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Integrated Assessment of Physico-Chemical Parameters And Heavy Metal Bioaccumulation in *Tilapia Guineensis* From Ondo State Coastal Ecosystems

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ABSTRACT

The presence of heavy metals in food remains an issue of public health concern. Therefore, this study determined some physico-chemical parameters of water and heavy metals' concentration in *Tilapia guineensis* from Oroto creek and Mahin Lagoon in Ondo State. Water and fish samples were collected monthly from February to April 2021 and transported in ice-chest to the laboratory for analyses. The physico-chemical parameters of water were determined with Hanna multi-parameter kit while heavy metals were estimated with Atomic Absorption Spectrophotometer after digestion. The temperature ($29.33 \pm 0.51^\circ\text{C}$), salinity ($38.33 \pm 5.38\text{mg/l}$), turbidity ($27.97 \pm 16.70\text{mg/l}$), TDS ($75.04 \pm 102.74\text{mg/l}$), conductivity ($45.20 \pm 29.33\mu\text{S/cm}$), pH ($7.35 \pm 0.11\text{mg/l}$), DO ($9.42 \pm 2.64\text{mg/l}$) and BOD ($2.81 \pm 2.81\text{mg/l}$) recorded for Oroto Creek and temperature ($29.68 \pm 0.52^\circ\text{C}$), salinity ($12.08 \pm 6.60\text{mg/l}$), turbidity ($9.81 \pm 4.43\text{NTU}$), TDS ($12.39 \pm 6.44\text{mg/l}$), conductivity ($20.04 \pm 10.49\mu\text{S/cm}$), pH (8.13 ± 1.57), DO ($11.90 \pm 5.89\text{mg/l}$) and BOD ($6.89 \pm 3.25\text{mg/l}$) recorded for Mahin Lagoon indicated slight pollution in both stations (according to the Comprehensive Pollution Index). *T. guineensis* from Oroto creek and Mahin lagoon had concentration of Zn ($14.73 \pm 6.68\text{mg/kg}$) and ($17.57 \pm 10.09\text{mg/kg}$); Pb ($0.22 \pm 0.34\text{mg/kg}$) and ($0.22 \pm 0.35\text{mg/kg}$); Fe ($19.58 \pm 4.25\text{mg/kg}$) and ($35.92 \pm 27.14\text{mg/kg}$); Cu ($0.13 \pm 0.19\text{mg/kg}$) and ($1.59 \pm 2.16\text{mg/kg}$); Cr ($0.00 \pm 0.00\text{mg/kg}$) and ($9.01 \pm 11.32\text{mg/kg}$); Cd ($0.09 \pm 0.11\text{mg/kg}$) and ($0.09 \pm 0.012\text{mg/kg}$); Ni ($1.42 \pm 1.60\text{mg/kg}$) and ($11.33 \pm 8.74\text{mg/kg}$); Co ($0.69 \pm 0.54\text{mg/kg}$) and ($1.30 \pm 0.75\text{mg/kg}$) respectively. The ecological risk quotient showed that Fe and Ni posed ecological risk to *T. guineensis* in both stations. The health risk assessments revealed that there may be non-carcinogenic health risk for the consumers of *T. guineensis* from the study area while there was no carcinogenic risk associated with the fish consumption; hence, urgent monitoring and clean-up programme is recommended in and around the study area.

Keywords: Food Safety; Food Poison; health quotient; Coastal pollution; Ecological risk assessment

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Introduction

There are serious concerns to human health and the ecosystem when heavy metals are present in aquatic settings (Hwang *et al.*, 2018). Anthropogenic activities have become more prevalent in Nigeria's coastal waters, especially in Ondo State, which could lead to the contamination of aquatic life and water bodies (Adekola *et al.*, 2020). For local people, tilapia guineensis, a popular fish species, is an essential source of protein (Bene *et al.*, 2015). Heavy metal buildup in this species, however, raises questions about public health and food safety (Okafor *et al.*, 2021). The purpose of this study was to evaluate the water quality and heavy metal contents in *T. guineensis* from two important coastal areas in Ondo State, Nigeria: Orotu Creek and Mahin Lagoon. By evaluating physico-chemical parameters and heavy metal concentrations, we aimed to understand the ecological risks associated with these contaminants and their potential health implications for consumers.

Methodology

Study Area and Sample Collection: The study was conducted in Orotu Creek and Mahin Lagoon, both located in Ondo State, Nigeria. Water and fish samples were collected monthly from February to April 2021. Water samples were taken to ensure representative sampling (Loto and Ajibare, 2021). Fish specimens of *T. guineensis* were caught using gill nets.

Physico-Chemical Analysis: Using a Hanna multi-parameter kit, water samples were examined for temperature, salinity, turbidity, total dissolved solids (TDS), conductivity, pH, dissolved oxygen (DO), and biochemical oxygen demand (BOD) (APHA, 2017). In accordance with conventional procedures for the analysis of water and wastewater, each parameter was measured in accordance with standard protocols to

guarantee accuracy and dependability (APHA, 2017).

Heavy Metal Analysis: Standard acid digestion was used to break down fish samples (Rasul *et al.*, 2019). An Atomic Absorption Spectrophotometer (AAS) was used to measure the amounts of heavy metals, such as zinc (Zn), lead (Pb), iron (Fe), copper (Cu), chromium (Cr), cadmium (Cd), nickel (Ni), and cobalt (Co) (Iweala *et al.*, 2020).

Ecological and Health Risk Assessment: The ecological risk quotient was calculated to assess the ecological risk posed by heavy metals (Ajibare *et al.* 2022). Health risk assessments were performed to evaluate both carcinogenic (Target cancer risk) and non-carcinogenic risks

Ecological risk quotient (ERQ) was calculated according to Olawusi-Peters *et al.*, (2019) as:

$$\text{Ecological Risk Quotient} = \frac{\text{Environmental Concentration (mg/kg)}}{\text{Recommended Limit (mg/kg)}} \quad (1)$$

Health risk index (HRI) was also determined as:

$$\text{Health Risk Index} = \frac{\text{Daily Intake of Metal (DIM)}}{\text{Reference Oral Dose (ROD)}} \quad (2)$$

(Olawusi-Peters and Adejugbagbe, 2020)

Where,

$$\text{DIM} = \frac{M \times CF \times \text{Daily intake of fish}}{\text{Average body weight}} \quad (3)$$

(Olawusi-Peters, 2021)

where CF is the conversion factor = 0.085 and M is the metal content in fish tissue (mg/kg). The average body weight of the fish consumers was set at 60 kg. According to Omobepade *et al.* (2020), the fish consumption rate in Nigeria was calculated to be 48g/person/day.

NOTE: Values below 1 for the Health Risk Index (HRI) and Ecological Risk Quotient (ERQ) are often regarded as acceptable because they are unlikely to cause significant chronic systemic risk adverse health consequences over the course of a lifetime of exposure. According to USEPA (2011), target cancer risk (TR), a measure of carcinogenic risk, was computed as follows:

$$TR = \frac{M \times FIR \times CPSo \times EF \times ED}{BW \times ATn} \times 10^{-3}$$

(4)

FIR, BW, EF, M, ED are already given above. The average life expectancy in Nigeria is 54 years, ATn is the average time for carcinogens (365 days/year × 54 years). The carcinogenic potency slope oral (mg/kg bw-day⁻¹) is known as CPSo. TR values for intake of only Ni, Pb, Cr, and Cd were computed to illustrate the carcinogenic risk because they were listed in the list of potent carcinogens (USEPA 2011). This is because Mn, Fe, Co, Cu, and Zn do not have any carcinogenic effects, and its CPSo has not yet been confirmed. According to the integrated risk information system

database (USEPA, 2011), their respective carcinogenic potency slope oral (CPSo) values for Ni, Pb, Cr, and Cd are 1.7, 0.009, 0.5, and 0.6. According to New York State Department of Health (NYSDOH, 2007) and Javed and Usmani (2016) the TR categories are described as, if TR ≤ 10⁻⁶ = Low; 10⁻⁴ to 10⁻³ = moderate; 10⁻³ to 10⁻¹ = high; ≥10⁻¹ = very high.

Results

Physico-Chemical Parameters: The physico-chemical analysis indicated that Oroto Creek had an average temperature of 29.33±0.51°C, salinity of 38.33±5.38 mg/l, and a pH of 7.35±0.11. In contrast, Mahin Lagoon showed a slightly higher temperature of 29.68±0.52°C and a lower salinity of 12.08±6.60 mg/l (Table 1). The Comprehensive Pollution Index suggested severe pollution in both locations (Table 2).

Heavy Metal Concentrations in Fish: The concentrations of heavy metals in *T. guineensis* from Oroto Creek were Zn (14.73±6.68 mg/kg), Pb (0.22±0.34 mg/kg), Fe (19.58±4.25 mg/kg), Cu (0.13±0.19 mg/kg),

Table 1: Physico-Chemical Parameters of Water Samples from Oroto Creek and Mahin Lagoon

Parameter	Oroto Creek	Mahin	WHO 2003; FEPA 2003
Temperature (°C)	29.33±0.51	29.68±0.52	30
Salinity (mg/l)	38.33±5.38	12.08±6.60	15
Turbidity(NTU)	27.97±16.70	9.81±4.43	50
TDS(mg/l)	75.04±102.74	12.39±6.44	30
Conductivity (µs/cm)	45.20±29.33	20.04±10.49	35
pH	7.35±0.11	8.13±1.57	6.6
DO(mg/l)	9.42±2.64	11.90±5.89	6
BOD(mg/l)	2.81±2.81	6.89±3.25	5
Nitrate(mg/l)	3.04±0.21	4.96±0.95	5
Phosphate(mg/l)	2.10±0.71	3.30±0.83	0.3
Sulphate(mg/l)	2.67±0.44	5.34±0.67	250

Table 2: Comprehensive Pollution Index (CPI) of Oroto Creek and Mahin Lagoon

Month	Mahin Lagoon	Interpretation	Oroto Creek	Interpretation
February	2.42	Severe pollution	1.65	Moderate pollution
March	2.51	Severe pollution	1.83	Moderate pollution
April	3.08	Severe pollution	2.65	Severe pollution
Mean	2.67	Severe pollution	2.02	Severe pollution

Cr (0.00 mg/kg), Cd (0.09±0.11 mg/kg), Ni (1.42±1.60 mg/kg), and Co (0.69±0.54 mg/kg). In Mahin Lagoon, the concentrations were Zn (17.57±10.09 mg/kg), Pb (0.22±0.35 mg/kg), Fe (35.92±27.14 mg/kg), Cu (1.59±2.16 mg/kg), Cr (9.01±11.32 mg/kg), Cd (0.09±0.012 mg/kg), Ni (11.33±8.74 mg/kg), and Co (1.30±0.75 mg/kg) (Table 3).

Table 3: Concentrations of Heavy Metals in *Tilapia guineensis* from Oroto Creek and Mahin Lagoon

Parameter	Oroto creek	Mahin lagoon	WHO (2003)	FAO (2007)
Zinc (mg/kg)	14.73±6.68	17.54±10.09	3	3
Lead (mg/kg)	0.22 ± 0.34	0.22 ± 0.35	0.01	0.01
Iron (mg/kg)	19.58 ± 4.25	35.92 ± 27.14	0.5–50	0.5–50
Copper (mg/kg)	0.13 ± 0.19	1.59 ± 2.16	1	1
Chromium (mg/kg)	0.00 ± 0.00	9.01 ± 11.32	0.05	0.05
Cadmium (mg/kg)	0.09 ± 0.11	0.09 ± 0.12	0.50	0.20
Nickel (mg/kg)	1.42 ± 1.60	11.33 ± 8.74	0.02	0.02
Cobalt (mg/kg)	0.69 ± 0.54	1.30 ± 0.75	0.50	0.50

Ecological Risk Assessment: The ecological risk quotient revealed that Fe and Ni posed significant ecological risks to *T. guineensis* in both study locations while Cr posed ecological risk to *T. guineensis* in Mahin lagoon (Table 4).

Health Risk Assessment: The health risk assessment indicated a potential non-carcinogenic risk for consumers of *T. guineensis* from both sites (Table 5), while no carcinogenic risk was identified (Table 6).

Table 4: Ecological Risk Quotients (ERQ) of Heavy Metals in *Tilapia Guineensis* Collected From Oroto Creek and Mahin Lagoon

Metal	Oroto creek	Mahin lagoon
Zinc	0.49	0.58
Lead	0.10	0.11
Iron	39.16	71.84
Copper	0.04	0.53
Chromium	0.00	3.92
Cadmium	0.18	0.18
Nickel	2.84	22.66
Cobalt	0.14	0.26

Table 5: Health Risk Index (HRI) of Heavy Metal In Tilapia Guineensis Mahin Lagoon and Oroto Creek

Metal	Oroto creek	Mahin lagoon
Zinc	3.34	3.98
Lead	3.53	3.65
Iron	1.90	3.49
Copper	0.22	2.70
Chromium	0.00	0.41
Cadmium	6.12	6.12
Nickel	4.83	38.52
Cobalt	156.40	294.67

Table 6: Target Cancer Risks of Heavy Metals in Tilapia Guineensis from Coastal Waters of Ondo State

Metal	Oroto creek	Mahin lagoon
Lead	1.43×10 ⁻⁶	1.48×10 ⁻⁶
Chromium	0	0.003456
Cadmium	4.14×10 ⁻⁵	4.14×10 ⁻⁵
Nickel	0.001852	0.014776

Discussion

The results of this study demonstrate the alarming concentrations of heavy metals in *T. guineensis* from Oroto Creek and Mahin Lagoon in the coastal waters of Ondo State, Nigeria, suggesting possible hazards to human health and aquatic life (Hwang *et al.*, 2018). According to Adekola *et al.* (2020), the small contamination levels found in the physico-chemical parameters indicate that human activity is having an impact on water quality, which may result in the buildup of metals in local fish populations.

The high levels of Fe and Ni in fish from both sites point to the possibility that these metals come from adjacent industrial operations or urban runoff, highlighting the

necessity of routine monitoring and regulatory actions to reduce contamination (Iweala *et al.*, 2020). Even if they are not immediate, the non-carcinogenic health risks connected to *T. guineensis* intake call for public health initiatives to inform consumers about possible hazards (USEPA, 2011).

Overall, this study emphasizes the urgent need for a comprehensive monitoring program to assess and manage water quality and heavy metal contamination in the coastal waters of Ondo State (Bene *et al.*, 2015; Loto and Ajibare, 2021). Addressing these issues is critical to safeguarding both environmental and public health.

Conclusion

This study assessed the water quality and heavy metal concentrations in *Tilapia guineensis* from Oroto Creek and Mahin Lagoon in Ondo State, Nigeria. The results indicated that both water bodies exhibited slight pollution, with specific heavy metals, particularly iron and nickel, posing significant ecological risks to the fish population. While non-carcinogenic health risks were identified for consumers of *T. guineensis*, the findings highlight the need for ongoing monitoring of heavy metal levels to safeguard public health and aquatic ecosystems. Therefore, proper education, monitoring and clean up procedure should be carried out promptly in and around the study area.

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