



**EVALUATION OF HEAVY METAL CONCENTRATIONS IN FISH TISSUES FROM THE TRIBUTARIES OF IKPUKULU RIVER IN OKIRIKA L.G.A, RIVERS STATE, NIGERIA**

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**Cite this article:**

Owoh, A. A., Green, A. F.,  
Bob-Manuel, K. N. O.,  
Inyang, D. U., Timothy, C. F.  
(2026), Evaluation of Heavy  
Metal Concentrations in Fish  
Tissues from the Tributaries  
of Ikpukulu River in Okirika  
L.G.A, Rivers State, Nigeria.  
African Journal of Biology  
and Medical Research 9(1),  
47-53. DOI:  
10.52589/AJBMR-  
VXIXK6DB

**Manuscript History**

Received: 12 Dec 2025

Accepted: 14 Jan 2026

Published: 4 Feb 2026

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**ABSTRACT:** *This study assessed the concentrations of selected heavy metals lead (Pb), chromium (Cr), cadmium (Cd), zinc (Zn), and nickel (Ni) in the muscle, liver, and gills of Tilapia guineensis obtained from three locations of the tributaries of the Ikpukulu River in the Dick-Fiberesima-Ama, Okrika Local Government Area, Rivers State, Nigeria. Sample analysis was conducted using Atomic Absorption Spectrophotometry (AAS). Results revealed bioaccumulation of these metals in fish tissues across all sampling points, with the general order of concentration observed as Zn > Cr > Ni > Pb > Cd at Dick-Fiberesima-Ama Creek (Point 1), Egbe-Ama Creek (Point 2), and Ogan-Ama Creek (Point 3). Mean concentrations ranged from 1.56±0.048 to 15.68±0.008 mg/kg in muscle, 2.85±0.053 to 11.35±0.053 mg/kg in liver, and 4.12±0.004 to 13.68±0.009 mg/kg in gills. Notably, levels of Pb, Cr, and Ni exceeded the permissible limits set by the World Health Organization (WHO 2011), indicating potential health risks for consumers. These elevated concentrations may be linked to anthropogenic activities such as illegal oil bunkering and waterway transportation. Therefore, public health awareness campaigns and the implementation of effective environmental management strategies are recommended to safeguard both human health and aquatic life in the region.*

**KEYWORDS:** Heavy metals, *Tilapia guineensis*, Ikpukulu Creek, Fish Tissues.



## INTRODUCTION

Aquatic ecosystems in the Niger Delta region of Nigeria face substantial threats from anthropogenic pollution, particularly due to oil-related activities, industrial effluents, and domestic waste discharge. One critical concern is the bioaccumulation of heavy metals in aquatic organisms, which poses health risks to both aquatic life and humans through food chain transfer (Avenant-Oldewage, 2001; Iwegbue *et al.*, 2013).

Fish, especially *Tilapia guineensis*, serve as excellent bioindicators due to their wide distribution, trophic position, and ability to bioaccumulate pollutants (Authman *et al.*, 2015). This study examines the levels of heavy metals in fish tissues across three sites subjected to varying degrees of pollution in the Niger Delta to assess the ecological risk and spatial-temporal patterns of contamination.

## MATERIALS AND METHODS

### Description of Study Area

This study was conducted on the tributaries of the Ikpukulu River in Okrika LGA, Rivers State, Nigeria. Three sampling stations were selected: Dic-Fiberesima Ama Creek (Station 1), Egbema Creek (Station 2), and Ogan Ama Creek (Station 3), with geographical coordinates of N 4°44'6.14260" E 7°1'39.69330", N 4°44'6.14260" E 7°1'41.65920", and N 4°44'8.07630" E 7°1'41.55110". Each station exhibited significant anthropogenic activities, including illegal bunkering, effluent discharge, poor sanitation, and reduced fishing activity.

### Sample Collection

Samples of *Tilapia guineensis* were collected monthly over three months (August to October). Gill nets (1–3 cm) were used to capture fish specimens. Fish were preserved on-site in coolers and subsequently frozen until analysis.

### Fish Sample Preparation & Analysis

Muscle, liver, and gill tissues were dissected using sterilized stainless-steel tools, oven-dried at 60°C until a constant weight was achieved, ground into powder, and digested using a mixture of HNO<sub>3</sub> and HClO<sub>4</sub> according to USEPA (2009) methods.

Heavy metal concentrations (Pb, Cr, Cd, Zn, Ni) were quantified using Atomic Absorption Spectrophotometry (GBC Avanta 2.02). Precautionary measures were taken to avoid contamination: use of analytical-grade reagents, deionized water, and acid-washed glassware.

### Statistical Analysis

Analysis and presentation of results was done using Microsoft Excel SPSS version 17. Data was subjected to JMP software to determine their correlation coefficient, principal component analysis (PCA) to determine the components responsible, and cluster analysis for their grouping. Analysis of Variance (ANOVA) was used to determine their relationships and levels of significance.



## RESULTS AND DISCUSSION

**Table 1: Mean Spatial Distribution of Heavy Metals in Muscles of *Tilapia guineensis***

Stations	Lead (mg/kg)	Chromium (mg/kg)	Cadmium (mg/kg)	Zinc (mg/kg)	Nickel (mg/kg)
Dick-Fiberesima Ama creek	3.78 <sup>b</sup> ±0.002	5.46 <sup>c</sup> ± 0.020	1.72 <sup>ab</sup> ± 0.006	12.62 <sup>b</sup> ±0.094	4.34 <sup>b</sup> ± 0.007
Egbe-Ama creek	3.38 <sup>c</sup> ±0.009	6.44 <sup>b</sup> ± 0.010	1.88 <sup>a</sup> ± 0.013	13.59 <sup>b</sup> ±0.052	4.47 <sup>b</sup> ± 0.009
Ogan ama creek	4.80 <sup>a</sup> ±0.088	8.37 <sup>a</sup> ± 0.049	1.56 <sup>b</sup> ± 0.048	15.68 <sup>a</sup> ±0.008	7.72 <sup>a</sup> ± 0.052

This means that those that do not share the same letter are significantly different at p<0.05

**Table 2: Mean Spatial Distribution of Heavy Metals in Gills of *Tilapia guineensis***

Stations	Lead(mg/kg)	Chromium(mg/kg)	Cadmium(mg/kg)	Zinc(mg/kg)	Nickel(mg/kg)
Dickk-Fiberesima Ama creek	5.15 <sup>b</sup> ±0.021	8.12 <sup>b</sup> ± 0.011	4.51 <sup>b</sup> ± 0.045	7.58 <sup>c</sup> ±0.006	5.79 <sup>b</sup> ± 0.002
Egbe-Ama creek	6.79 <sup>a</sup> ±0.050	7.13 <sup>c</sup> ± 0.006	4.88 <sup>a</sup> ± 0.051	10.28 <sup>b</sup> ±0.050	8.74 <sup>a</sup> ± 0.009
Ogan-Ama creek	4.12 <sup>c</sup> ±0.004	9.43 <sup>a</sup> ± 0.005	3.91 <sup>c</sup> ± 0.038	13.68 <sup>a</sup> ±0.009	5.14 <sup>c</sup> ± 0.014

Means that do not share the same letter are significantly different at p<0.05

**Table 3: Mean Spatial Distribution of Heavy Metals in Liver of *Tilapia guineensis***

Stations	Lead(mg/kg)	Chromium(mg/kg)	Cadmium(mg/kg)	Zinc(mg/kg)	Nickel(mg/kg)
Dickk-Fiberesima Ama creek	4.72 <sup>a</sup> ±0.007	7.47 <sup>b</sup> ± 0.077	3.84 <sup>a</sup> ± 0.043	9.74 <sup>b</sup> ±0.025	6.33 <sup>a</sup> ± 0.126
Egbe-Ama creek	4.53 <sup>a</sup> ± 0.009	8.13 <sup>a</sup> ± 0.006	3.84 <sup>a</sup> ± 0.006	9.74 <sup>b</sup> ±0.025	6.15 <sup>a</sup> ± 0.005
Ogan-Ama creek	3.87 <sup>b</sup> ± 0.096	7.37 <sup>c</sup> ± 0.008	2.85 <sup>b</sup> ± 0.053	11.35 <sup>a</sup> ±0.054	5.15 <sup>b</sup> ± 0.010

This means that those that do not share the same letter are significantly different at p<0.05

**Table 4: Mean Temporal Distribution of Heavy Metals in Muscles of *Tilapia guineensis***

Months	Lead(mg/kg)	Chromium(mg/kg)	Cadmium(mg/kg)	Zinc(mg/kg)	Nickel(mg/kg)
August	4.00 <sup>a</sup> ± 0.653	6.75 <sup>b</sup> ± 1.260	1.72 <sup>a</sup> ± 0.161	13.95 <sup>a</sup> ±1.377	5.52 <sup>a</sup> ± 1.666
September	3.95 <sup>a</sup> ± 0.584	6.79 <sup>a</sup> ± 1.308	1.74 <sup>a</sup> ± 0.105	13.92 <sup>a</sup> ±1.382	5.48 <sup>a</sup> ± 1.625
October	4.01 <sup>a</sup> ± 0.671	6.74 <sup>b</sup> ± 1.280	1.71 <sup>a</sup> ± 0.147	14.01 <sup>a</sup> ±1.300	5.50 <sup>a</sup> ± 1.677

Means that do not share the same letter are significantly different at p<0.05

**Table 5: Mean Temporal Distribution of Heavy Metals in Gills of *Tilapia guineensis***

Months	Lead(mg/kg)	Chromium(mg/kg)	Cadmium(mg/kg)	Zinc(mg/kg)	Nickel(mg/kg)
August	5.37 <sup>a</sup> ±1.182	8.23 <sup>a</sup> ± 0.100	4.43 <sup>a</sup> ± 0.045	10.53 <sup>a</sup> ±2.651	6.55 <sup>a</sup> ± 1.666
September	5.34 <sup>a</sup> ± 1.133	8.23 <sup>a</sup> ± 0.999	4.42 <sup>a</sup> ± 0.372	10.49 <sup>a</sup> ±2.650	6.55 <sup>a</sup> ± 1.664
October	5.36 <sup>a</sup> ± 1.185	8.23 <sup>a</sup> ± 0.999	4.46 <sup>a</sup> ± 0.454	10.52 <sup>a</sup> ±2.646	6.56 <sup>a</sup> ± 1.659

This means that those that do not share the same letter are significantly different at p<0.05

**Table 6: Mean Temporal Distribution of Heavy Metals in Liver of *Tilapia guineensis***

Months	Lead(mg/kg)	Chromium(mg/kg)	Cadmium(mg/kg)	Zinc(mg/kg)	Nickel(mg/kg)
August	4.39 <sup>a</sup> ±0.357	7.68 <sup>a</sup> ± 0.342	3.53 <sup>a</sup> ± 0.480	10.14 <sup>ab</sup> ±0.953	5.90 <sup>a</sup> ± 0.584
September	4.33 <sup>a</sup> ±0.451	7.67 <sup>a</sup> ± 0.347	3.49 <sup>a</sup> ± 0.534	10.10 <sup>b</sup> ± 0.898	5.91 <sup>a</sup> ± 0.581
October	4.40 <sup>a</sup> ±0.356	7.63 <sup>a</sup> ± 0.383	3.50 <sup>a</sup> ± 0.466	10.17 <sup>a</sup> ± 0.936	5.83 <sup>a</sup> ± 0.501

This means that those that do not share the same letter are significantly different at p<0.05

The mean concentration of lead in this study ranged from 3.38 to 6.79 mg/kg, which is significantly higher than the 0.37–1.63 mg/kg reported by Abu and Nwokoma (2016). It also exceeds the 0.17–0.23 mg/kg found in fish tissue from the Sombreiro River by Wokoma (2014), the 0.039–0.009 mg/kg reported by Bob-Manuel et al. (2015), and the 0.00–0.01 mg/kg recorded by Adata *et al.* (2016) in *Tilapia* from Kaa waters in Ogoniland, Rivers State. However, it falls within the 3.40 mg/kg level reported in the liver of *Clarias gariepinus* by Farombi *et al.* (2007). The mean lead concentration reported in this study exceeds the permissible limits set by the World Health Organization (WHO) and the Federal Environmental Protection Agency (FEPA).

Chromium levels in this study ranged from 5.46 to 9.43 mg/kg, which are higher than the 1.243–3.689 mg/kg reported by Bob-Manuel *et al.* (2015) in organs of *Clarias gariepinus* from Okilo Creek and the 1.22±0.70 mg/kg found in *O. niloticus* by Ekweozor *et al.* (2017) from Azuabie Creek. It also surpasses the 0.16–0.86 µg/g recorded in *K. axillaris* by Vijayakumar *et al.* (2011) and the 0.094 mg/kg reported in catfish by Orosun *et al.* (2016). Although the chromium levels in *T. guineensis* in this study are lower than those reported by Obot et al. (2016) (12.88–21.18 mg/kg in *Ilisha africana*) and Saeed *et al.* (2014) (70.5±0.74 mg/kg from the Tembi River), they still exceed the WHO and FEPA permissible limits.



The mean cadmium concentration in this report (1.56–4.88 mg/kg) is higher than the 0.74 mg/kg, 0.6 mg/kg, and 0.038 mg/kg reported by Ekweozor *et al.* (2017), Farombi *et al.* (2007), and Edem *et al.* (2009), respectively, in various tissues of *O. niloticus* and *Clarias gariepinus*. However, it is lower than the 2.43–10.73 mg/kg reported in *Ilisha africana* by Obot *et al.* (2016). Importantly, the cadmium levels observed in this study fall within WHO's permissible limits.

Zinc concentrations ranged from 7.58 to 15.68 mg/kg, which is lower than the 84.76–136.9 mg/kg reported by Yilmaz (2009), the 77.47 mg/kg reported by Wangboje & Ikhuabe (2015), and the 19.05 mg/kg observed in the kidney of *Clarias gariepinus* by Farombi *et al.* (2007). On the other hand, it is higher than the 0.54 mg/kg found in *Tilapia zilli* by Akan *et al.* (2009) from Lake Chad and falls within the 0.13–20.1 µg/g range reported in *R. kanagurta* tissue by Vijayakumar *et al.* (2011). Overall, the zinc levels observed in *T. guineensis* in this study are within the permissible limits established by WHO and FEPA.

The mean concentration of nickel ranged from 4.34 to 8.74 mg/kg, which exceeds the WHO and FEPA permissible limits. These levels are higher than those reported by Wokoma (2014) and Bob-Manuel *et al.* (2015), who recorded ranges of 0.28–2.89 mg/kg and 0.201–2.327 mg/kg, respectively, in *Pseudotolithus elongatus* and *Clarias gariepinus*. They are also above the  $3.69 \pm 0.54$  mg/kg found in *Chrysichthys nigrodigitatus* from the Sombreiro River by Wokoma (2014), but lower than the 17.0–90.23 mg/kg range reported by Obot *et al.* (2016) in *Ilisha africana* from the lower Cross River estuary. Additionally, the nickel levels in this study are higher than the 0.56–1.86 ppm observed in the heart of *Clarias gariepinus* by Babatunde *et al.* (2012).

## CONCLUSION

This study assessed the concentration and spatial-temporal distribution of heavy metals (Pb, Cr, Cd, Zn, Ni) in the muscle, gill, and liver tissues of *Tilapia guineensis* from tributaries of the Ikpukulu River in Okrika, Rivers State. The results revealed varying levels of contamination across sampling stations and months, with most metal concentrations significantly exceeding WHO and FEPA permissible limits particularly for lead, chromium, cadmium, and nickel.

The observed bioaccumulation of heavy metals indicates considerable anthropogenic input from activities such as illegal oil bunkering, industrial discharge, and poor waste management in the study area. *Tilapia guineensis* proved to be an effective bioindicator species, reflecting the extent of ecological stress and pollution in these aquatic systems.

The elevated levels of toxic metals not only pose a threat to the health of aquatic organisms but also raise significant concerns for human health through the consumption of contaminated fish. Therefore, immediate and sustained environmental management interventions are necessary to safeguard public health and preserve aquatic biodiversity in the Niger Delta region.



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