Advances in Tropical Biodiversity and Environmental Sciences
10(1): 13-17, February 2026
e-ISSN:2622-0628
DOI: 10.24843/ATBES.2026.v10.i01.p03
Available online at: https://ojs.unud.ac.id/index.php/ATBES/article/view/717

Chromium (Cr) Content in Water, Gills, and Muscles of Tilapia Fish (*Oreochromis niloticus*) in Tukad Badung, Bali

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Abstract. Increased human activity along the Tukad Badung River degrades the river's water quality. One cause is waste from various anthropogenic activities containing heavy metals, which can affect water quality and the organisms living in it. The purpose of this study was to determine the chromium (Cr) content in water and tilapia (*Oreochromis niloticus*). The study was conducted in the Tukad Badung River from February to March 2023. The sampling technique used the time-composite and sample-composite methods. The results of the study showed that the Tukad Badung waters were not polluted, as the Cr content did not exceed the thresholds set by Government Regulation of the Republic of Indonesia No. 82 of 2001 and Bali Governor Regulation No. 8 of 2007. Meanwhile, the Cr content in tilapia muscles at station II was 0.036 mg/L, and at station III, it was 0.727 mg/L in the muscles and 2,220 mg/L in the gills. The highest Bioconcentration Factor (BCF), which was found in the gills of tilapia, was 74, but the level of Cr accumulation ability at all stations in the Tukad Badung waters was still classified as a low accumulative category.

Keywords: bioconcentration factor; chromium (Cr); tilapia (*Oreochromis niloticus*); water quality.

I. INTRODUCTION

The Tukad Badung River is located in Bali Province. Along the Tukad Badung, residents engage in various activities, including household activities and small- and medium-sized industries [1]. Human activities around Tukad Badung include agriculture, livestock, workshops, markets, hospitals, hotels, and dyeing industries. Some of these activities can affect water quality and aquatic organisms [2].

Waste produced by the community, if disposed of without proper processing, will reduce the quality of the river water. This pollution affects aquatic life [3]. Human activities such as industry, agriculture, and unmanaged household waste are the main sources of Chromium. The entry of Chromium (Cr) in particular can significantly harm the aquatic environment [4].

Chromium (Cr) is harmful to aquatic life and humans. Chromium present in various forms, namely hexavalent chromium (Cr (VI) which is more toxic and potentially more dangerous than trivalent chromium (Cr (III) [5]. Although chromium can naturally enter waters through rock weathering, human-induced activities significantly increase its concentration. High levels of pollution can affect fish physiology and cause anatomical damage [6]. Exposure to chromium can cause adverse effects in humans, including nasal and skin irritation, skin discoloration, and kidney damage [7].

Tukad Badung is a popular fishing spot in Denpasar, Bali. There are concerns about potential health impacts on the community if they consume fish with chromium levels above the threshold. Therefore, research on the chromium content in water and tilapia (Oreochromis niloticus) from Tukad Badung is very important to conduct to mitigate

impacts on the aquatic ecosystem and prevent negative impacts on public health.

II. RESEARCH METHODS

Time and Location

This research was conducted for 2 months, from February 2023 to March 2023, in the Tukad Badung river, Bali. The research stations were divided into four stations.

I) Station I is located in Tukad Bangiang, Mengwi Subdistrict, Badung District. This location is the closest to the river's source.
II) Station II is located in the Denpasar area at Taman Tukad Korea. This station is also near a market.
III) Station III is situated in the Taman Pancing Barat area, where there are many fishing activities, and it is in proximity to a screen printing industry.
IV) Station IV is in the Taman Pancing Timur area. This region also has fishing activities and is close to several textile industries around Tukad Badung.

Equipment and Materials

The research instruments used were: dropper pipette, volumetric pipette, volumetric flask, beaker, measuring glass, ball filler, shaker, analytical balance, filter paper, stirring rod, oven, hotplate, centrifuge, ultrasonic bath, pH meter, plastic spoon, plastic bag, salinometer, coolbox, and AAS (absorption spectrophotometer). The research materials used were: river water samples, fish gill and muscle samples, hydrochloric acid (HCl), nitric acid (HNO3), alcohol, and distilled water (aqueous).

Research Methods

This study employs a quantitative descriptive method and a purposive sampling approach to determine sampling points. Water samples were collected at each station in 1 L. Three fish were collected from each station, stored in a cool box, and tested in the laboratory immediately. The Chromium (Cr) content in the Tukad Badung waters was compared with the threshold value set by Government Regulation of the Republic of Indonesia No. 82 of 2001, which is 0.05 mg/L. The levels of heavy metals accumulated in the gills and muscles of tilapia were compared with the FAO threshold value of 1 mg/kg set in 1983. The study's stages include sampling, preparing fish and water samples, and measuring water quality.

Research Parameters

The chromium (Cr) content in fish at station I was not detected in the muscle tissue and gills of fish, at station II Cr was detected at 0.325 mg/kg in the muscle tissue of fish, while in the gills it was detected higher at 1.294 mg/kg, at station III the Cr content was detected at 0.727 mg/kg in the muscle tissue of fish while in the gills it was detected at 2.220 mg/kg higher than in the muscle of fish. At station IV, no chromium was detected in the muscle tissue and gills of fish. From these results, it shows that the highest chromium levels in fish are found at station III, both in muscle tissue and gills, which determine the accumulation of chromium (Cr) in water, gill organs, and muscles of tilapia fish (*Oreochromis niloticus*) [20]. Bioconcentration Factor is a coefficient used to classify the efficiency of toxic element accumulation in biota and its medium. According to reference [8]. Bioconcentration Factor can be calculated using the following formula [8]:

$$\mathrm{BF} = \frac{Cb}{Cw}$$

Note: BF is the Bioconcentration Factor (number of toxic elements that accumulate in biota and its medium) (L/Kg); Cb is the concentration of toxic contents in biota (organisms); and *Cw* represents the concentration in water.

III. RESULT AND DISCUSSION

Result

Chromium (Cr) content in Tukad Badung

The results of the study (Figure 1) showed chromium (Cr) concentrations at four stations along the Tukad Badung River. Based on the measurement results, it is known that the chromium (Cr) content in station I at Tukad Bangiang, Mengwi, was not detected, station II at Tukad Korea was 0.036 mg/L, station III at Taman Pancing Barat was 0.030 mg/L, and station IV at Taman Pancing Timur was 0.010 mg/L. The results of the study showed that all stations had chromium content that did not exceed the required threshold set by the Government Regulation of the Republic of Indonesia No. 82 of 2001 and Bali Governor Regulation No. 8 of 2007, which is 0.05 mg/L.

Chromium (Cr) Content in Nile Tilapia (Oreochromis niloticus) Muscles and Gills in Tukad Badung.

In this study, Figure 2 shows the chromium (Cr) content in fish samples taken from four stations in the Tukad Badung River. The chromium (Cr) content in fish at station I was not detected in the muscle tissue and gills of fish, at station II Cr was detected at 0.325 mg/kg in the muscle tissue of fish, while in the gills it was detected higher at 1.294 mg/kg, at station III the Cr content was detected at 0.727 mg/kg in the muscle tissue of fish while in the gills it was detected at 2.220 mg/kg higher than in

the muscle of fish. At station IV, no chromium was detected in the muscle tissue and gills of fish. These results show that the highest chromium levels in fish are found at station III, both in muscle tissue and gills.

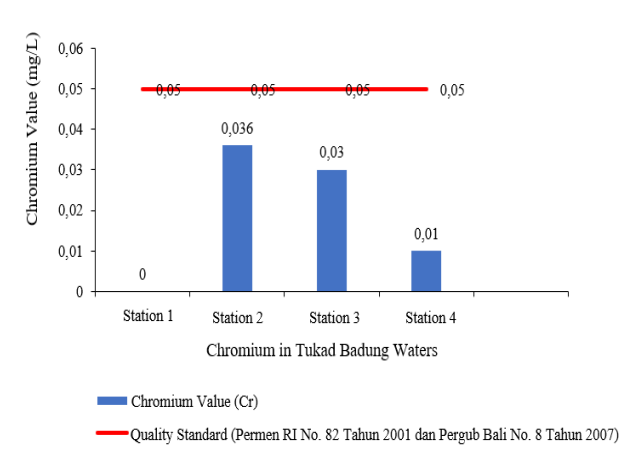

Figure 1. Chromium (Cr) in Tukad Badung River

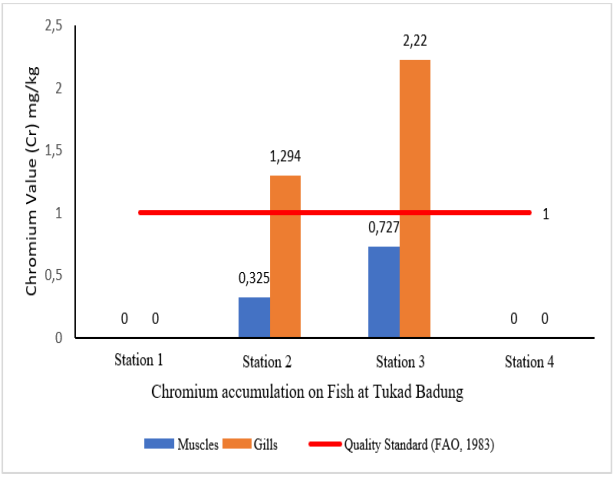

Figure 2. Chromium (Cr) content in Nile tilapia (*Oreochromis niloticus*) in Tukad Badung.

Bioconcentration factor (BCF) in fish from Tukad Badung waters.

Bioconcentration Factor (BCF) values were calculated for the organs tested for chromium (Cr) content (Table 1). BCF values are used to determine the accumulation ability of chromium (Cr) in the muscle and gills of tilapia (*Oreochromis niloticus*) concerning the water in the Tukad Badung waters. The results show the BCF values as follows: At station I, Cr was not detected in both muscle and gills of the fish, at station II the results in BCF for muscle tissue was 9.027, and for gills, it was 35.94, station III results in BCF for muscle tissue was 24.23, and for gills it was 74 and Cr was not detected in both muscle and gills of the fish at station IV.

Table 1.
Bioconcentration Factor (BCF) in tilapia (*Oreochromis niloticus*) from Tukad Badung River

Station	BCF (Muscles /Water)	BCF (Gills/Water)
	Chromium (Cr)	Chromium (Cr)
I (Tukad Bangiang, Mengwi)	*Not detected*	*Not detected*
II (Tukad Korea, Denpasar)	9,027	35,94
III (Taman Pancing Barat)	24,23	74
IV (Taman Pancing Timur	*Not detected*	*Not detected*

Water conditions (DO, pH, temperature) in Tukad Badung

The results of water quality parameter measurements showed variations in dissolved oxygen (DO), pH, and temperature at Station I. The average DO value was 4.7 mg/L at station I, 6.9 mg/L at station II, 7.0 mg/L at station III, and 6.9 mg/L at station IV. The average pH at station I was 7.44, station II 6.93, station III 6.77, and station IV 6.89. The average temperature at station I was 25.1°C, station II 28.63°C, station III 30.67°C, and station IV 29.83°C.

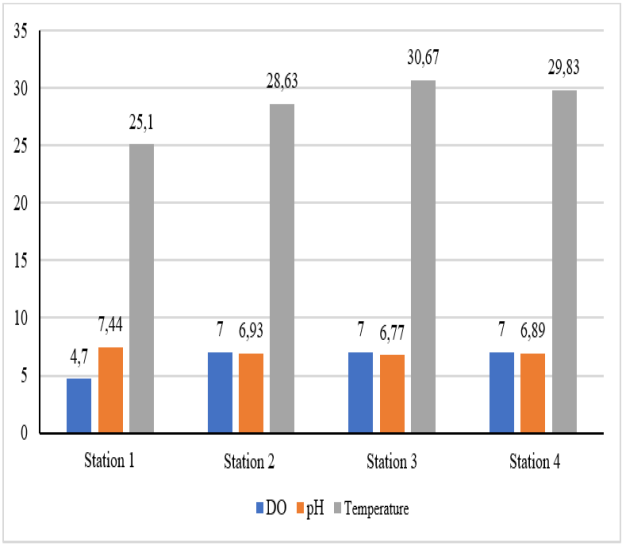

Figure 3. Average of Water quality parameters (DO, pH, Temperature) in Tukad Badung.

Discussion

Analysis of Chromium (Cr) content at four stations in the Tukad Badung River showed that the results at each station did not exceed the water quality standards set by the Republic of Indonesia Government Regulation No. 82 of 2001 and Bali Governor Regulation No. 8 of 2007,

which is 0.05 mg/L. Station I (Tukad Bangiang, Mengwi) did not detect chromium (Cr), possibly because anthropogenic activities in that area are still limited compared to other stations [5]. At Station I, most activities are agricultural and livestock-related, with few significant sources of industrial pollutants. However, at station II (Tukad Korea), the chromium concentration was 0.030 mg/L. At this station, various anthropogenic activities, including household activities and small industries, especially textile dyeing, contribute to chromium pollution [9]. Station III (Taman Pancing Barat) also contains chromium, which is also possible due to waste from textile dyeing industry activities, workshops, and household activities [10]. Finally, station IV (Taman Pancing Timur), which is closest to the estuary, has the lowest chromium concentration, because station IV is located far from industrial activities and there is a possibility of pollutant dilution because sampling was carried out during the rainy season, which causes an increase in water flow [11].

Chromium (Cr) analysis in tilapia (*Oreochromis niloticus*) at stations I and IV showed no detectable chromium in either the muscles or gills. The absence of Cr can be attributed to the lack of pollution sources at the location, so it does not cause Cr accumulation in the fish. At Stations I and IV, there are no textile industries or small fabric-dyeing industries that could lead to chromium contamination [12]. At Station IV, it is located close to the estuary and near a mangrove forest, which can reduce the concentration of toxic metals in the water. Mangroves are communities of mangrove plants in tidal areas that play an important role in stabilizing ecosystems [13]. The mangrove ecosystem comprises organisms, including plants and animals, that interact with environmental factors and with one another in the mangrove habitat [14].

Station II (Tukad Korea) showed chromium levels in muscles were measured at 0.325 mg/kg. and gills were measured at 1.294 mg/kg. At Station III (Taman Pancing Barat) the chromium content in the muscles was measured at 0.727 mg/kg and in the gills at 2.220 mg/kg. The concentration of chromium in the muscles was below the 1983 FAO limit of 1 mg/kg, while in the gills it exceeded the threshold. Variation in chromium accumulation in different fish tissues is associated with the physiological role of fish in metal metabolism. The greater accumulation of Cr in gills is possible because gills are the organs most frequently exposed to pollutants in water, as they are the entry point for pollutants via the respiratory mechanism, which is in line with previous research [15]. Several factors influence the accumulation of toxic metals in freshwater fish, including behavioral, biological, and environmental factors [16]. The highest metal concentration is found in aquatic organisms, including fish, compared to the water column, because various microorganisms can accumulate metals in their cells. These organisms are then consumed by other organisms in the food chain, potentially leading to bioaccumulation of hazardous substances in fish tissues [17].

Bioconcentration Factor (BCF) of chromium in tilapia (*Oreochromis niloticus*). At stations I and IV, the BCF value was not detected due to the absence of chromium (Cr) content in both the water and the fish. Station II BCF value in the muscle and the gills, both indicating low accumulation. Station III, a BCF value in the muscle and the gills, also indicates low accumulation. The presence of Cr accumulation detected in tilapia muscle was caused by chromium heavy metal contamination in the fish habitat from the disposal of textiles, metal plating, and other industrial waste. The fish samples taken were classified as adult fish. Age is a significant factor that affects the duration of exposure to toxic substances, leading to the accumulation of pollutants in fish tissue [18].

The results of this study indicate that the water quality parameters of the Tukad Badung River support aquatic life, as indicated by DO, temperature, and pH. In this study, the average DO, temperature, and pH values are within the standards set by Bali Governor Regulation No. 8 of 2007. A decrease in dissolved oxygen can reduce the efficiency of oxygen uptake for aquatic biota, including fish. Increasing temperature not only increases the metabolism of aquatic organisms but can also increase their toxicity. pH can affect the solubility of heavy metals in water [19].

IV. CONCLUSION

In this study, water samples collected at four stations showed that chromium (Cr) concentrations were below the established limit of 0.05 mg/L. However, the accumulation of chromium (Cr) in fish, especially in the gills, has exceeded the FAO 1983 threshold of 1 mg/kg at station II (Tukad Korea) 1.294 mg/kg and station III (Taman Pancing Barat) 2.22 mg/kg and the highest BCF at station III is 74, but is still included in the low accumulative category.

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