JPPIPA 10(4) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Measurement of Heavy Metal Mercury (Hg) Content in The Swamp Eel (*Monopterusalbus*) as a Bioindicator from Lake Rawa Taliwang

Dinda Noviantika[1], Khairuddin[1], M. Yamin[1]

[1] Biology Education, Faculty Teacher Training and Education, Mataram University, Mataram, Indonesia

Received: February 28, 2024
Revised: April 13, 2024
Accepted: April 25, 2024
Published: April 30, 2024

Corresponding Author:
Khairuddin
khairuddin.fkip@unram.ac.id

DOI: 10.29303/jppipa.v10i4.7324

Abstract: The presence of heavy metals in Lake Rawa Taliwang can originate from various activities in the upstream river, around settlements, and within the lake itself. Mercury (Hg) is a highly toxic heavy metal due to its neurotoxic nature, affecting both organisms and humans. One of the fish found in Lake Rawa Taliwang is the swamp eel. Swamp eels are often caught for consumption and cultured by the local community. This study aims to determine the mercury (Hg) concentration in swamp eels (*Monopterus albus*) and assess their suitability for consumption. Sampling was conducted using purposive sampling technique at two stations with two replications at each station. Data analysis involved determining mercury concentration in the swamp eel samples using Atomic Absorption Spectroscopy (AAS). The results showed that the mercury concentration in swamp eels from Lake Rawa Taliwang was 0.13 mg/kg. According to the BPOM regulation no. 9 of 2022, the mercury concentration in these swamp eels is still below the permissible limit for metal contamination in food. This indicates that swamp eels were taken from Lake Rawa Taliwang is safe for consumption.

Keywords: Bioindicator; Heavy Metals; Mercury; Monopterus albus

Introduction

The lake is part from a region with form basin big on the surface Earth containing fresh water or salt water and surrounded by land. One of them many lake in Indonesia which is in the West Sumbawa area, namely lake Swamp Taliwang. Swamp Lake Taliwang Enough famous with Lake Lebo Taliwang is called by the community around. Swamp Lake Taliwang own possible area of 820 ha happen various surrounding activities start from activity agriculture, mining and industry electronic. His height activity humans around lake can cause exists content metal heavy (Khairuddin et al., 2022).

Content metal the weight contained in the lake Swamp Taliwang can originate from various activity both upstream river, around settlements and on lakes. Pollution metal heavy to environment is a close process connection with use metal heavy by humans (Legiarsi et al., 2022).

Moreover from activity agriculture people who use it insecticides, herbicides, fungicides and fertilizers, then there is water opportunities and organisms that exist in Rawa Lake Taliwang contaminated metal heavy like copper and cadmium, even metal heavy others (Khairuddin et al., 2022; Kirana et al., 2022; Simanjuntak et al., 2012). Enhancement population resident in a area can cause happen increase in the volume of waste produced from activity. Besides that enhancement population resident give influence to its height metal heavy on something resulting environment from waste congested or liquid. Contamination metal heavy on the ecosystem waters in a way intensive relate with release metal heavy by waste domestic, industrial and activity man others (Budiastuti et al., 2016).

How to Cite:
Noviantika, D., Khairuddin, K., & Yamin, M. (2024). Measurement of Heavy Metal Mercury (Hg) Content in The Swamp Eel (Monopterusalbus) as a Bioindicator from Lake Rawa Taliwang. *Jurnal Penelitian Pendidikan IPA*, *10*(4), 1640–1647. https://doi.org/10.29303/jppipa.v10i4.7324

The condition of Rawa Taliwang Lake has been indicated to be experiencing heavy metal pollution as evidenced by several research results. Shoalichin et al. (2022) conducted research on the metal content of Pb in betok fish, obtaining a concentration of 0.1 mg/kg. Research by Khairuddin et al. (2023) also found that the heavy metal Hg content in rice field snails was at a concentration of 0.96 ppm – 1.91 ppm. The Sumbawa Regency Environmental Agency carried out monitoring at Rawa Taliwang Lake which found Hg content in one of the river points. The presence of Hg comes from community gold processing which has the potential to pollute the Rawa Taliwang lake (P3E Bali Nusra, 2016).

Hg or mercury is one of the most toxic elements among the heavy metals available and if exposed to high concentrations it will cause permanent brain damage and kidney damage (Yulis, 2018). Mercury (Hg) is a heavy metal that is very toxic because it is a neurotoxin, both for organisms and humans. As a heavy metal, mercury that enters the aquatic environment will be difficult to decompose. Apart from being deposited in water, mercury will also settle in sediment (Irsan et al., 2020). Mercury (Hg) is a type of metal that is often found in nature such as mountains and is distributed in rocks, mined grain, soil and air as organic and inorganic compounds. Generally levels in soil, water and air are relatively low. Various types of human activities can increase these levels, for example mining activities which can produce as much as 10,000 tons of mercury/year (Suryani et al., 2021).

One of the coal and mineral mining companies that has a permit to operate in the West Sumbawa Regency area is PT. Amman Mineral Nusa Tenggara (AMNT) which is located in Sekongkang sub-district (Wijimulawiani & Pradilla, 2023). Gold mining waste that is not managed properly can increase heavy metal pollution in the environment. The type of heavy metal that usually pollutes the environment due to gold mining is mercury (Nurbarasamuma et al., 2022). Mercury (Hg) that accumulates in waters can enter the bodies of aquatic biota, one of which is fish. Fish can actually avoid heavy metal pollution in waters because they are nekton organisms (Koniyo, 2020). In limited environmental conditions such as lakes, fish cannot avoid heavy metal pollution.

One of the fish found in Rawa Taliwang Lake is the eel. Rice eels are often caught for consumption and cultivated by local communities. Rice eel is a type of carnivorous fish that requires quite high levels of protein in its feed. Eels live in shallow and muddy waters, river banks, canals and lakes with a depth of less than three meters. The metal content found in the bodies of small fish consumed by eels can cause the accumulation of heavy metals. These heavy metals can accumulate in the fish's body for a long time (Rosahada et al., 2018). Consuming eel fish with mercury content in it can be dangerous to health. Health risks that can arise include acute poisoning, brain function abnormalities, anemia, miscarriage and decreased intelligence levels in children (Hidayat, 2020).

Based on the description that has been presented, researchers feel it is necessary to conduct research measuring mercury content using bioindicators for rice eel fish found in Rawa Taliwang Lake.

Method

Time and place study

This research was conducted at Rawa Taliwang Lake, West Sumbawa Regency. The samples used were taken at two stations with different coordinate points. Station 1 is at the coordinates 8°42'38.7" South Latitude and 116°51'13.3" East Longitude and station 2 is at the coordinates 8°42'17" South Latitude and 116°51'26" East Longitude. Sample processing and testing was carried out at the Mataram University Analytical Laboratory and the NTB Environmental Laboratory. The research was conducted from September to December 2023 This research was conducted at Rawa Taliwang Lake, West Sumbawa Regency. The samples used were taken at two stations with different coordinate points.

Station 1 is at the coordinates 8°42'38.7" South Latitude and 116°51'13.3" East Longitude and station 2 is at the coordinates 8°42'17" South Latitude and 116°51'26" East Longitude. Sample processing and testing was carried out at the Mataram University Analytical Laboratory and the NTB Environmental Laboratory. The research was conducted from September to December 2023.

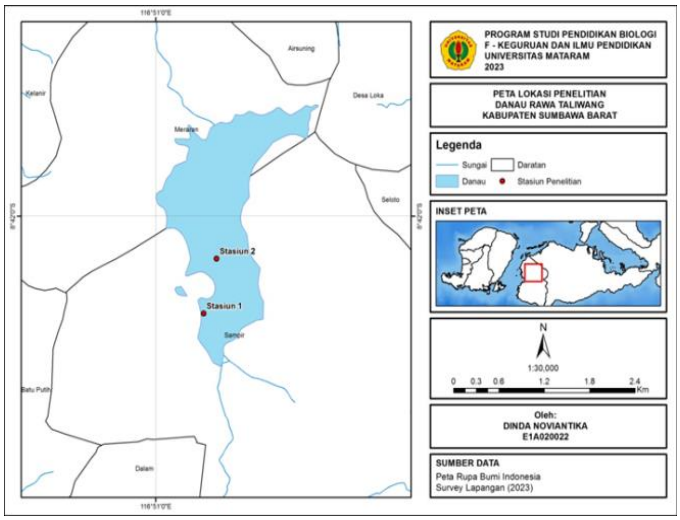

Figure 1. Research Location Map

Tools and materials study

The tools used in this research are field equipment and laboratory equipment. Field equipment includes pH meters, salinometers, conductivity meters, Secchi disks, Global Positioning System (GPS), cameras, fishing nets, cool boxes and writing instruments. Laboratory equipment includes refrigerators, knives, analytical balances, Kjeldhal flasks, Kjeldhal terms, volumetric pipettes, dropper pipettes, plastic spoons, filter paper, Petri dishes and a set of Atomic Absorption Spectrophotometry (AAS) equipment. The materials used included 2 rice eels from station 1 and station 2, distilled water, H_2SO_4, HCl 6 M, HNO_3 0.1 M, and HNO_3 65%.

Retrieval method sample

Rice eel samples were taken using a purposive sampling method through direct observation at Rawa Taliwang Lake. Rice field eels were caught using traps in two locations, namely station 1 and station 2. 2 samples of eels were taken from station 1 and 2 eels from station 2. Then the samples taken were put in a fish box containing ice cubes, then taped and taken to the Analytical Laboratory of Mataram University. Next, the samples were placed in the refrigerator for 7 hours to maintain the freshness of the fish before processing.

Samples taken from the refrigerator were placed for 20 minutes at room temperature, namely 20°C to 25°C, then cleaned and washed using distilled water. Rice eel meat from each sample was taken, then cut into small pieces and weighed 0.5 grams using an analytical balance. Next, the digestion process was carried out, namely the rice field eel meat was put into a different kjeldhal flask, then 1 gram of catalyst was added (a mixture of Na2SO4 and CuSO4 with a ratio of 20:1) and 6 ml of H2SO4 solvent. Add 5 ml of concentrated HNO3 to the sample solution. The sample was then heated to a temperature of 350°C using Kjeldhal Term for 2-3 hours until the solution was clear. If it is not clear then add 5 ml of HNO3 until the solution is clear.

Next, create a curve, namely the Hg working standard solution is prepared at a minimum of 5 coordination points. Working standard solutions and samples were read on AAS with a wavelength of 253.7 nm. AAS settings according to Mustofa (2017) include: wavelength 253.7 nm, acetylene rate at 2.0 L/minute, air flow rate at 10.0 L/minute, gap width at 0.5 nm.

Data analysis

Data analysis was carried out by calculating the concentration of mercury in rice eels using the following formula (S. Mulyani et al., 2012).

$$K = (a-b)\ W \times V \quad (1)$$

Information:

K = heavy metal content in the sample (mg/kg or ppm)

a = sample concentration value from AAS reading results (mg/l)

b = blank concentration value from AAS reading (mg/l)

V = final volume of sample solution (L)

W = sample weight (kg)

The results of calculating the Hg content were then compared with BPOM regulation Number 9 of 2022 concerning requirements for heavy metal contamination in processed food to determine the suitability of consuming rice eels taken from Rawa Taliwang lake. The maximum limit for Hg content in processed fish products is 0.50 mg/kg (except for processed predator fish such as shark, tuna, marlin, 1.0).

Result and Discussion

Findings of mercury (Hg) in samples rice field eels in Rawa Lake Taliwang

The process of measuring the mercury content (Hg) in the meat samples carried out at the West Nusa Tenggara Province Environmental Service Laboratory showed that there was mercury (Hg) content in rice eels from Rawa Taliwang Lake. The average concentration of mercury (Hg) content in rice eels at station 1 (8°42'38.7" South Latitude and 116°51'13.3" East Longitude) and station 2 (8°42'17" South Latitude and 116°51'26 " BT) got the same value, namely 0.13 mg/kg. The results of the analysis of mercury content in rice eels are presented in Table 1

Table 1. Mercury concentration

Sample location	Test	Concentration sample (mg/I)	content (mg/kg)
Station 1	1	0.0007	0.13
	2	0.0007	0.13
Station 2	1	0.0007	0.13
	2	0.0007	0.13

At each station 1 and station 2, environmental parameters such as pH, temperature and salinity were measured. The results of measuring environmental parameters can be seen in Figure 2.

These findings are supported by previous research conducted by Mulyani et al. (2023) which found that the mercury (Hg) content in tilapia fish from Rawa Taliwang Lake was 0.73 mg/kg. Based on previous research conducted by Azizah & Maslahat (2019), mercury was also found in other types of fish, namely wader fish at 0.630 – 1.029 mg/kg. Not only in fish, mercury is also found in rice field snails at 0.96 – 1.91 ppm based on research conducted by (Khairuddin et al., 2023). Apart from that, mercury also accumulates in other organisms

such as shellfish, based on the results of research conducted by (Khairuddin et al., 2018) found that the mercury content in several types of blood cockles (Anandara granosa) was 0.040 ppm, hiatula shellfish (Hiatula Chinensis) was 0.031 ppm and shellfish (Siliqua winteria) at 0.017 ppm.

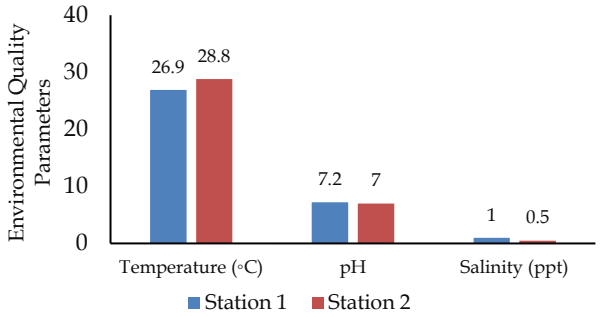

Figure 2. Environmental Parameters

The high content of mercury in water is the cause of the discovery of mercury content in aquatic organisms. The presence of mercury content in the aquatic environment is in line with research conducted by Rasul (2022) which found that the mercury content in water bodies in Parigi Moutong Regency was 12.67 – 13.60 (mg/L). This indicates that water bodies such as rivers are potential locations for finding mercury content. In fact, rivers are a form of aquatic ecosystem that has an important role in the hydrological cycle and functions as a water catchment area for the surrounding area, so that the condition of a river is greatly influenced by the characteristics of the surrounding environment (Budiastuti et al., 2016; Indirawati, 2017; Yaqin et al., 2015).

The mercury (Hg) content in Rawa Taliwang Lake is estimated to come from various human activities ranging from agricultural activities, gold mining and metal industry activities. Agricultural activities are estimated to have the potential to increase the mercury (Hg) content in Rawa Taliwang Lake. Supported by the research results of (Khairuddin et al., 2018), there is heavy metal content in mangrove plants in Bima Bay which is thought to come from agricultural areas around the research location. Not only that, the research results of Riyanti & Yeni (2021) reveal that there is a significant influence on the increase in mercury, especially in agricultural irrigation flows. The use of fertilizers, fungicides, insecticides, herbicides and other types of poison on agricultural land contain heavy metals which can accumulate in waters, especially during the rainy season (Haryanti & Martuti, 2020; Khairuddin et al., 2021; Zulfiah et al., 2017).

The existence of gold mining is also the cause of the mercury content in Lake Rawa Taliwang. In the hilly area around Rawa Taliwang Lake, many illegal mines are found (Wahyuni, 2019). The results of research conducted by Yulis (2018) stated that the impact of gold mining without a permit was proven to increase Hg levels caused by direct waste disposal. Waste from these activities enters the waters carried by water flows and empties into lakes, causing aquatic organisms to be exposed to heavy metal pollution (Saputri et al., 2023). According to Adhani & Husaini (2017) stated that naturally heavy metals enter in several ways, namely flows from upstream river areas due to erosion by water wave movements, due to volcanoes in the deep sea as well as particles or sediment due to chemical processes, and flows originating from environment around the estuary.

The presence of mercury in Rawa Taliwang Lake is also thought to come from metal industry waste around the lake. There are 9 metal goods industries located in West Sumbawa City. Water pollution due to the impact of industrial development can cause serious problems for the survival of marine biota, such as fish, shrimp, crabs, and others (Irianti et al., 2017). This is in line with research conducted by Rinawati (2021) showing the results of mercury concentration in waters 79 m from the industrial location of 1.17 ppm which is above the quality standard (0.05 ppm). Khairuddin et al. (2019) stated that mercury pollution will certainly increase along with the development of existing technology and industry. If industries that use heavy metals do not pay attention to environmental safety then heavy metal pollution cannot be avoided.

Feasibility of consuming rice eel fish in Rawa Taliwang Lake

Based on BPOM regulation no. 9 of 2022 which regulates the maximum limit for mercury content for processed fish products, namely 0.50 mg/kg. for the results of measurements carried out at the West Nusa Tenggara Province Environmental Laboratory using AAS (Atomic Absorption Spectophotometry) on rice field eels at station 1 (8°42'38.7" South Latitude and 116°51'13.3" East Longitude) and station 2 (8°42 '17" South Latitude and 116°51'26" East Longitude) with 2 repetitions of each sample, the same average concentration of mercury content in eels was obtained, namely 0.13 mg/kg. The average mercury content (Hg) in eel fish samples is presented in the data in Table 2

Table 2. Average Mercury Content in Fish Rice Field Eel

Sample location	Repetition	Content Hg (mg/kg)	Average (mg/kg)
Station 1	1	0,13	0,13
	2	0.13	
Station 2	1	0.13	0.13
	2	0.13	
Average Total (mg/kg)			0.13

This shows that eels are found in Rawa Taliwang Lake which is located at station 1 (8°42'38.7" South Latitude and 116°51'13.3" East Longitude) and station 2 (8°42'17" South Latitude and 116°51' 26" BT) is still below the threshold and is still suitable for consumption. However, the presence of mercury in rice eel fish has become a concern for all groups to reduce consumption of rice eel fish and pay attention to the environment around the lake so that there is no more waste pollution. The presence of mercury in rice eels occurs due to the bioaccumulation process of heavy metals due to mercury contamination in Rawa Taliwang Lake.

The bioaccumulation process of heavy metals can be influenced by many factors starting from the concentration of heavy metals in sediment, the concentration of heavy metals in water, the pH of water and sediment at the bottom of waters, the lower the pH of water and sediment, the more soluble heavy metals in the form of ions in water, the level of water pollution. in the form of COD (chemical oxygen demand), sulfur content in water and sediment, types of aquatic animals, age and body weight of aquatic animals, and life stages of eggs and larvae (Adhani & Husaini, 2017). Mercury compounds that enter organisms will experience biological changes (biomagnification) and cause significant disruption to the life of aquatic biota as well as humans as peak consumers (Irianti et al., 2017). So Mariwy et al. (2022) recommend not consuming fish that has been contaminated with mercury, even at low concentrations. Not only that, mercury that accumulates in the bodies of biota can stimulate enzymatic systems which can reduce the ability of biota to adapt to polluted environments.

There are several variations of the term heavy metal, but it is generally agreed that the use of the term heavy metals is closely related to its toxicity conditions. Heavy metals such as Hg are one of the pollutants because they have toxic properties with a tendency to enter the food chain system and the ability to remain in an environment for a long time (Sulistiono et al., 2018). In line with this statement, the Environmental Agency (BLH, 2010) explains that heavy metals become dangerous due to the bioaccumulation process. Bioaccumulation means an increase in the concentration of these chemical elements in the body of living creatures according to the food pyramid. Heavy metals can accumulate through the food chain, the higher the level of the food chain occupied by an organism, the accumulation of heavy metals in its body also increases (Koniyo, 2020).

Thus, humans who are peak consumers will experience a large bioaccumulation process of heavy metals in their bodies. Humans who occupy the highest trophic level of the food chain will accumulate the highest Hg metal compared to eels. Patients who are exposed to mercury through steam can experience problems with the respiratory tract and problems in the form of deterioration of brain function. Deterioration of brain function is caused by disturbances in the cortex. Mercury that enters the body either through inhalation or swallowing causes damage to the digestive tract, liver and kidneys. Mercury entering through the skin can cause local dermatitis (Adhani & Husaini, 2017). In addition, increased exposure to mercury can change brain function, triggering embarrassment, seizures, memory problems, irritability and changes in vision and hearing. Exposure to higher levels of metallic mercury fumes for a short time can trigger lung damage, vomiting, diarrhea, nausea, skin rashes and increased heart rate or blood pressure (Jaishankar et al., 2014).

The concentration of heavy metals in Rawa Taliwang Lake is influenced by environmental factors. Several physical and chemical factors in waters that influence metal absorption are salinity (sea water), alkalinity (fresh water), the presence of other chemical compounds, temperature and pH. Ismarti (2016) stated that the amount of heavy metals absorbed and distributed in the body of biota depends on the form of the compound, pollutant concentration, activity of microorganisms, sediment texture, and the biota that live in the environment. Temperature is an important factor for the life of aquatic organisms, because temperature can affect the metabolism and reproduction of aquatic organisms.

Based on the results of pH measurements at Rawa Taliwang Lake at station 1 it was 7.2 while at station 2 it was 7.0. These results indicate that the pH in Rawa Taliwang Lake can still be tolerated by the organisms in it. Based on the Decree of the State Minister for the Environment in 2004, the measurement results obtained were still within the quality standard, namely 6.5 – 8.5. According to Testi et al. (2019), heavy metals will form complex compounds with other compounds at a pH of more than 9. So the pH obtained has no effect on the toxicity of heavy metals in waters.

Based on the results of salinity measurements at Rawa Taliwang Lake at station 1 it is 1.0 while at station 2 it is 0.5. Differences in salinity greatly influence heavy metal concentrations. According to Testi et al. (2019), the lower the salinity, the higher the concentration of heavy metals. When there is a decrease in salinity due to desalination, the concentration of heavy metals will increase so that the level of bioaccumulation becomes greater (Hidayah et al., 2019).

Based on the results of temperature measurements carried out at Rawa Taliwang Lake at station 1 it was 26.9°C while at station 2 it was 28.8°C. The temperature in Rawa Taliwang Lake still supports the life of the organisms in it because the normal water temperature limit set by the Quality Standards Decree of the Minister

of the Environment in 2004 is in the range of 28-32°C. However, at station 1 with a temperature of 26.9°C, it was influenced by wave factors that existed at the time of the measurement. So that increasing temperature can increase the toxicity of mercury in waters (Mariwy et al., 2022; Rahardja et al., 2012).

Conclusion

Based on the research that has been carried out, it was concluded that the results of measurements carried out using AAS showed that the concentration of mercury in rice eels originating from Rawa Taliwang Lake was 0.13 mg/kg. Then, according to BPOM regulation no. 9 of 2022, the concentration of mercury in rice eels is still below the threshold for metal contamination in food. This shows that the rice eels taken from Rawa Taliwang Lake are suitable for consumption.

Acknowledgments
Thanks are expressed to the Analytical Laboratory of the University of Mataram, the NTB Environmental Laboratory, supervisors and fellow research team students at Lake Rawa Taliwang, West Sumbawa Regency

Author Contributions
This article was prepared by three authors, namely D.N, K, and M.Y. All members of the writing team carried out each stage together.

Funding
This research received no external funding.

Conflicts of Interest
The authors declare no conflict of interest.

References

Adhani, R., & Husaini, H. (2017). *Logam Berat Sekitar Manusia*. Lambung Mangkurat University Press. https://shorturl.asia/hJRjQ

Azizah, M., & Maslahat, M. (2019). Kandungan Logam Berat Timbal (Pb. *LIMNOTEK Perairan Darat Tropis Di Indonesia*, *1*(1), 83–93. https://doi.org/10.14203/limnotek.v28i2.331

Budiastuti, P., Raharjo, M., & Dewanti, N. A. Y. (2016). Analisis Pencemaran Logam Berat Timbal di Badan Sungai Babon Kecamatan Genuk Semarang. *Jurnal Kesehatan Masyarakat*, *4*(5), 119–125. https://doi.org/10.14710/jkm.v4i5.14489

Haryanti, E. T., & Martuti, N. K. T. (2020). Analisis Cemaran Logam Berat Timbal (Pb) dan Kadmium (Cd) Dalam Daging Ikan Kakap Merah (Lutjanus sp.) Di TPI Kluwut Brebes. *Life Science*, *9*(2), 149–160. https://doi.org/10.15294/lifesci.v9i2.47158

Hidayah, Y. N., Supriyantini, E., & Suryono, S. (2019). Efektivitas Gracilaria gigas sebagai Biofilter Logam Berat Tembaga (Cu) pada Media dengan Salinitas yang Berbeda. *Buletin Oseanografi Marina*, *8*(2), 87–95. https://doi.org/10.14710/buloma.v8i1.19486

Hidayat, R. (2020). *Pengaruh Pajanan Merkuri Terhadap Kadar Merkuri Rambut Ibu Hamil di Kabupaten Bulukumba Tahun 2020* [Universitas Hasanuddin]. Retrieved from https://repository.unhas.ac.id/id/eprint/3070/

Indirawati, S. M. (2017). Pencemaran logam berat Pb dan Cd dan keluhan kesehatan pada masyarakat di Kawasan Pesisir Belawan. *JUMANTIK (Jurnal Ilmiah Penelitian Kesehatan)*, *2*(2), 54–60. Retrieved from https://doi.org/10.30829/jumantik.v2i2.1165

Irianti, T. T., Kuswandi, K., Nuranto, S., & Budiyanti, A. (2017). *Logam Berat dan Kesehatan*. Grafika Indah.

Irsan, I., Male, Y. T., & Sellano, D. A. J. (2020). Analisis Kandungan Merkuri (Hg) pada Ekosistem Sungai Waelata dan Sungai Anahoni yang Terdampak Aktifitas Pertambangan Emas di Pulau Buru, Maluku. *Chem. Prog*, *13*(1), 31–38. https://doi.org/10.35799/cp.13.1.2020.29062

Ismarti, S. (2016). Pencemaran Logam Berat di Perairan dan Efeknya pada Kesehatan Manusia. *OPINI*, *1*(4), 1–11. Retrieved from https://shorturl.asia/sHmB7

Jaishankar, M., Tseten, T., Anbalagan, N., Mathew, M., Blessi, B., N., K., & Beeregowda, D. (2014). Toxicity, Mechanism and Health Effects of Some Heavy Metals. *Interdiscip Toxicol*, *7*(2), 60–72. https://doi.org/10.2478/intox-2014-0009

Khairuddin, K., Yamin, M., & Kusmiyati, K. (2021). Analisis Kandungan Logam Berat Tembaga (Cu) pada Bandeng (Chanos chanos forsk) yang Berasal dari Kampung Melayu Kota Bima. *Jurnal Pijar MIPA*, *16*(1), 97–102. Retrieved from https://shorturl.asia/FNuKd

Khairuddin, K., Yamin, M., & Kusmiyati, K. (2022). Analysis of Cd and Cu Heavy Metal Content in Climbing perch (Anabas testudineus) Derived from Rawa Taliwang Lake, West Sumbawa Regency. *Jurnal Biologi Tropis*, *22*(1), 186–193. Retrieved from https://shorturl.asia/QkNAq

Khairuddin, K., Yamin, M., & Kusmiyati, K. (2023). Analysis of (Hg) Heavy Metal Content in Rice Snail (Pila ampullacea) Derived from Rawa Taliwang Lake, West Sumbawa Regency. *Jurnal Biologi Tropis*, *23*(2), 414–421. https://doi.org/10.29303/jbt.v23i2.4875

Khairuddin, K., Yamin, M., & Syukur, A. (2019). Penyuluhan Tentang Sumber sumber Kontaminan Logam Berat Pada Siswa SMAN 1 Belo Kabupaten Bima. *Jurnal Pendidikan Dan Pengabdian Masyarakat*,

2(1). https://doi.org/https://shorturl.asia/GFxE3

Khairuddin, K., Yamin, M., Syukur, A., & Muhlis, M. (2018). Analisis Logam Pencemar Pada Klas Bivalvia Dari Teluk Bima. In *Prosiding Seminar Nasional Pendidikan Biologi* (pp. 784–787). Retrieved from https://shorturl.asia/6Hkxw

Kirana, G. C., Khairuddin, K., & Yamin, M. (2022). Analyss of Heavy Metal Content of Copper (Cu) in Cork Fish From Rawa Taliwang Lake, West Sumbawa Regency 2021. *Jurnal Biologi Tropis*, *22*(3), 1033–1039. https://doi.org/10.29303/jbt.v22i3.3957

Koniyo, Y. (2020). Analisis kualitas air pada lokasi budidaya ikan air tawar di Kecamatan Suwawa Tengah. *Jurnal Technopreneur (JTech*, *8*(1), 52–58. https://doi.org/10.30869/jtech.v8i1.527

Legiarsi, K., Khairuddin, K., & Yamin, M. (2022). Analysis of Cadmium (Cd) Heavy Metal Content in Headsnake Fish (Channa striata) Derived from Rawa Taliwang Lake, West Sumbawa Regency 2021. *Jurnal Biologi Tropis*, *22*(2), 595–601. https://doi.org/10.29303/jbt.v22i2.3509

Mariwy, A., Lerebulan, F., & Manuhutu, J. B. (2022). Analisis Kandungan Merkuri (Hg) Pada Beberapa Jenis Ikan Hasil Tangkapan Nelayan Di Desa Kaki Air Teluk Kayeli Pulau Buru. *Chemistry Progress*, *15*(2), 63 69. https://doi.org/10.35799/cp.15.2.2022.44488

Mulyani, I., Yamin, M., & Khairuddin, K. (2023). Analysis of Mercury (Hg) Content in Tilapia Fish (Oreochromis mossambicus) from Rawa Taliwang Lake to Enrich the Course Materials on Ecotoxicology. *Jurnal Penelitian Pendidikan IPA (JPPIPA*, *9*(1), 1–4. https://doi.org/10.29303/jjppipa.v

Mulyani, S., Lani, I. G. A., T., dan A., & S. (2012). Identifikasi Cemaran Logam Pb dan Cd pada Kangkung yang Ditanam di Daerah Kota Denpasar. *Bumi Lestari*, *2*(2), 345–349. Retrieved from https://doi.org/https://garuda.kemdikbud.go.id/documents/detail/1968205

Mustofa, M. H. (2017). *Penentuan Kadar Logam Kadmium (Cd) dalam Jamu Pegal Linu Menggunakan Variasi Zat Pengoksidasi Secara Spektroskopi Serapan Atom (SSA*. Skripsi Universitas Islam Negeri Maulana Malik Ibrahim Malang. Retrieved from http://etheses.uin-malang.ac.id/6489/

Nurbarasamuma, C., M., A., E., & Deniyatno. (2022). Pencemaran Logam Berat Hg, As, Cd Di Sedimen Sungai Langkowala Akibat Aktivitas Penambangan Kabupaten Bombana Sulawesi Tenggara. *Jurnal Lingkungan Almuslim*, *1*(1), 01–07. Retrieved from http://journal.umuslim.ac.id

Rahardja, B. S., Marsyalita, F., & Cahyoko, Y. (2012). Analisis Kandungan Merkuri (Hg) pada Air, Sedimen, Ikan Keting (Arius caelatus), dan Ikan Mujair (Oreochromis mossambicus) di Kali Jagir Surabaya [Analysis Of Mercury (Hg) in Water, Sediment, Keting Fish (Arius caelatus), and Mujair Fish (Oreochromis moss. *Jurnal Ilmiah Perikanan Dan Kelautan*, *4*(2), 113–118. Retrieved from https://e-journal.unair.ac.id/JIPK/article/download/11557/6573

Rasul, E. (2022). Analisis Kandungan Merkuri (Hg) pada Badan Air, Sedimen dan Biota yang Terdampak Aktivitas Pertambangan Emas di Kabupaten Parigi Moutong. *Jurnal Riset Kimia*, *8*(1), 39–44. https://doi.org/10.22487/kovalen.2022.v8.i1.15835

Rinawati, D. (2021). Pada Air Sumur Penduduk di Kampung Sayur Desa Talaga. *Jurnal Medikes (Media Informasi Kesehatan*, *8*(1), 91–100. Retrieved from www.jurnal.poltekkesbanten.ac.id/Medikes/article/view/228

Riyanti, H. B., & Yeni, Y. (2021). Determination of Level of Lead (Pb) and Cadmium (Cd) Migration on Bowl and Clear Plastic Cup Using Atomic Absorption Spectrophotometer. *IOP Conference Series: Earth and Environmental Science*, *819*(1), 12054. https://doi.org/10.1088/1755-1315/819/1/012054

Rosahada, A. D., Budiyono, & Yunita Dewanti, N. A. (2018). Biokonsentrasi logam berat tembaga (Cu) dan pola konsumsi ikan mujair di wilayah Danau Rawapening. *Jurnal Kesehatan Masyarakat*, *6*(6), 1–7. https://doi.org/10.14710/jkm.v6i6.22150

Saputri, A., Khairuddin, K., & Yamin, M. (2023). Analysis of Cadmium (Cd) Heavy Metal Content in Mosambique Tilapia Fish (Oreochromis mossambicus) Derived from Rawa Taliwang Lake to Enrich Ecotoxicology Lecture Material in 2022. *Jurnal Biologi Tropis*, *23*(2), 390–397. https://doi.org/10.29303/jbt.v23i2.4845

Shoalichin, L. M., Khairuddin, K., & Yamin, M. (2022). Analysis of lead (Pb) Heavy Metal Content Climbing Perch Fish (Anabas testusdineus) Derived from Rawa Taliwang Lake, West Sumbawa Regency 2021. *Jurnal Biologi Tropis*, *22*(3), 834–839. https://doi.org/10.29303/jbt.v22i3.3923

Simanjuntak, C., Zahid, A., & others. (2012). *Assessment of heavy metals (Al, Zn, Cu, Cd, Pb And Hg) in demersal fishes of Kuala Tanjung Coast, North Sumatra*. Retrieved from https://repository.unri.ac.id/handle/123456789/8162

Sulistiono, I., Y., & Lumban, B. D. T. F. (2018). Kandungan Logam Berat pada Ikan Beloso

(Glosogobius giuris) di PerairanSegara Anakan bagian Timur, Cilacap, Jawa Tengah, Indonesia. *Jurnal Pengolahan Hasil Perairan Indonesia*, *21*(3), 423–432. Retrieved from https://shorturl.asia/znDZT

Suryani, D., Darmawan, D., Sriwahyuni, S., & Yarmaliza, Y. (2021). Analisis Dampak Kandungan Logam Merkuri (Hg) pada Air Sungai Terhadap Kesehatan Masyarakat di Desa Paya Ateuk Kecamatan Pasie Raja Kabupaten Aceh Selatan. *Jurnal Jurmakemas*, *1*(2), 203–215. Retrieved from http://jurnal.utu.ac.id/JURMAKEMAS/article/view/4880

Testi, E. H., Soenardjo, N., & Pramesti, R. (2019). Logam Pb pada Avicennia marina Forssk, 1844 (Angiosperms: Acanthaceae) di Lingkungan Air, Sedimen, di Pesisir Timur Semarang. *Journal of Marine Research*, *8*(2), 211–217. https://doi.org/10.14710/jmr.v8i2.25212

Wahyuni, T. E. (2019). Lebo Taliwang Peyangga Kehidupan yang Perlu Pemulihan. *Jurnal Warta Konservasi Lahan Basah*, *27*(2), 3– 12. Retrieved from https://indonesia.wetlands.org/id/publikasi/warta-konservasi-lahan-basah-vol-27-no2-juni-2019/.

Wijimulawiani, B. S., & Pradilla, N. C. (2023). Analisis Pengaruh Sosial Ekonomi PT Amman Mineral Nusa Tenggara (AMNT) terhadap Tenaga Kerja di Desa Beru Kecamatan Jereweh Kabupaten Sumbawa Barat. *Jurnal Konstanta Ekonomi Pembangunan*, *2*(1), 77–90. https://doi.org/10.29303/konstanta.v2i1.521

Yaqin, K., Fachruddin, L., & Rahim, N. F. (2015). Studi kandungan logam timbal (pb) kerang hijau, Perna viridis terhadap indeks kondisinya. *Jurnal Lingkungan Indonesia (Vol. III No. 6)*, *309*, 317. Retrieved from https://shorturl.asia/Ur0ug

Yulis, P. A. R. (2018). Analisis Kadar Logam Berat Merkuri (Hg) dan (pH) Air Sungai Kuantan Terdampak Penambangan Emas Tanpa Izin (PETI. *Jurnal Pendidikan Kimia*, *2*(1), 28–36. https://doi.org/10.19109/ojpk.v2i1.2167

Zulfiah, A., Seniwati, S., & Sukmawati, S. (2017). Analisis Kadar Timbal (Pb), Seng (Zn) Dan Tembaga (Cu) Pada Ikan Bandeng (Chanos Chanos Forsk.) Yang Berasal Dari Labbakkang Kab. Pangkep Secara Spektrofotometri Serapan Atom (SSA). *As-Syifaa Jurnal Farmasi*, *9*(1), 85–91. https://doi.org/10.56711/jifa.v9i1.257