Analysis of lead (Pb) levels in water, sediment and mollusks in secondary irrigation channels in Gorontalo Province, Indonesia

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Abstract. Tahir IA, Lamondo D, Baderan DWK. 2020. Analysis of lead (Pb) levels in water, sediment and mollusks in secondary irrigation channels in Gorontalo Province, Indonesia. Intl J Bonorowo Wetl 11: 1-6. This study was conducted in July-August 2020 in the secondary irrigation channels of Gorontalo Province, aimed to determine the lead content in the water, sediment and gastropods in the channels. The sampling points were located in four sub-districts, i.e., North Bulango Sub-district, Sipatana Sub-district, Central City Sub-district and Hulonthalangi Sub-district. The samples were analyzed using Atomic Absorption Spectrophotometer (AAS). The data were analyzed qualitatively by comparing them with the contamination thresholds set by the government of Indonesia. The results showed that the levels of lead in water in the four stations were 0.37 mg/L, 1.30 mg/L, 1.69 mg/L and 0.38 mg/L, respectively, in the sediment 1.1268 ppm, 0.9719 ppm, 0.7602 ppm, and 0.5290 ppm, respectively, and in each mollusk species, i.e., Bellamunya sp. 0.2924 mg/kg, Pomacea canaliculata 0.2413 mg/kg and Pomacea canaliculata 0.1873 mg/kg. The lead levels in the water, sediment and gastropods in the study sites exceeded the contamination thresholds set by the Indonesian government.

Keywords: Lead, mollusks, secondary channels, sediment, water

INTRODUCTION

Irrigation channels are built for the distribution and supply of water to agricultural areas, especially rice fields in order to maintain high agricultural production. According to the Government Regulation of the Republic of Indonesia Number 20 of 2006, irrigation channels are divided into 3, namely, primary, secondary, and tertiary irrigation channels. Secondary irrigation channel is a channel that carries water from the primary irrigation channel to the tertiary irrigation channel.

The secondary irrigation channels from the Lomaya dam are 25,733 meters long (Biahimo et al. 2015), passing through settlements and houses. Some residents who live along the secondary irrigation channels dispose of household waste, such as liquid waste, batteries, children's toys, wall paint, and plastic food or beverage packaging to the irrigation channels. The materials discharged into this irrigation channel are likely to contain heavy metal lead (Pb) as stated by Lamondo (2020) that batteries, children's toys, wall paint, and plastics contain lead. Eshmat et al. (2014) also reported that heavy metal pollutants, i.e., lead (Pb) and cadmium (Cd), that occurred in Ngemboh waters were caused by the disposal of resident waste originating from organic and inorganic materials.

The secondary irrigation channels become a place for liquid waste disposal from motor vehicle washing businesses and workshops. This liquid waste is likely to contain lead as research by Nadeak et al. (2015) showed that the liquid waste in motorized vehicle workshops in the city of Tanjungpinang observed at 3 small workshops with 3 sampling points had lead levels exceeding the threshold of more than 0.1 mg/L.

The secondary irrigation channels also receive waste from agriculture in the form of fertilizers and pesticides which are likely to contain lead. Research conducted by Sukarjo et al. (2018) showed that applying fertilizer to rice plants could increase the metal content of lead and cadmium in soil and rice plants.

The secondary irrigation channels are also close to highways having heavy traffic of motor vehicles which produce smoke containing Pb. This smoke will crystallize in the air and when it rains, the lead will be carried away with rainwater and enter the waterways. Pratama et al. (2012) showed that the content of lead metal in Tapak River water ranged from 0.01 to 1.11 ppm. This was thought to have come from the motorized vehicle pollutants in the water bodies and also smoke from the factories around the river.

The secondary irrigation water is also used to irrigate rice fields. If this irrigation water is polluted and used to irrigate rice fields, the lead will accumulate in agricultural crops and it will accumulate in the fish and gastropods which will cause metabolic and respiratory disorders.

If animals and plants that have been contaminated with lead are consumed by humans, the lead will accumulate in the body, causing health problems such as weakness, headaches, fatigue, tingling hands, anemia renal dysfunction, physiological dysfunction, liver dysfunction, and decreased fertility. Research by Lamondo et al. (2015) on male reproduction, showed that lead could cause apoptosis in spermatogenic cells.
Heavy metals in the water will settle and then accumulate in the sediment, so sediment is often used as an indicator of environmental pollution. Wicaksono et al. (2016) state that as the heavy metal content in water will settle in the sediment, the concentration of lead in the water will decrease. This is supported by Saputra's research (2018) which showed that the lead content in the sediment was 2.95 ppm, greater than that in the water, i.e., 0.0183 ppm. This can occur because heavy metals that enter water bodies will experience deposition and dilution, then will accumulate in aquatic biota.

Apart from water and sediment, biota can also be used as a bio-indicator of lead pollution in secondary channels. Baderan et al. (2019) state that gastropods that live on the bottom of waters can be used as bioindicators of pollution because they are filter feeders, have low mobility and have a high tolerance for environmental pollution.

MATERIALS AND METHODS

Study area
This study was conducted from July to August 2020 in Lomaya irrigation secondary channels, Gorontalo, Indonesia with a length of 25.733 m. Samplings were done in 4 observation stations (Figure 1). (i) Station I is the entry point for secondary channel (Inlet) river water; the location is at the Lomaya dam, Lomaya Village, North Bulango Sub-district, Bone Bolango District. (ii) Station II is a secondary channel for receiving household waste and washing motor vehicles; the location is at Jalan Tondano, Bulotadaa Barat Village, Sipatana Sub-district, Gorontalo City. (iii) Station III is a secondary channel for receiving household waste, workshops, agricultural waste, and washing motor vehicles; the location is at Jalan Arif Rahman Hakim, Dulalowo Village, Kota Tengah Sub-district, Gorontalo City. (iv) Station IV is the place where water comes out from the secondary channel (outlet) at Jalan Yos Sudarso, Tenda Village, Hulonthalangi Sub-district, Gorontalo City.

Procedure
Preparation of samples
Water test sampling for lead inspection: (i) the sampling point area was determined, (ii) the jerry cans were rinsed 2-3 times with sample water, (iii) water sample was taken using a 600 mL jerry can (Kitong et al. 2012).

Sediment sampling for lead examination: (i) the sampling area point was set, (ii) sediment was taken using a paralon pipe vertically, (iii) the sediment obtained was separated, cleaned from other objects and inserted into the plastic (Rangkuti 2009).

Sampling of golden snails for lead examination: (i) the sampling area was determined by plotting the size of 1 m x 1 m, (ii) the snails were taken and put into a plastic container that had been labeled and put into a coolbox (Nur et al. 2015).

Water sample preparation (SNI 6989.8:2009)
Fifty milliliters of water were put in a 100 mL Erlenmeyer, then added with 5 mL of concentrated HNO3 then covered using a funnel. Then, it was heated slowly until the remaining volume was 15-20 mL until it formed slightly white precipitate or the solution became clear. Then the funnel was rinsed and the rinsing water was put into a beaker. The solution was then transferred into a 50 mL volumetric flask and added with distilled water to the mark, and then homogenized. Then the solution was ready for analysis using AAS.
**Sediment sample preparation (SNI 06-6992.3-2004)**

The dry sediment as much as 3 grams were weighed and put in the Erlenmeyer, then added with 25 mL of distilled water and stirred using a stirring rod. Next, 5-10 mL of concentrated HNO₃ concentrated was added, stirred, then added with 3-5 boiling stones and then closed using a watch glass. Then Erlenmeyer was heated on a hot plate at a temperature of 100°C until the volume of the remaining solution was 10 mL. Then added with 5 mL of nitric acid, 5 mL of concentrated HNO₃, 3 mL of perchloric acid, 3 mL of concentrated HClO₄. Then it was reheld in an electric bath until the lead smoke was white and the test sediment solution became clear, then it was heated again for 30 minutes, then the sediment sample was cooled, and filtered with filter paper with a pore size of 8.0 μm. Furthermore, the results of the sediment sample filtrate were put into a 100 mL volumetric flask and distilled water was added to the mark. Then it was ready to be tested using AAS.

**Snail sample preparation (SNI 2354.5-2011)**

The snail was weighed as much as 5 grams. Then, a spiked solution of 0.05 mg/kg (the result of a mixture of snail and 0.25 mL of standard Pb solution) was made, then evaporated on a hot plate with a temperature of 100°C until dry, then the sediment and spiked were inserted into the ashing furnace in stages from 100°C-450°C every 30 minutes to 18 hours. Then it was cooled at room temperature and added with 1 mL of HNO₃ 65%, then the solution was homogenized, then it was evaporated again on a hot plate at 100°C until dry. Next, the snail and Spiked samples were put back into the ashing furnace, and the temperature was gradually increased to 100°C every 30 minutes until the temperature reached 450°C, and maintained for 3 hours. After the ash turned white, the snail and spiked samples were cooled to room temperature. As much 5 mL of 6 M HCL was added to each sample of snail and spiked was homogenized until the ash was dissolved in the acid. Then it was reheld on the hot plate at 100°C until dry. Then 10 mL of 0.1 M HNO₃ was added and chilled for 1 hour; then, the solution was transferred to a 50 mL polypropylene, modifier matrix solution was measured and added to the limit mark. The sample was ready to be tested using AAS.

**Data analysis**

The concentrations of lead in the water were compared with the quality standards set in Government Regulation no. 82 of 2001 concerning water quality management and water pollution control, which is 0.03 mg/L, the concentrations of lead in sediments were compared with quality standards set in the Decree of the Minister of Environment No. 51 of 2004, and the concentrations of lead in snails were compared with the quality standard set in SNI 7387: 2009 regarding the maximum limit of heavy metal contamination in food.

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**RESULTS AND DISCUSSION**

**Lead levels in water**

The lead levels in water were different among stations (Figure 2). The water in station III had the highest level of lead, i.e., 1.69 mg/L, while the water in station I the least, i.e., 0.37 mg/L.

**Levels of lead in sediment**

The lead contents in the sediment were different among stations. The sediment in station I had the highest level of lead, i.e., 1.1268 mg/kg, while the water in station IV the least, i.e., 0.5290 mg/kg (Figure 3).

**Levels of lead in mollusks**

Mollusks were found only in stations II and III. In station II, 2 species of gastropods were found, namely Bellamnya sp. and Pomacea canaliculata, and in station III only Pomacea canaliculata was found. The lead levels of each species at station II were 0.2924 mg/kg and 0.2413 mg/kg, respectively, and at station III 0.1873 mg/kg (Figure 4).

**Environmental parameters**

The water temperature at 4 stations ranged from 24°C to 30°C with an average of 27.5°C. The pH of the water was the same for all stations, i.e., 7. Dissolved oxygen levels were different among the four stations: at station I, it was 4.8 mg/L, station II 3.1 mg/L, station III 1.3 mg/L and station IV 4.0 mg/L (Figure 5). The average value of dissolved oxygen level at the four stations was 3.3 mg/L.

![Figure 2. Lead content in water](image)

![Figure 3. Concentrations of lead in sediment](image)
The lead content in water at station IV was 4.8 mg/L, which was 30°C higher temperature than station II and station III. Pratama et al. (2012) reported that the content of lead in the air in the city of Semarang which is densely populated with vehicles was around 2-4 μg/Nm³, whereas, in rural areas where the vehicles were less dense, it was less than 0.2 μg/Nm³. The high concentration of lead in city air is due to the use of fuel that still contains tetraethyl lead (TEL) as an additive to increase the octane value of the fuel (Eshmat et al. 2014). Pratama et al. (2012) reported that the content of lead in Tapak River ranged from 0.01 to 1.11 ppm, which was thought to come from motorized vehicle pollutants in water bodies.

The lead content in water at station IV was low, i.e., 0.38 mg/L, due to the large channel size and the high current speed. High current velocity can cause dilution which affects lead levels in the waters (Happy et al. 2012).

The lead content in gastropods, water and sediment (Lamondo 2020) were higher than the lead content found in secondary data from DLHK Gorontalo province. The secondary data showed that the lead level in the water in the Bolango river, which is the source of water for irrigating the secondary irrigation channel, is <0.002 mg/L. The high lead content in this study is thought to be caused by waste disposal into secondary irrigation channels. Environmental parameters also affect the levels of heavy metal lead in water. The highest temperature occurred at station II and station III which was 30°C and both stations also had the highest levels of lead in the water, namely 1.30 mg/L-1.69 mg/L.

The lowest dissolved oxygen levels were found at stations II and III, namely 3.1 mg/L and 1.3 mg/L, respectively, while the highest DO was found at stations I and IV, namely 4.8 mg/L and 4.0 mg/L, respectively. A low DO concentration value can indicate that the waters are
polluted. Research conducted by Yunitawati (2012) reported that dissolved oxygen in the Cantigi river ranged from 1.11-4.1 mg/L, indicating that the Cantigi river was moderately polluted.

Lead measurements were also carried out in the sediment because sediment is widely used as an indicator of the environment contaminated with metals in water (Ali et al. 2016). Research on heavy metals in sediment and water can be used to measure the impact of metals produced by industry, households and activities which can cause water pollution. The lead levels in the secondary channels ranged from 0.5290 mg/kg to 1.1268 mg/kg, exceeding the threshold set by the Minister of Environment Regulation number 51 of 2004, which is 0.07 mg/kg.

Generally, the lead content in the sediment is higher than in the water because the heavy metals in the water will settle in the sediment. Cahyani (2017) found that the levels of lead in water ranged from 0.042-0.104 mg/kg while in the sediment ranged from 1.56-1.98 mg/kg. The concentration of lead in the sediment is influenced by environmental factors, namely temperature. Happy (2012) states that the drop in water temperature will cause metals to easily settle into the sediments. Parallui (2013) also states that an increase in seawater temperature can reduce the absorption of heavy metals in fine particles from pollution that settle on the bottom of the water. When the water temperature rises, heavy metal compounds will dissolve in the water due to the decrease in velocity of settlement into the particles. The lowest temperature in the secondary irrigation channel occurred at station I, namely 24°C.

Gastropods can be used as bioindicators of environmental pollution because they have low mobility characteristics, live in the bottom of the waters and are filter feeders. Generally, Pomacea canaliculata and Bellamnya sp. filter the food around them. Widowati et al. (2019) state that golden snails get food by filtering food, so they can accumulate lead.

Gastropods were found only in 2 observation stations, namely at stations II and III. At station II there were 2 species of Gastropods, namely Bellamnya sp. and Pomacea canaliculata and at station III only 1 species, namely Pomacea canaliculata. Gastropods were found in only 2 stations, because these stations have muddy substrates, which gastropods prefer, and are close to rice fields. Isnaningsih et al. (2011) state Pomacea canaliculata can be found in rice fields, lakes, or swamps and these snails like muddy substrates. Sari et al. (2011) also state that Bellamnya sp. likes muddy substrates and running water.

The lead levels in gastropods ranged from 0.1873 mg/kg to 0.2924 mg/kg, much lower than the threshold set in SNI 7387: 2009 regarding the maximum limit of lead contamination in food, which is 1.0 mg/kg. The lead content in gastropods was lower than the lead content in water, which was 0.37 mg/L to 1.69 mg/L. This is in contrast with the results of research conducted by Wulandari et al. (2012) that the lead content in S. glomerata oysters was higher than in water, namely 0.505 mg/kg-2.960 mg/kg, and in water only 0.0035 mg/L-0.0470 mg/L. The lower level of lead in the gastropods compared to that in the water is probably caused by physiological processes that occur in the body of the snail. The body of the snail has the protein metallothionein (MT) which has the ability to bind lead in the body. The MT which contains about 30% of cysteine contains residual thiols. There are 2 domains that function to bind different metals, namely α- and β- (Smith et al. 2015).

Metallothionein is divided into 4 groups, namely MTI, MTII, MTIII, and MTIV. Metallothionein can be found in all living things such as bacteria, mammals, vertebrates and invertebrates. MT can also be found in various body tissues such as kidneys, liver, testes, muscles, intestines, gills, blood, epithelial cells and urine. The MT concentration will increase if the organism accumulates more heavy metals in its body. After being detoxified, heavy metals will be excreted in the urine (Engel 1984).

The low level of lead in the snails’ body compared to the level of lead in the water may also be caused by the small size of the snail, so the possibility of contact between the snails and the lead in the water was low. This was confirmed by Wulandari et al. (2012) who stated that the high Pb content in S. glomerata oysters was influenced by the width, height, and length, and so, a large oyster was able to accumulate more metal than the small one. This study concluded that the lead levels in water, sediment and gastropods in the study sites exceeded the threshold set by the government.

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