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Mozambique Tilapia Fish from Taliwang Lake as Bioindicator to Determine Lead Heavy Metal in 2022

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Abstract: This study aims to determine the content of the heavy metal Lead (Pb) in*mozambiqutilapia* fish fromRawa Taliwag Lake and to find out wheter*mozambiqutilapia* fish as a bioindicator originating from Rawa Taliwang Lake is suitable for consumption in accordance with The Indonesian Food and Drug Authority regulations Number 9 of 2022 concerning Requirements for Heavy Metal Contamination in Processed Foods. This research is a quantitative descriptive research. Sampling was carried out using purposive sampling method. The number of samples taken as many as 4 tails. The part taken is mozambiqutilapia fish meat which will then be analyzed using the Atomic Absorption Spectrophotometry (AAS) method. Sample analysis was carried out at the Analysis Laboratory of the Faculty of Mathematics and Natural Sciences, University of Mataram and the Environmental Laboratory Center for the Environment and Forestry Office of West Nusa Tenggara Province. This research took place from August 2022-March 2023. The results showed that the heavy metal content of Lead in the bodies of Lake fish from Rawa Taliwang Lake ranged from 0.197 mg/kg to 0.199 mg/kg so that an average of 0.197 mg/kg was obtained. Tilapia fish from Rawa Taliwang Lake is still below the threshold so it is still safe for consumption.

Keywords: Lead (Pb); MozambiquTilapia Fish; Rawa Taliwang Lak

Introduction

Rawa Taliwang Lake is one of the Natural Tourism Parks located in Taliwang City, West Sumbawa Regency with an area of ± 820 ha. Administratively, Rawa Taliwang Lake included in two districts, namely Taliwang District and Seteluk District (Widada *et al*., 2015; Kawirian *et al*, 2018). Geographically, Rawa Taliwang Lake is located at coordinates 8°40'54"-8°43'9" S and 116°50'52"-116°55'27" E at an altitude of 200-400 meters above sea level (BKSDA, 2015; Kawirian *et al*., 2018; Legiarsi *et al*., 2022).

Rawa Taliwang Lake plays an important role, especially ecological and economic role. The ecological role of this lake is as a habitat for various types of wildlife and a haven for several types of water birds (BKSDA, 2015). Furthermore, the economic role of Rawa Taliwang Lake is as a source of income for the surrounding community, such as fish seekers (fishermen) and fish traders (Wandi *et al*., 2021). The community uses this lake as an area for catching and cultivating freshwater fish. Several types of freshwater fish are used by the community, ranging from Mozambiqu tilapia fish, **Trichogaster** trichopterus, Climbing Perch Fish, Cork, and Eel. In addition, this lake is a source of water for agricultural irrigation, a source of household raw water, and a potential for ecotourism.

Exploitation of Rawa Taliwang Lake will cause various environmental damages, especially heavy metal. Agricultural and non-agricultural activities are one of the contributors of heavy metals. These materials include associated elements in inorganic fertilizers (Cd, Cr, Pb); liquid waste (Cd, Ni, Cu, Pb); animal husbandry (Cu, Zn, As); pesticides (Cu, As, Hg, Pb); as well as compost (Cd, Cu, Ni Pb) (Mulyadi, 2013).

Fish is one of the aquatic biota that is susceptible to changes in the physical and chemical conditions of the waters. Fish that live in confined areas (such as lakes) have a higher risk of heavy metal contamination

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than open water fish (such as the ocean) (Khairuddin *et al*, 2021). Therefore, fish is one of the bioindicators of heavy metals in water. One type of fish commonly used is Mozambiqu tilapia fish (*Oreochromis mossambicus*).

Mozambiqu tilapia fish accumulates heavy metals when they come in contact with a medium containing toxic substances. Fish accumulate toxic chemicals such as heavy metals directlyfrom water and diet, and contaminant residues may ultimately reach concentrations hundreds or thousands oftimes above those measured in the water, sediment and foodThis contact can occur in three ways, namely through food, entering through the gills, and diffusion through the skin surface. (Yulaipi & Aunurohim, 2013; Habib et al, 2014). Fish that has been contaminated with heavy metals will be very dangerous for humans as one of its main consumers (Febryanto *et al*., 2011; Cahyani *et al*., 2016; Yunanmalifah *et al*., 2021; Santoso *et al*., 2023). Lead (Pb) is a heavy metal that generally pollutes waters.

Lead (Pb) is one of the most dangerous heavy metals when it pollutes the environment. Heavy metals are commonly found in natural waters and some are essentials to living organisms, yet they may become highly toxic when present in high concentration. Lead (Pb) pollution in the aquatic environment generally occurs due to sources of pollution from industrial waste disposal, mining, oil spills, the printing industry, industries that produce metals and paints, and oil refineries (Yulaipi & Aunurohim, 2013; Hananingtyas, 2017; Friday et al, 2013). High accumulation of Lead (Pb) in the bodies of living things can cause various disorders in the organs of the body to the point of causing death in living things. The heavy metal Lead (Pb) can enter the human body either through the skin, inhalation, or through food (Susanti *et al*., 2016; Khairuddin *et al*., 2018).

The tolerance limit for the heavy metal Lead (Pb) in fish consumed by humans is regulated inThe Indonesian Food and Drug Authority guidelines Number 9 of 2022 concerning Maximum Limits of Heavy Metal Contamination in Processed Foods, namely for fish and processed fish products the limit for heavy metal content is 0.30 mg/kg, so that if the fish consumed by humans has levels of Lead (Pb) greater than the tolerance limit, it will be toxic to the human body (BPOM, 2022). Based on this background, this study aims to determine the content of the heavy metal Lead (Pb) in mozambiqu tilapia fishoriginating from Rawa Taliwang Lake and determine whether mozambiqu tilapia fishis suitable for consumption following The Indonesian Food and Drug Authority regulations No. 9 of 2022 concerning Requirements for Heavy Metal Contamination in Processed Foods.

Method

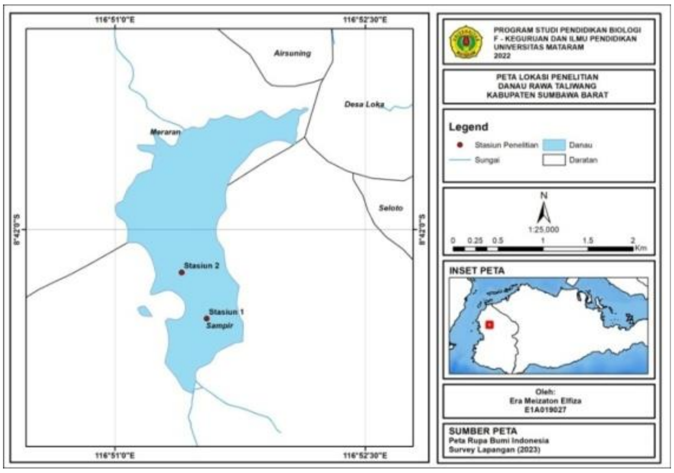


Figure 1. Research sites

The population in this study were all mozambiqu tilapia fishfound in Rawa Taliwang Lakeand sample for this study were mozambiqu tilapia fishcaught in fishing nets. Station 1 is located on the east side with coordinates 8°42′35″ S and 116°51′35″ E and station 2 is located on the west side with coordinates 8°42′17″ S and 116°51′26″ S. Sampling was carried out using fishing nets which are traditional fishing tools. The samples that have been obtained are stored in sample boxes filled with ice cubes and analyzed at the Analysis Laboratory of the Faculty of Mathematics and Natural Sciences, University of Mataram and the Environmental Laboratory Center for the Environment and Forestry Office of West Nusa Tenggara Province. The variable in this study was the content of Lead (Pb) in mozambiqu tilapia fish from Rawa Taliwang Lake, West Sumbawa Regency.

The tools used in this study include equipment in the field and in the laboratory. Field tools include a thermometer, pH meter, salinometer, Global Positioning System (GPS), camera, cool box and stationery. Laboratory equipment include polypropylene bottles, plastic funnels, Erlenmeyer, beaker cups, measuring cups, hot plates, filter paper, measuring flasks, microwaves, volumetric pipettes, knives, dropping pipettes, refrigerators, plastic spoons, analytical balances and a set of atomic absorption spectrometer tools. The materials used in this study were 2 mozambiqu tilapia fish taken from the observation station, aquadest, filter paper, catalyst, H2SO4, 6 M HCL, 0.1 M HNO3, and 65% HNO3.

Fish scales from samples were cleaned and washed using distilled water. Next, the samples were separated between the bones and the flesh. Then, the fish meat is cut into smaller sizes. Samples of cut meat were weighed as much as 5 grams in a porcelain cup.

The sample destruction process uses a mixture of 1 gram of catalyst, 0.5 gram of sample and H_2SO_4. The use of a catalyst aims to speed up the reaction time. Then, 50 mL of the distructed sample was taken using a pipette and put into a 100 mL Erlenmeyer. In addition, 5 ml of concentrated HNO_3 was added and closed using a glass funnel. The sample is then slowly heated to a volume of 15-20 mL. If the sample looks not clear, re-enter 5 mL HNO3 (repeat until the sample is clear/heavy metal). The funnel is cleaned using water and the water is put into the Erlenmeyer. Put the test sample into a 50 ml volumetric flask (filter) and add distilled water. The lead (Pb) concentration was then measured using the Atomic Absorption Spectrophotometer (AAS) test method.

The data used is the content of Lead (Pb) in mozambiqu tilapia fish samples from Rawa Taliwang Lake in units of milligrams/kilograms (mg/kg) or parts million (ppm). The data obtained from the *Atomic Absorption Spectrophotometry* (AAS) method is then narrated descriptively in the form of tables and graphs. These results were analyzedthen compared with the limit for heavy metal lead (Pb) according to BPOM, which is 0.30 mg/kg following:

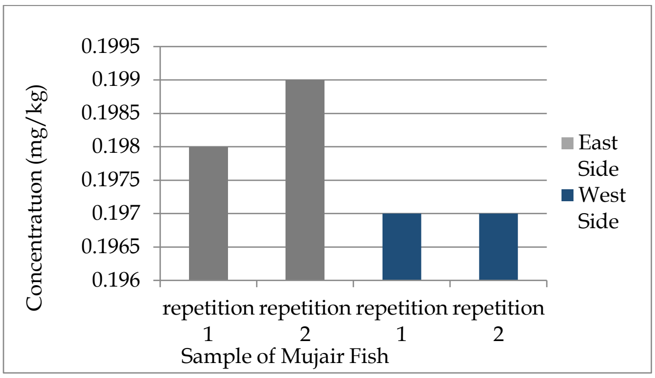
$$\text{Concentration of Pb} = \frac{(D-E)X\text{Fp}XV}{W} \quad (1)$$

Descriptions:
D : Concentration of sample (mg/l) from AAS
E : Blank concentration (mg/l) from AAS
F_P : Dilution factor
V : The final volume of sample solution (l)
W :Sample weight (kg)
(BSN,2011).

Resultand Discussion

Lead Heavy Metal Findings (Pb)

Based on the analysis results of the heavy metal Lead (Pb) using Atomic Absorption Spectrophotometry (AAS) followed by calculating the concentration of lead in the sample, the results are obtained (Figure 2).



Gambar2. Graph of Lead Heavy Metal Concentration in Mozambiqu Tilapia Fish

The results showed that the content of the heavy metal Lead contained in the body of mozambiqu tilapia fish was around 0.197 mg/kg to 0.199 mg/kg. Based on this, it can be seen that the average concentration of Lead found in fish is 0.197 mg/kg. These results indicate that the content of the heavy metal Lead contained in the body of mozambiqu tilapia fish can still be consumed in accordance with BPOM guidelines Number 9 of 2022 concerning Maximum Limits of Heavy Metal Contamination in Processed Foods.

Lead content that is below the threshold does not indicate that fish is fit for consumption. This is because the heavy metal Lead is toxic, accumulative, and cannot be decomposed. Consuming food contaminated with lead metal will have a negative impact on health. Some of these negative impacts are damaging various organs of the human body, disrupting the nervous system, blood formation system, kidneys, heart system, and reproductive system.

There are several research results regarding the content of heavy metals contained in the bodies of fish in Rawa Taliwang Lake. The results of the research by Shoalichin, *et al* (2022) showed that the concentration of the heavy metal Lead contained in the body of the betok fish in Rawa Taliwang Lake was 0.1 mg/kg. This value is below the threshold based on a lead content of less than 0.2 mg/kg according to BPOM guidelines No. 5 concerning Maximum Limits of Heavy Metal Contamination in Processed Foods. In addition, the results of research from Kirana, *et al* (2022) stated that the average copper content in snakehead fish from Rawa Taliwang Lake was 0.679 mg/kg. These results are also below the threshold (20.0 mg/kg) according to the Regulation of the Directorate General of Drug and Food Control Number: 03725/B/SK/VII/89. Furthermore, the results of research by Saputri, *et al* (2023) show that the cadmium level in mozambiqu tilapia fish meat is 0.1977 mg/kg so that it can still be consumed by the public because it has not exceeded BPOM Regulation No. 9 of 2022, which is 0.30 mg/kg.

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The contamination of mozambiqu tilapia fish with the heavy metal lead (Pb) is due to human activities around their habitat. Referring to the research results of Khairuddin, *et al* (2019) heavy metals can come from the metal ore processing industry, the pesticide industry, the mining industry, the metal plating industry and the paint stripping process. In addition, heavy metals can also come from food contaminated with heavy metals, for example seafood. The heavy metal Lead (Pb) can also be in the form of gas. Lead (Pb) gas emissions originate from the by-product of the combustion process of tertramethyl-Pb and tetraethyl-Pb compounds contained in motor vehicle fuel. Lead (Pb) emissions from burning gasoline will increase the amount of Pb in the air (Khairuddin, *et al*. 2018).

Effect of Environmental Parameters

Heavy metals are any metallic chemical elements with a high atomic weight that are toxic in small amounts. Heavy metals have been discovered in the atmosphere, soil, water, sediments, and biota, which includes aquatic species. Environmental factors such as the season, pH of the water, temperature, dissolved oxygen, and salinity have been found to influence the amount of hazardous heavy metals (Ni, Cu, Zn, and Pb) in fish. Elements enter the aquatic environment as a result of weathering of the earth's crust, human activities, and industrial effluents (Habib, et al. 2014).

Heavy metals enter the body of fish through the process of osmoregulation and are affected by the level of salinity found in the waters. According to Yudiati, *et al* (2009) different conditions of water salinity can affect the rate of absorption of heavy metals in fish bodies. High salinity levels will reduce toxicity. This is because salinity describes the concentration of ions contained in waters caused by 7 main ions, namely Sodium (Na^+), Calcium (Ca^{2+}), Chloride (Cl^-), Potassium (K^+), Sulfur (SO_4^{2-}), and Biocarbonate (HOC^{3-}). Rawa Taliwang Lake as a fresh water type of water has a low salinity <0 ppt. Low salinity conditions in Rawa Taliwang Lake cause higher toxicity of the heavy metal Lead (Pb). Reducing salinity will increase heavy metal toxicity (Sullivan, 2000). This is in accordance with the results of research by Abiyana & mahniah (2001) which states that the relationship between salinity and Lead (Pb) content is inversely proportional.

The degree of acidity (pH) is an element to measure the level of acidity or alkalinity of waters. The acidity degree (pH) value for station 1 is 7.5 while the acidity degree (pH) value for station 2 is 7.6. The value of the degree of acidity (pH) which is good for the survival of aquatic organisms ranges from 6-9. The degree of acidity (pH) in the waters of Rawa Taliwang Lake is classified as normal and good for the survival of aquatic organisms. Referring to the research results of Tataningdatu, *et al* (2013) that the ideal pH for the life of freshwater biota ranges from 6.8-8.5. Too low a degree of acidity (pH) can cause the solubility of heavy metals in water to increase or be toxic to aquatic organisms.

Accumulation of heavy metals in the body of mozambiqu tilapia fish can be affected by water temperature. Water temperature is inversely proportional to the level of Lead (Pb). The higher the water temperature will cause a lower concentration of Lead (Pb). Conversely, the lower the water temperature will cause the concentration of Lead (Pb). In accordance with the statements of Wardhani (2018) and Khairuddin, *et al* (2021) that water temperature tends to increase the accumulation and toxicity of heavy metals, including lead (Pb) and copper (Cu). The levels of heavy metals such as Cu and Cd will be higher in the fish's body if the water temperature is higher (Khairuddin *et al*, 2022). In addition, temperature also affects the concentration of heavy metals in sediments. Lower temperatures will make it easier for heavy metals to settle in sediments. While the higher the temperature causes heavy metal compounds to dissolve easily in water (Sukoasih, 2016). The temperature of the waters in the research location is stable and suitable as a habitat for Mozambiqu tilapia fish. The temperature conditions at the study site which are on the east side are 30°C while on the west side are 29°C. The content of heavy metal lead on the west side is lower than on the east side.

Prevention of Lead (Pb) Heavy Metal Contamination in Rawa Taliwang Lake

Prevention of Lead (Pb) heavy metal pollution aims to ensure that the waters where Mozambiqu tilapia fish live are not contaminated with the heavy metal Lead or reduce the possibility of pollution containing the heavy metal Lead, especially in Rawa Taliwang Lake. Lead pollution is closely related to human activities (for example the use of batteries, ammunition, glass, ceramics, domestic waste, transportation, and waste water from ore mining). The heavy metal Lead (Pb) can enter the waters through various ways such as rainwater and sewage which flows directly into the waters. Therefore, special attention is needed to the presence of Lead (Pb) wastes around the waters of Rawa Taliwang Lake and prevent these wastes from entering the waters of Rawa Taliwang Lake and access to the waters that flow into the swamp.

Planting biofilter plants in Rawa Taliwang Lake can absorb and filter various pollutants such as trash, sewage and heavy metals including lead which pollutes the waters. Mangrove plants are one of the biofilter plants that can absorb various heavy metals in nature such as Fe, Cr, Cu, Co, Ni, Pb, Zn, and Cd. In addition, the element Pb in the air that comes from motorized vehicle exhaust is easily captured by the stomata on mangrove leaves (Hastuti, *et al*., 2013; Khairuddin *et al*., 2018). Therefore, the existence of this plant in the waters of Rawa Taliwang Lake can be one of the steps to reduce heavy metal pollution, especially Lead. Mangrove trees have efforts to overcome other toxic materials, including by weakening the effects of toxins through pollution (dilution), namely by storing lots of water to dilute the concentration of heavy metals in their body tissues so as to reduce the toxicity of these metals. One among several mangrove species that has the ability to absorb heavy metals is Api-api (*avicennia marina*).

Another biofilter plant is Hydrilla (*Hydrilla verticillata*). These aquatic plants can grow quickly and can develop in water from a few centimeters to 20 meters. Hydrilla can grow in a variety of habitats, usually found in shallow water to a depth of 0.5 m and can grow in water to a depth of 10 m. According to research by Urifah, *et al* (2017) stated that Hydrilla can absorb the heavy metal lead (Pb) with a processing time of 7 days with a variable weight of Hydrilla of 40 grams can produce residual Pb levels in waters of 0.7174 ppm resulting in root absorption of 0. .47 mg/kg, 0.36 mg/kg for stems and 0.38 mg/kg for leaves.

Reducing the consumption of Mozambiqu tilapia fish originating from waters contaminated with heavy metals can help reduce the accumulation of heavy metals in the human body. Therefore, as a consumer, it is necessary to pay attention to the source of fish and other foods that will be eaten in order to avoid various hazards including contamination of large amounts of heavy metals which can damage the function of certain organs in the fish's body.

Conclusion

The content of Lead (Pb) contained in mozambiqu tilapia fish meat from Rawa Taliwang Lake ranges from 0.197 to 0.199 mg/kg. The average value of heavy metal lead (Pb) in fish is 0.197 mg/kg. Mozambiqu tilapia fish from Rawa Taliwang Lake can still be consumed because the Lead content in Mozambiqu tilapia fish is still below the threshold set based onThe Indonesian Food and Drug Authority guidelines No. 9 of 2022 concerning the Maximum Limit of Heavy Metal Contaminants in Processed Food, which is 0.30 mg/kg.

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References

Abiyana., H.,Z.&Mahmiah. (2021). Kandungan Logam Berat Timbal (Pb) Pada Bahan Baku Air Untuk Produksi Garam di Kawasan Ladang Garam Sedayulawas Lamongan. *J-Tropimar,* 3 (2). https://doi.org/10.30649/jrkt.v3i2.45

Badan Pengawasan Obat dan Makanan (BPOM). (2022). *Peraturan Badan Pengawasan Obat Dan Makanan Nomor 9 Tahun 2022 TentangPersyaratan Cemaran Logam Berat dalam Pangan Olahan*.Jakarta.

Badan Standardisasi Nasional (2011). *Cara Uji Kimia – Bagian 5 : Penentuan Kadar Logam Berat Timbal (Pb) dan Kadmium (Cd) pada Produk Perikanan*. No. SNI 2354.5: 2011, BSN, Jakarta.

BKSDA. (2015). *Buku Informasi Kawasan Konservasi Nusa Tenggara Barat*. Mataram: Balai KSDA NTB.

Friday, U., Wokoma, O. A. F., & Edoghotu, A. J. (2013). Levels of bioaccumulation of some heavy metals in Fish (Tilapia zilli) and their concentration in water and sediment of Owubu Creek, Niger Delta, Nigeria. *Resources and Environment*, *3*(3), 59-64. 10.5923/j.re.20130303.03

Habib, I. Y., Na'aliya, J., Muhammad, M., & Danladi, F. I. (2014). Analysis of Heavy Metals in Muscle Tissues of Tilapia Zilli of Gwale Pond, Kano State, Nigeria. *International Journal of Scientific and Research Publications*, *258*. 10.29322

Hastuti, E. D., Anggoro, S., & Pribadi, R. (2013, September). Pengaruh Jenis dan Kerapatan Vegetasi Mangrove terhadap Kandungan Cd dan Cr Sedimen di Wilayah Pesisir Semarang dan Demak. In *Prosiding Seminar Nasional Pengelolaan Sumber daya Alam dan Lingkungan* (pp. 331-336). 978-602-17001-1-2

Kawirian, R. R., Mahrus, M., & Japa, L. (2018, June). Struktur Komunitas Fitoplankton Danau Lebo Taliwang Sumbawa Barat. In *Prosiding Seminar Nasional Pendidikan Biologi* (pp. 50-59). 978-602-61265-2-8

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. http://dx.doi.org/10.29303/jbt.v22i1.3105

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). 10.29303/JPPM.V2I1.1015

Khairuddin, K., Yamin, M., Syukur, A., & Mahrus, M. (2018). Penyuluhan Tentang Dampak Logam Berat Pada Manusia Di Sman 1 Woha Bima Tahun 2017. *Jurnal Pendidikan dan Pengabdian Masyarakat*, *1*(2). 10.29303/JPPM.VII2.843

Khairuddin, K., Yamin, M., Syukur, A., & Muhlis, M. (2018, June). Analisis Logam Pencemar Pada Klas Bivalvia Dari Teluk Bima. In *Prosiding Seminar Nasional Pendidikan Biologi* (pp. 784-787). 978-602-61265-2-8

Khairuddin, M. Y., & Syukur, A. (2018). Analisis Kandungnan Logam Berat pada Tumbuhan Mangrove. *Jurnal Biologi Tropis*, *18*(1), 69-79. 10.29303/jbt.v18i1.731

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. http://dx.doi.org/10.29303/jbt.v22i3.3957

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. http://dx.doi.org/10.29303/jbt.v22i2.3509

Santoso, D. (2023). Test of Mercury (Hg) Content in Mozambique Tilapia Fish (Oreochromis Mossambicus) from Lake Rawa Taliwang Nature Tourism Park, West Sumbawa Regency. *Jurnal Biologi Tropis*, *23*(1), 280-285. http://dx.doi.org/10.29303/jbt.v23i1.4563

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. http://dx.doi.org/10.29303/jbt.v23i2.4845

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

Sukoasih, A., & Widiyanto, T. (2017). Hubungan Antara Suhu, pH Dan Berbagai Variasi Jarak Dengan Kadar Timbal (Pb) Pada Badan Air Sungai Rompang dan Air Sumur Gali Industri Batik Sokaraja Tengah Tahun 2016. *Buletin Keslingmas*, *36*(4), 360-368. https://doi.org/10.31983/keselingmas. v36i4.3115

Sullivan, J. K. (1977). Effects of salinty and temperature on the acute toxicity of cadmium to the estuarine crab Paragrapsus gaimardii (Milne Edwards). *Marine and Freshwater Research*, *28*(6), 739-743. https://doi.org/10.1071/MF9770739

Tatangindatu, F., Kalesaran, O., & Rompas, R. (2013). Studi parameter fisika kimia air pada areal budidaya ikan di Danau Tondano, Desa Paleloan, Kabupaten Minahasa. *E-Journal Budidaya Perairan*, *1*(2). https://doi.org/10.35800/bdp.1.2.2013.1911

Urifah, D., Dwicahyono, H. B., & Yulliastuti, R. (2017). Adsorpsi logam timbal (Pb) oleh tanaman hydrilla (Hydrilla verticillata). *Jurnal Riset Teknologi Industri*, *11*(2), 100-108. 10.26578/jrti.v11i2.3043

Yudiati, E., Sedjati, S., Enggar, I., & Hasibuan, I. (2009). Dampak pemaparan logam berat kadmium pada salinitas yang berbeda terhadap mortalitas dan kerusakan jaringan insang juvenile udang Vaname (Litopeneus vannamei). *ILMU KELAUTAN: Indonesian Journal of Marine Sciences*, *14*(4), 29-35. 10.14710/ik.ijms.14.4.29-35

Yulaipi, S., & Aunurohim, A. (2013). Bioakumulasi logam berat timbal (Pb) dan hubungannya dengan laju pertumbuhan Ikan mujair (Oreochromis mossambicus). *Jurnal Sains dan Seni ITS*, *2*(2), E166-E170. http://dx.doi.org/10.12962/j23373520.v2i2.3965

Yunanmalifah, M. A., & Yamin, M. (2021). Analysis of Heavy Metal Content of Copper (Cu) in Milkfish (Chanos chanos Forsk) from Milkfish Farms in Bima Bay 2020. *Jurnal Biologi Tropis*, *21*(3), 778-782. http://dx.doi.org/10.29303/jbt.v21i3.2841