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Heavy Metal Levels of Lead and Cadmium in Baronang Fish from South Sulawesi, Indonesia

Niveles de metales pesados de plomo y cadmio en el pez Baronang del sur de Sulawesi, Indonesia

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SUMMARY

Objective: *The purpose of this study was to determine the content of the heavy metals in the Baronang fish at Kayu Bangkoa pier and the Kera-Kera Pier in the Makassar city, South Sulawesi, Indonesia in 2020.* **Methods:** *This was an observational descriptive approach research. The accidental sampling technique was used at two locations, Kayu Bangkoa pier, and Kera-Kera pier. Baronang fish samples were taken using fishing rods or nets and each bait was examined and analyzed in the laboratory.* **Result:** *The results of the examination of Baronang fish samples from each sample at three different points around the Bangkoa Wood Pier, indicated a lead (Pb) parameter for sample 1 was 0.14 µg/g, for sample 2 <0.001 µg/g, while sample 3 was <0.001. For the parameter of cadmium (Cd), sample 1 yield was 10.087 mg/g, sample 2 was 0.085 mg/g, and sample 3 was 0.086 mg/g. The results of the examination of the Baronang fish sample indicate that lead (Pb) and cadmium (Cd) parameters were below standard SNI 7387: 2009, namely lead (Pb) 0.3 and cadmium (Cd) 0.1. While the results of the examination of Baronang fish samples from each sample at three different points around the Kera-Kera Pier indicated lead (Pb) parameters for sample 1 which were <0.001 µg/g, sample 2 <0.001 µg/g and sample 3 <0.001.* **Conclusion:** *The Baronang fish samples at three points of Bangkoa Wood Pier presented a Pb parameter below the SNI 7387: 2009 standard, namely lead (Pb) 0.3, while the results of the cadmium (Cd) examination of the three samples all had passed the maximum limit of the SNI standard 7387: 2009, that was 0.1.*

Keywords: *Baronang fish, cadmium (Cd), environmental, lead (Pb).*

RESUMEN

Objetivo: *El propósito de este estudio fue determinar el contenido del metales pesados en el pez Baronang en el muelle de Kayu Bangkoa y el muelle de Kera-Kera en la ciudad de Makassar, South Sulawesi,*

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Indonesia en 2020. **Métodos:** *Se utilizó un enfoque observacional descriptivo. La técnica de muestreo accidental se utilizó en dos lugares, el muelle de Kayu Bangkoa y el muelle de Kera-Kera. Se tomaron muestras de peces Baronang utilizando cañas de pescar o redes y luego cada cebo se examinó y analizó en el laboratorio.* **Resultado:** *Los resultados del examen de las muestras de pescado Baronang en tres puntos diferentes alrededor del muelle de madera de Bangkoa indicaron parámetros de plomo (Pb) de la muestra 1 de 0,14 μg/g, la muestra 2 <0,001 μg/g mientras que la muestra 3 fue <0,001. Para el parámetro de cadmio (Cd) la muestra de 1 fue de 0.087 mg/g, la muestra 2 de 0.085 mg/g y la muestra 3 de 0.086 mg/g. Lo que indican parámetros de plomo (Pb) y cadmio (Cd) para el pescado Baronang con valores por debajo del estándar SNI 7387: 2009, a saber, plomo (Pb) 0,3 y cadmio (Cd) 0,1. Mientras que los resultados del examen de muestras de pescado Baronang de tres puntos diferentes alrededor del muelle de Kera-Kera indicaron para parámetros de plomo (Pb) que la muestra 1 era <0,001 μg/g, la muestra 2 <0,001 μg/g y la muestra 3 <0.001.* **Conclusión:** *Las muestras de pescado Baronang tomadas en tres puntos indicaron parámetros de plomo (Pb) por debajo del estándar SNI 7387: 2009, mientras que los de cadmio (Cd) superaron el límite máximo de la norma SNI 7387: 2009.*

Palabras clave: *Pez Baronang, cadmio (Cd), ambiental, plomo (Pb).*

INTRODUCTION

Heavy metal contamination of aquatic ecosystems has been a problem in environmental health for decades. Heavy metals are highly hazardous contaminants due to their persistence, toxicity, and bioaccumulation in various segments of the environment, such as water, sediments, air, and biota (1,2). Heavy metal concentrations lower than the required amounts may cause deficiency effects, while high concentrations of these metals lead to health problems (3). Toxic metals including lead (Pb) and cadmium (Cd) are hazardous because they can cause severe health problems in minute quantities (4,5).

One of the most vulnerable environmental aspects of heavy metal contamination is water (6). Coastal ecosystems are very sensitive to heavy metal contaminants. In this case sediments and marine organisms can accumulate pollutants, and fish can get enriched with metals that are subsequently transferred to man through human consumption (7).

Recently, heavy metal pollution in an aquatic ecosystem is becoming a critical issue. Based on the results of provenance analyses of heavy metals suggest that geogenic sources were the main source of water contamination (8,9). Nonetheless, industry activity and human activities have increased concentrations of heavy metals above normal levels in the environment contributing to serious and widespread environmental issues leading to chronic toxicity (10-13).

In line with this, in Indonesia based on research conducted by the Oceanography Center of LIPI (The Indonesian Institute of Science), reported that high levels of metals are generally detected at the stations located close to the mainland, indicating that heavy metals are enrichment from terrestrial anthropogenic activities (14).

In a study about the incidence of Pb, and Cd in seafood from Africans on the Indian and the Red Sea coasts, it was found that some seafood from African Indian and the Red Sea coasts such as fish have presented Cd and Pb concentrations of higher than permitted limit by FAOUN/EU regions, indicating a possible threat to public health (15).

Based on a study on the bioaccumulation of Cadmium (Cd) and Chromium (Cr) contained in water and fish carried out in the Tallo Makassar river using quantitative and observational methods, it was found that the cadmium content in 3 research points was <0.003 mg/L (13) . This cadmium content fulfills the requirements based on the determination of heavy metal content which refers to the government regulation PP number 82 of 2001 concerning Water Quality Management and Water Pollution Control with the designation of water with class II criteria, where the maximum cadmium (Cd) content is 0.01 mg/L. The content of heavy metal cadmium in this fish is not only caused by industrial activities but also due to the densely populated environmental conditions and the behavior of the people who always dispose of domestic waste in the area around the river (13).

In addition, based on research conducted in the waters of Benoa Bay, Bali, it was found that the content of heavy metals Pb and Cd in the water had exceeded the quality standards for dissolved metals in water for marine biota as stated in the

Bali Governor Regulation No. 16 of 2016. For the Baronang fish itself, the content of heavy metal Cd has exceeded the maximum limit of metal contamination, which is 0.1 mg/kg, while the Pb content in some samples has exceeded the maximum limit of heavy metal contamination of SNI 7387: 2009 (16). Cd drug and supervisory food body (BPOM) 0.10, Pb 0.20 NAV.

Fish are a significant bioindicator of heavy metal contamination in the aquatic ecosystem, as they are at the top of the food web and can accumulate considerable amounts of heavy metal in their tissues (13,17-19). Generally, higher concentrations of metals were found in the liver and gills than in muscles (20). A study using a dry ashing-acid digestion method in fish collected from Sri Murni Lake and Kepong Metropolitan Lake around Kepong district, Kuala Lumpur, found that the highest concentration of Pb was detected in the gills (0.151 ± 0.12 mg/g) while Cd, was highly accumulated in the bones (1.750 ± 3.43 mg/g) (21).

The evidence indicate that, water and the ecosystem in it are very susceptible to being contaminated by heavy metals which have a broad impact on long-term public health conditions. Therefore, periodic research and monitoring of water and fish quality should be given attention so that the quality of the lake ecosystem, especially in relation to heavy metal elements, is under control which makes activities involving water contact safe (10). Thus, the purpose of this study was to determine the content of the heavy metal lead (Pb) in the Baronang fish at Kayu Bangkoa pier and the Kera-Kera Pier in the city of Makassar, South Sulawesi, Indonesia in 2020.

METHODS

The method used in this study was sampling using the incidental sampling method, at two locations of the Bangkoa Wood Pier and the Kera-Kera Pier. Baronang fish samples were taken using fishing rods or nets and each bait is then examined and analyzed in the laboratory. Primary data collection was done utilizing field observations or reviewing the research location by taking samples of Baronang fish then examined and analyzed in the laboratory.

Baronang fish examination samples were taken at six points at two locations of the Bangkoa Wood Pier and the Kera-Kera pier. Then measured using Automic Absorption Spectrophotometer (AAS) equipment by laboratory staff, in the South Sulawesi Provincial Health Office Laboratory.

RESULTS

This research was conducted in two different places with sampling on 20 November 2020 at the Kayu Bangkoa pier in the Bulogading Village Ujung Pandang sub-district and on March 20, 2016, at Kera-Kera Pier in Tamalanrea Indah Village, Tamalanrea District, then the clean water samples were taken to the Great Hall Makassar Health Laboratory, South Sulawesi Province to determine the results of examining clean water samples.

Based on the results of the examination of Great Hall Makassar Health Laboratory, South Sulawesi Province, with samples of Baronang Fish, to determine water quality based on SNI 7387: 2009, the maximum limit of heavy metal contamination in food was as follows: categorize "Qualified (Q) = not reach the maximum limit)" and "Unqualified Qualified (UQ) = reach the maximum limit).

Table 1 shows that the samples of Baronang Fish originating from the Bangkoa Wood Pier were taken at the first point for lead (Pb), and contain the following heavy metals: sample 1: 0.14 μg/g, sample 2 <0.01 μg/g, and sample 3 <0.01 μg/g. As for the results of cadmium (Cd) sample, sample 1 was 0.087 μg/g, sample 2 was 0.085 μg/g, and sample 3 was 0.086 μg/g . From the results of the sample examination on Baronang Fish, all of them were at levels below the SNI 7387: 2009 standard, namely 0.03 mg/kg for lead (Pb), and cadmium also meet the requirements, namely 0.1 mg/kg.

Table 2 shows that the samples of Baronang Fish originating from the Kera-Kera Pier were taken at the first point for lead (Pb), presented the following levels, sample 1: <0.01 μg/g), sample 2 <0.01 μg/g, and sample 3 <0.01 μg/g, values that are below the standard of SNI 7387: 2009, namely 0.01 mg/kg. As for the results of the cadmium (Cd), sample 1 was 0.087 μg/g, sample

Table 1

Results of Sampling of Baronang Fish at the Bangko Wood Pier Bulogading Village Kec. Ujung Pandang

No .	Sample Code	Sample	Lead (Pb) (µg/ g)	Cadmium (Cd) (µg / g)	Level	
					Pb	Cd
1	Sample 1	Baronang fish	0.14	0.087	Q	Q
2	Sample 2	Baronang fish	<0.01	0.085	Q	Q
3	Sample 3	Baronang fish	<0.01	0.086	Q	Q

Source: Primary Data, 2020 *Q: Qualified

Table 2

Results of Sampling of Baronang Fish at Kera-Kera Pier Kelurahan Tamalanrea Indah Kec. Tamalanrea

No .	Sample Code	Sample	Lead (Pb) (µg/g)	Cadmium (Cd) (µg/g)	Level	
					Pb	Cd
1	Until 1	Baronang fish	<0.01	0.170	Q	UQ
2	Sample 2	Baronang fish	<0.01	0.301	Q	UQ
3	Sample 3	Baronang fish	<0.01	0.386	Q	UQ

Source: Primary Data, 2020 *UQ: Unqualified

2 0.085 µg/g, and sample 3 0.086 µg/g. From the results of the sample examination on Baronang Fish, all of them did not meet the requirements of the SNI 7387: 2009 standard, namely 0.01 mg/ kg for cadmium (Cd) while the lead (Pb) met the requirements, namely 0.3 mg/kg.

DISCUSSION

Fish has many health benefits due to its nutritional content. However, heavy metals contamination such as lead (Pb) and cadmium (Cd) in aquatic ecosystems, especially in fish, which is the daily consumption of the community, is a major threat to the quality of public health due to its negative impact due to long-term consumption (22).

The metals that pose the highest risks to human health are cadmium and lead, which cause important complications in the nervous system, kidneys, bones, lungs, and cardiovascular system due to their toxicity and possible carcinogenic effect (23). Even contamination of heavy metals has been linked to the development of mental retardation and even death in instances of very high exposure in the human body (20). Some of them contribute to the possible adverse effects, particularly in the fetus and young children (9).

Cd toxicity by consumption of contaminated fish can cause the following signs and symptoms: increased salivation, choking or vomiting, abdominal pain, vertigo, loss of consciousness, painful spasms of the anal sphincter, and impairment of renal function for severe toxicity (24,25).

Various systems are affected by Pb toxic exposure in fish, such as disruption of neurotransmitter function that occurs due to Pb accumulation causing neurotoxicity and

interfering with the immune system response (26). In humans, Pb can cause defined specific changes in gene and protein expression in response to lead challenges and determine the injurious effects of exposure to lead on a cellular level (27).

Acute Pb toxicity after ingestion of contaminated seafood usually occurs in the brain and kidney, and its absorption in the gastrointestinal tract is influenced by nutritional calcium and iron status and age (children adsorb more, and consequently, are more vulnerable than adults (28)).

Exposure pathways (dietary and waterborne), environmental factors (salt-water or freshwater), and Pb binding capacity with protein influence the accumulation pattern of heavy metals exposure. The main cause of heavy metal contamination in the African countries bordering the Indian Ocean and the Red Sea port activity, tourism, and petroleum activities (15). In Pakistan, particularly in the Swat River, heavy metal contamination might be due to geogenic (mafic and ultramafic rocks) and anthropogenic activities including industrialization, municipal water, pesticides application, wastewater from farm fields sewage sludge, automobile workshops, mining effluents, hotels effluents and urban districts including (Charsadda Malakand Agency and Swat) located near Swat River (29).

Similar to other countries, in Indonesia, especially in Makassar, heavy metal contamination of cadmium (Cd) and lead (Pb) in waters and fish occurs due to various activities such as ports, tourism, and fisheries activities. Besides that, the density of human settlements which causes a large amount of waste and industrial wastewater is also a major factor in pollution in water areas (30).

Even though the concentration of heavy metals in the waters, especially in fish, is still below the threshold, the control and monitoring of heavy metals in fish are most important to minimize associated fish poisoning (15). Toxic heavy metal(loids) (THMs) are released into natural water systems from geological and anthropogenic sources and easily accumulated via water and sediments in aquatic fish species . The monitoring of THMs concentrations in river water, sediments, and fish muscles is, therefore, essential to make sure acquiescence with food security guidelines and resulting end-user safety (29).

Levels of lead (Pb) and cadmium (Cd) Heavy Metals in Baronang Fish at Bangkoa Wood Pier

Water conditions contaminated by various metals will significantly affect the aquatic ecosystem in both inland and marine waters. Lead (Pb) is a metal that is widely used by humans, so this metal also causes contamination impacts on the environment. Pb metal pollution can also be caused by the entry of industrial waste containing Pb metal into water bodies. Furthermore, with the presence of the biomagnification process in the waters, the concentration of Pb metal will continue to increase. Heavy metals enter the fish's body tissues through several ways, namely: the respiratory tract (gills), the digestive tract (intestines, liver, kidneys) through the process of the food chain, and penetration through the skin (flesh muscle) (31).

It was done an examination at the Baronang Fish Testing Laboratory at the Makassar Health Laboratory Center, South Sulawesi Province of samples of Baronang fish originating from two different pier areas, in Bulogading and Tamalanrea Indah sub-districts, taken at 6 different points. The results of the examination of Baronang fish samples at 3 points taken around the Bangkoa Wood Pier, demonstrated that lead (Pb) levels were in sample 1 of 0.14 μ/g, for sample 2 of <0.001 μg/g while sample 3 resulted <0.001. For cadmium (Cd) sample 1 resulted in 0.087 mg/g, sample 2 0.085 mg/g, and sample 3 with 0.086 mg/g. This data indicated that from the examination of the Baronang Fish samples at three points, the levels of lead (Pb) and cadmium (Cd) are below the standard of SNI 7389: 2009. Meanwhile, Budiman research at the Wangisgara station in the upstream Citarum river showed that the cadmium (Cd) content in Betok fish was 11 ppb with a weight of 22.9 g, for 92 ppb catfish with a weight of 36.9 gr and a high level of cadmium (Cd) in Betok fish. Cadmium (Cd) in Tilapia was 105 ppb with a weight of 20.2 g. Thus, the three types of fish have exceeded the quality standards set by SNI 7387: 2009 concerning the limit of metal contamination in fish meat and its processed products (32).

At point 2 there is the Losari Beach Platform around Losari Beach. There are houses, Stella Maris Hospital, Siloam Hospital, Arya Duta

Makassar Hotel, Aerotel Smile Makassar, D'bugis Ocean, Anging Mammiri Hotel, and community settlements that can produce liquid waste and solid which can cause heavy metal pollution. This suggests that heavy metals originating from human activities can come from industrial or household waste materials, and are from sludge from dirty drains, recycling, and lead-containing manufactured products (gasoline, paint, printing ink, main water pipes, tin solder cans, and battery casings. The solubility of heavy metals in water bodies is controlled by the degree of acidity of the water, the type, and concentration of metals, and the state of mineral components (33).

Point 3 is near the Container Port where occurs the entry and exit of cargo ships around the area which can induce pollution such as Oil Spills, Hotel Pantai Gapura, Hotel Makassar Golden and Cafe Balliriate, and Zona Cafe Borate metal was not identified because it is still influenced by sea characteristics such as tides, sea breezes, and saltwater infiltration.

Levels of Heavy Metal Lead (Pb) and Cadmium (Cd) in Baronang Fish at Kera-Kera Pier

Cadmium (Cd) enters the environment because of human activities. Cadmium (Cd) in water bodies can come from atmospheric deposits, dust, sewage processing water, and industrial wastewater. Cadmium enters the water more due to human activities such as industry where the waste products from the factory are discharged directly into the water which will accumulate at the bottom of the waters and form sediment. Cadmium (Cd) can also enter organisms that live in water where Cadmium (Cd) can enter via oral, inhalation, or dermal. Cd enters the body of an organism, for example, as fish.

We assessed samples in Baronang Fish Testing Laboratory at the Makassar Health Laboratory Center, South Sulawesi Province that the samples of Baronang Fish originating from two different pier areas, in Bulogading and Tamalanrea Indah Villages, were taken at 6 different points from two different piers. The results of the examination of Baronang fish samples at 3 points taken around the Kera-Kera Pier were for lead (Pb) on sample 1 were of <0.001 μg/g, for sample 2 <0.001 μg/g, while sampling 3 with a < 0.001. For cadmium (Cd) sample 1 yield 0.170 mg/g, for sample 2 0.301 mg/g, while for sample 3 0.386 mg/g, indicating that the levels for Pb are below the SNI 7387: 2009 standard, while Cd passed the maximum limit of the SNI 7387: 2009 0.1 standards.

The results of the examination of Baronang fish samples on the heavy metal Cadmium (Cd) were identified at point 1, in the vicinity of the Kera-Kera Pier, where the area is adjacent to the pond, residential areas that have an impact on waste disposal and plastic waste disposal, and a stopover for passenger and sea boats where the boat uses fuel engines. Cadmium fuel contains up to 0.5 ppm. Similarly, Latif et al. (34) assessed the quantity and quality of river water as a source of raw water Tallo conducted the Tallo River watershed. The study aimed to determine the quantity and quality of Tallo River water that can be used as a source of standard water in this water provider to meet the needs of the city of Makassar. Tallo River has several settlements, the Steam Power Plant (PLTU), the plywood factory industry, aquaculture, and agriculture. Based on the description of the location with the location of Tallo River drainage of waste products from the surrounding location and the length of the watershed that crosses the township in the city of Makassar, it can be a harmful and negative impact on humans and the environment. Of measurements using meter current as primary data in calculating the flow obtained Tallo River that Tallo river discharge of 33.8 m^3/sec. In terms of water quality, there were 3 parameters of concern, that is parameters of Physical, Chemical, and Biological. They concluded that the water quality in the Tallo River is included in the Group B Water Quality Standards (Quality Standards and Criteria for Environmental Damage) Pursuant to the Governor of South Sulawesi. Whereas Setiawan demonstrated at point 3 that the waters of the Tallo River are experiencing high pressure due to the presence of settlements, PLTU, aquaculture, and agriculture. Point 3 is also not far from the Pampang River, causing pollution and a lot of getting into the water (35). Pampang River is flanked by the Tallo River (70 km from the length of the main river) to the north there are several settlements, the alcohol industry, the chocolate processing industry, and hospitals. Thus, Cadmium (Cd) found in this river could enter the body, being the greatest cadmium

concentrations found in the kidneys and the liver. Urinary cadmium excretion is slow; however, it constitutes the major mechanism of elimination. Due to slow excretion, cadmium accumulates in the body over a lifetime, and its biological half-life may be up to 38 years.

CONCLUSION

The results of an examination of Baronang fish samples from each sample at three different points around the Bangkoa Wood Pier found that the lead (Pb) parameters stated that of the sample examination on Baronang Fish, all the samples were below the SNI 7387: 2009 standard, namely 0.03 mg/kg for lead (Pb) and cadmium also meet the requirements, 0.1 mg/kg.

The results of the examination of Baronang fish samples from each sample at three different points around the Kera-Kera Pier with lead (Pb) parameters stated that originating from the Kera-Kera Pier were taken at the first point for lead (Pb), found all samples below the standard of SNI 7387: 2009, namely 0.01 mg/kg. As for the results of the cadmium (Cd) from all the samples, they are above the maximum limit of the requirements of the SNI 7387: 2009 standard.

Suggestions

Suggestions to the public and industry who live and have activities in the coastal areas and streams around the Bnagkoa Timber Pier to reduce the risk of pollution such as direct disposal of garbage and waste into rivers/sea.

It is also expected that the community will maintain the sanitation of the industrial environment around the Tallo River basin which uses heavy metal materials such as Cadmium (Cd) to carry out better treatment of their waste before being discharged into the environment to reduce the pollutant load that enters the waters of the Tallo River, Makassar City.

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Authors' Contributions

All contributors contributed significantly to this study and all authors agree with the content of the manuscript.

Conflict of Interest

The author(s) declared no potential conflicts of interest with respect to the research authorship, and/or publication of this article.

Availability of Data and Materials

All data generated or analyzed during this study are included in this published article.

Ethical Approval

This article received ethical clearance from *Ethic Commission, Universitas Muslim Indonesia*. Registration Number: UMI0320015671.

Significance for public health

Indonesia is one of the largest consumers of fish in the world. Heavy metal contamination has been a problem in environmental health that can affect human health . This study describes the content of the heavy metal lead (Pb) in the Baronang fish at Kayu Bangkoa pier and the Kera-Kera Pier in the city of Makassar, South Sulawesi, Indonesia in 2020.

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