377g

Warnick, S. L, and H.L. Bell. The acute toxicity of some heavy metals to different species of aquatic insects. Water Environment Federation 2014 41(2): 280–284.

Zolnikov, T. R, and R.D. Ortiz. A systematic review on the management and treatment of mercury in artisanal gold mining. Science of the Total Environment . 2018 633: 816–824. https://doi.org/10.1016/j.scitotenv.2018.03.241