

Histopathological structure of the kidney of tawes fish (*Barbonymus gonionotus*) contaminated with lead (Pb) in the Hasanuddin University Lake, Makassar

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ABSTRACT

Tawes fish (*Barbonymus gonionotus*) is one of the aquatic animals that has the potential to be contaminated by the heavy metal lead (Pb). Lead (Pb) contamination in the ecosystem can potentially cause organ damage in tawes fish. The aim of this study was to determine the levels of lead (Pb) contamination in tawes fish (*Barbonymus gonionotus*) residing in the Hasanuddin University lake in Makassar and to evaluate the resulting damage to their kidney tissues. A total of 20 tawes fish were used as samples in this study, with 4 kidney samples taken from each station. The lead (Pb) concentration was measured using an Atomic Absorption Spectrophotometer (AAS). Kidney tissue samples were fixed in 10% neutral buffered formalin (NBF), dehydrated using graded alcohol, embedded in paraffin, sectioned at 5 μm thickness, and stained with hematoxylin-eosin before observation. The data were analyzed using quantitative descriptive methods. The results showed that lead (Pb) concentrations in the kidneys of contaminated tawes fish ranged from 0.27 to 3.38 $\mu\text{g/g}$, with an average of $1.00 \pm 0.20 \mu\text{g/g}$, exceeding the maximum permissible limit for heavy metal contamination in fish as specified by the Indonesian National Standard (SNI), which is 0.3 mg/kg. Histopathological analysis of the kidneys revealed fat degeneration, inflammatory cell infiltration, hemorrhage, necrosis, and an increased number of melano-macrophage centers.

INTRODUCTION

Lead (Pb) is a toxic and hazardous heavy metal, recognized as a pollutant that threatens the survival of aquatic organisms (Yulaipi and Aunurohim, 2013). Due to its high solubility, persistence, bioaccumulation, and biomagnification, lead (Pb) poses a significant threat to aquatic ecosystems (Shukla et al., 2017). Fish are one of the potential aquatic animals that can become contaminated and are sensitive to pollutants, making them good indicators of water pollution (Dutta et al., 2015). The toxic effects of accumulated lead (Pb) in fish can cause damage to vital organs, particularly the kidneys, leading to physiological dysfunction and potentially death (Darmono, 2001). The kidneys are particularly susceptible to toxic substances such as heavy metals that enter the fish's body, resulting in tissue damage. Compared to other organs, the kidneys are more sensitive to toxic waste due to their primary role in excretion and filtration of various compounds within the fish's body (Hayatun, 2019). The accumulation of lead (Pb) in

fish occurs through exposure to contaminated media, as toxicants from the aquatic environment are transferred into the fish (Sahetapy, 2011).

One of the lakes suspected to be contaminated with lead (Pb) is the lake located within Hasanuddin University, Makassar. The pollution in this lake is believed to originate from laboratory activities conducted at the university, as well as household waste discharged from nearby residential areas, resulting in elevated concentrations of heavy metals, particularly lead (Pb), in the lake water (Nahrun, 2016).

One of the fish species inhabiting this lake is the tawes (*Barbonymus gonionotus*), a native species of Indonesia (Prastyarini, 2011). Therefore, this study aims to measure the concentration of lead (Pb) contamination in tawes (*B. gonionotus*) inhabiting the Hasanuddin University lake and to assess the associated kidney tissue damage.

METHODOLOGY

Sample collection

Sampling of tawes fish (*B. gonionotus*) was conducted in the Hasanuddin University lake, Makassar, at five different stations. Station 1 is located in the northern part of the lake, where two active drainage channels discharge waste into the lake. Station 2 is situated in the eastern part; station 3 in the southern part; station 4 in the southwest, right at the sluice gate that connects the main lake with the adjacent lake across the road; and station 5 is located in the central part of the lake, near a land area that juts into the water (Figure 1).



Figure 1. Study location map (Yaqin et al., 2018)

A total of four fish samples were collected from each station, resulting in 20 fish samples in total. The fish were caught using a net. Necropsy was then performed to isolate the kidney organs, which were placed into storage tubes and transported to the Central Health Laboratory in Makassar for lead (Pb) level analysis.

Measurement of lead (Pb) levels in fish kidney

A total of 2 g of each kidney sample was placed into a digestion tube, mixed with 0.5 mL of distilled water, and digested with 10 mL of concentrated HNO_3 at approximately 100°C for 2 hours. After cooling

for 15 minutes, 0.5 mL of HClO_4 was gradually added, and the mixture was reheated for 1 hour. The resulting solution was then diluted with distilled water to a final volume of 50 mL and filtered using Whatman No. 42 filter paper. The filtrate was subsequently analyzed for lead content using an Atomic Absorption Spectrophotometer (AAS) (Yaqin et al., 2018).

Histopathological examination

Kidney tissues were preserved in 10% formalin, followed by dehydration through a graded ethanol series, cleared with xylene, and embedded in paraffin. Tissue sections were then cut and stained using hematoxylin and eosin. Subsequently, histopathological examination and image documentation were conducted using a high-resolution optical microscope equipped with a camera (Jabbar et al., 2021).

RESULT AND DISCUSSION

The analysis results of lead (Pb) contamination

The analysis results of lead (Pb) contamination in tawes fish (*B. gonionotus*) from five stations in Hasanuddin University Lake are presented in Table 1.

Table 1. The results of lead (Pb) contamination levels in the kidneys of tawes fish (*B. gonionotus*) using the Atomic Absorption Spectrophotometer (AAS) method

No.	Sample code	Body weight (g)	Body length (mm)	Lead content ($\mu\text{g/g}$)
Station 1				
1	GS1.1	147,98	225,00	0,41
2	GS1.2	94,40	185,00	0,85
3	GS1.3	51,03	147,00	3,38
4	GS1.4	42,52	143,00	3,08
Range		42,52 - 147,98	143,00 - 225,00	0,41 - 3,38
Average $\pm$ Standard error		83,98 $\pm$ 24,17	175 $\pm$ 19,17	1,93 $\pm$ 0,76
Station 2				
1	GS2.1	85,05	185,00	0,47
2	GS2.2	59,53	163,00	0,38
3	GS2.3	45,36	156,00	1,08
4	GS2.4	48,19	160,00	0,54
Range		45,36 - 85,05	156,00 - 185,00	0,38 - 1,08
Average $\pm$ Standard error		59,53 $\pm$ 9,04	166,00 $\pm$ 6,49	0,62 $\pm$ 0,16
Station 3				
1	GS3.1	136,08	200,00	0,43
2	GS3.2	138,91	209,00	0,36
3	GS3.3	53,86	156,00	1,68
4	GS3.4	56,13	167,00	1,41
Range		53,86 - 138,91	156,00 - 209,00	0,36 - 1,68
Average $\pm$ Standard error		96,25 $\pm$ 23,83	183,00 $\pm$ 12,75	0,97 $\pm$ 0,34
Station 4				
1	GS4.1	121,9	202,00	0,34
2	GS4.2	138,91	217,00	0,27
3	GS4.3	45,35	162,00	0,68
4	GS4.4	39,69	155,00	0,46
Range		39,69 - 138,91	155,00 - 217,00	0,27 - 0,68
Average $\pm$ Standard error		86,46 $\pm$ 25,63	184,00 $\pm$ 15,11	0,44 $\pm$ 0,09

Station 5				
1	GS5.1	150,25	232,00	0,52
2	GS5.2	175,77	240,00	0,46
3	GS5.3	59,53	165,00	1,68
4	GS5.4	56,7	174,00	1,46
Range		56,7 - 175,77	165,00 - 240,00	0,46 - 1,68
Average $\pm$ Standard error		110,56 $\pm$ 30,73	202,75 $\pm$ 19,35	1,03 $\pm$ 0,32
Combined station				
Range		39,69 - 175,77	143,00 - 240,00	0,27 - 3,38
Average $\pm$ Standard error		87,36 $\pm$ 10,21	182,15 $\pm$ 6,70	1,00 $\pm$ 0,20

Based on Table 1, the kidney samples of tawes fish from the Hasanuddin University Lake in Makassar were found to be contaminated with lead (Pb) as determined by AAS analysis, with concentrations ranging from 0.27 to 3.38 $\mu\text{g/g}$ and an average of $1.00 \pm 0.20 \mu\text{g/g}$. These results indicate that the lead (Pb) concentrations in the kidney samples exceed the maximum allowable limit for heavy metal contamination in fish and fishery products, as specified by the Indonesian National Standard (SNI) 7387:2009, which is 0.3 mg/kg. These findings are consistent with a study by Yaqin et al. (2018), which also reported lead (Pb) contamination in the Hasanuddin University Lake. Lead (Pb) contamination contributes to increased bioaccumulation and biomagnification in aquatic organisms, making it detectable in fish (Mu'jijah et al., 2019).

The Kruskal-Wallis statistical test showed no significant difference ($P > 0.05$) in lead (Pb) contamination concentrations among all samples collected from the different stations. According to Sagala et al., (2014), one of the factors influencing the distribution of lead (Pb) contamination in aquatic environments is the current flow pattern. The relatively small size of the Hasanuddin University lake likely allows the lead (Pb) contamination to disperse throughout the entire body of water, resulting in no significant differences in lead (Pb) levels in the kidney organs of tawes fish (*B. gonionotus*).

Histopathological results of the kidneys of tawes fish (*B. gonionotus*)

The histopathological analysis results showed varying degrees of kidney tissue damage in tawes fish (*B. gonionotus*) at each station, based on the samples with the highest lead (Pb) concentrations (Figure 2).

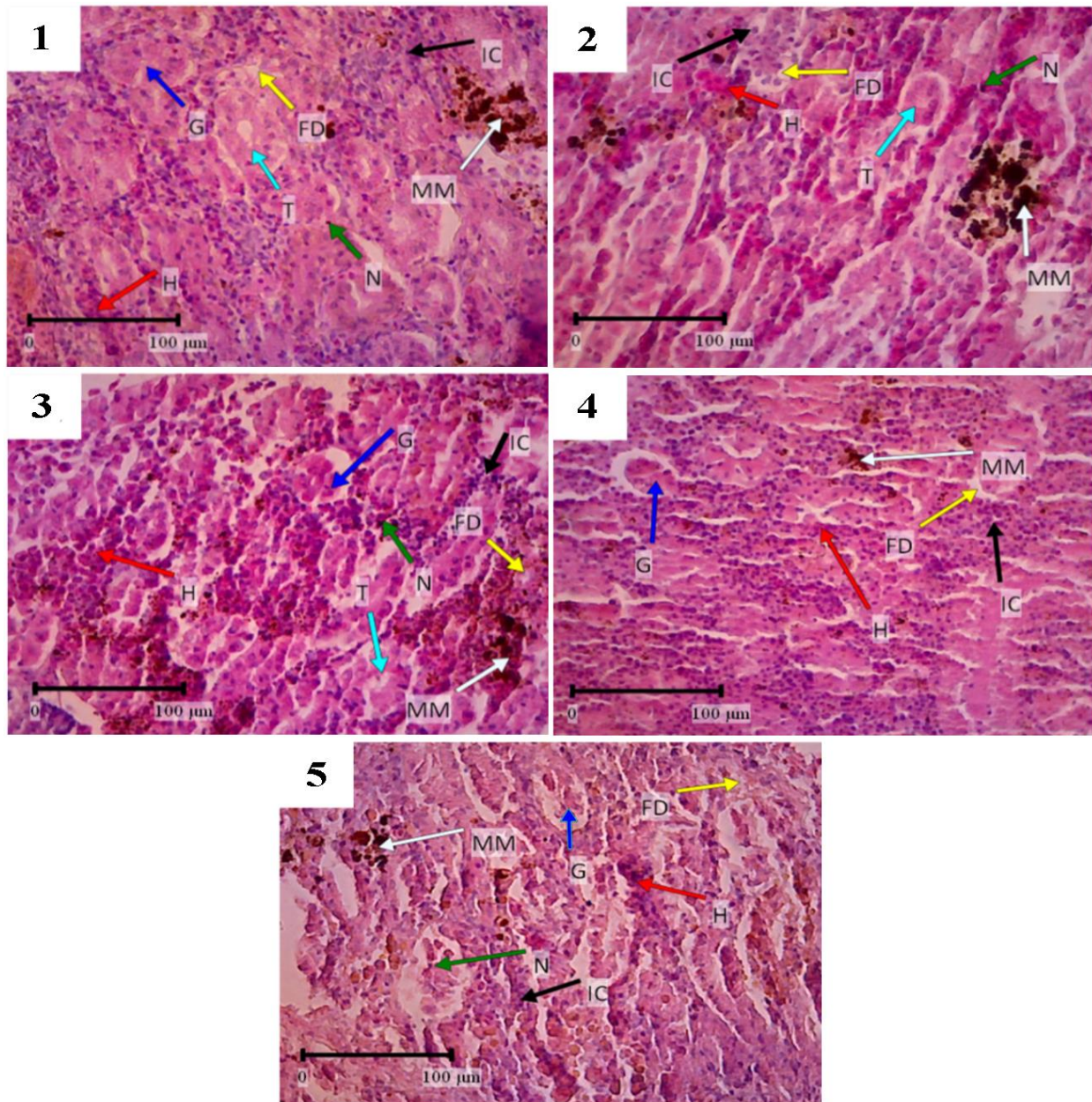


Figure 2. Histopathological structures of the kidney of tawes fish (*B. gonionotus*) contaminated with lead (Pb) at all stations (1-5); FD (yellow): fat degeneration; IC (black): inflammatory cell infiltration; MM (white): melano-macrophages; N (green): necrosis; T (light blue): tubules; G (dark blue): glomerulus; H (red): hemorrhage (H&E, 40x)

Based on the histopathological observations shown in Figure 2, pathological changes were observed in the kidney tissue structure of tawes fish (*B. gonionotus*) contaminated with lead (Pb) at all stations in the Hasanuddin University Lake, Makassar. The observed alterations included fat degeneration, inflammatory cell infiltration, the presence of melano-macrophages, necrosis, and hemorrhage. These findings are consistent with the study conducted by Risna et al., (2020), which reported various histopathological changes in the kidneys of *Glossogobius* sp. depending on lead (Pb) contamination levels, including swollen glomeruli, necrosis, and changes in melano-macrophages. Similar findings were reported by Mandia et al., (2013), who observed hypertrophy of tubular cells, cell lysis, and necrosis in the kidney tissue of

Osteochilus hasseltii. In addition, Mahboob et al., (2020) reported tubular cell necrosis, tubular hemorrhage, and glomerular damage in *Oreochromis niloticus* (Nile tilapia).

Lead (Pb) is a type of metal that can cause water pollution. When lead contaminates aquatic environments, it can affect aquatic organisms. The entry of lead into an organism's body may occur through the food chain, through the gills, or via diffusion by penetrating the skin surface. Once inside, the metal is absorbed into tissues, accumulates, and at certain concentrations, can cause kidney damage (Triadayani, 2010). The severity of tissue damage caused by lead (Pb) varies and is directly proportional to the amount of accumulated lead in the body. This is influenced by several factors, including internal factors (such as body size and age of the fish) and external factors (such as the dose of the toxic substance, its concentration, duration of exposure, route of entry into the body, and others) (Rosalina et al., 2019).

CONCLUSION

This study confirms elevated lead (Pb) contamination in the kidneys of tawes fish (*Barbonymus gonionotus*) from Hasanuddin University Lake, Makassar. Pb concentrations ranged from 0.27 to 3.38 $\mu\text{g/g}$, averaging $1.00 \pm 0.20 \mu\text{g/g}$, exceeding the 0.3 mg/kg limit set by SNI 7387:2009. Levels were similar across all five stations, indicating widespread contamination from laboratory and domestic waste sources throughout the lake.

Histopathological analysis revealed consistent kidney damage, including fat degeneration, inflammatory cell infiltration, hemorrhage, necrosis, and increased melano-macrophage centers. These tissue alterations reflect Pb accumulation and toxicity, disrupting renal function and compromising fish health. The observed changes correspond to exposure intensity and align with reported heavy metal effects in other freshwater fish species.

Lead pollution in this lake poses a substantial threat to aquatic biota and carries potential human health risks through food consumption. Urgent measures are required to control pollution sources, implement monitoring, and restore water quality. Sustained management will be essential to protect the lake ecosystem and ensure the safety of its fishery resources.

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