



**ENVIRONMENTAL MONITORING AND ASSESSMENT: A CASE STUDY OF THE
BIOCHEMICAL AND HAEMATOLOGICAL PROPERTIES OF *Coptodon zillii* AND
Oreochromis niloticus FROM UREJE RESERVOIR IN EKITI STATE**

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Abstract

The health of aquatic organisms, especially fish, can serve as a reliable indicator of environmental conditions in freshwater ecosystems. This study assessed the biochemical and haematological parameters of *Coptodon zillii* and *Oreochromis niloticus* from Ureje Reservoir in Ekiti State, Nigeria, to determine the physiological status and potential exposure to environmental stressors. Blood samples were analyzed monthly (October–December) for key haematological indices including packed cell volume (PCV), red and white blood cell counts (RBC, WBC), haemoglobin (Hb), and differentials, as well as biochemical parameters such as albumin, creatinine, urea, alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP). Results revealed species-specific variations, with *C. zillii* generally showing higher values of RBC ($3.40 \times 10^{12}/\text{ml}$), WBC ($21.03 \times 10^9/\text{ml}$), PCV (29.83%) and Hb (9.72 g/100ml) compared to *O. niloticus* ($2.92 \times 10^{12}/\text{ml}$, $19.87 \times 10^9/\text{ml}$, 24.20% and 9.04 g/100ml respectively), whereas *O. niloticus* had elevated ALT (49.28 mg/dl), AST (21.60 mg/dl), and urea (43.15 g/100ml) levels compared to *C. zillii* (38.32 mg/dl, 18.49 mg/dl, and 38.43 g/100ml, respectively), possibly indicating greater environmental or physiological stress. Albumin levels were higher in *C. zillii* (45.60 g/100ml), whereas creatinine values were relatively similar across species. These findings suggest potential ecological impacts and highlight the usefulness of haematological and biochemical biomarkers in monitoring fish health and water quality.

Keywords: Fish physiology, Blood parameters, Freshwater ecosystem, Environmental monitoring, *Coptodon zillii*, *Oreochromis niloticus*

Introduction

Aquatic ecosystems play a crucial role in sustaining biodiversity, providing food, supporting livelihoods, and maintaining water quality. In freshwater environments

such as reservoirs, fish are among the most important organisms due to their ecological functions and economic value. The health of these fish species can serve as an early warning system for detecting environmental

changes and pollution (Adewoye *et al.*, 2013). Haematological and biochemical parameters are widely used as biomarkers for assessing physiological stress, disease states, and environmental quality in aquatic organisms (Nwani *et al.*, 2010). Fish respond to environmental stressors by altering their internal biochemical and haematological profiles. Parameters such as red blood cell (RBC) and white blood cell (WBC) counts, haemoglobin concentration (Hb), packed cell volume (PCV), and liver enzymes like ALT and AST, serve as diagnostic indicators of physiological disturbance or organ dysfunction. These changes are particularly useful for monitoring the effects of environmental pollution, including oxidative stress, immune suppression, liver damage, and kidney impairment (Adesina *et al.*, 2022).

The Ureje Reservoir in Ado-Ekiti, Ekiti State, Nigeria, is a critical water body that supports local fisheries, agriculture, and domestic water needs. However, rapid urbanization, increased agricultural activities, and poor waste management practices around the reservoir have raised concerns about the ecological integrity of the water body (Balogun *et al.*, 2025). Runoff containing pesticides, fertilizers, sewage, and domestic waste can introduce a variety of pollutants such as heavy metals, nitrates, phosphates, and organic matter into the water. These contaminants may cause sublethal or lethal effects on aquatic organisms and accumulate in the food chain, ultimately posing risks to human health through fish consumption.

Studies have reported elevated levels of heavy metals such as iron, zinc, and chromium in water, sediment, and fish tissues from the reservoir, with some concentrations exceeding World Health Organization (WHO) permissible limits, raising concern for aquatic life and human

consumers (Adeyeye *et al.*, 2017; Ogunfowokan *et al.*, 2017). Additionally, high bacterial loads have been recorded in both water and fish samples, particularly in areas with significant effluent influx, indicating potential sub-lethal effects on fish that may not be detectable through physical observation alone, thereby causing potential health risks for aquatic life and human consumers (Aladesida *et al.*, 2020).

Coptodon zillii and *Oreochromis niloticus* are among the most prevalent and ecologically important fish species in the Ureje Reservoir, and they function effectively as bioindicators for evaluating the environmental health of aquatic ecosystems (Oso *et al.*, 2024). Recent studies in the reservoir identified them as the two dominant species, highlighting their ecological prevalence (Ogunjobi *et al.*, 2023 and Oso *et al.*, 2024). *O. niloticus*, commonly known as Nile tilapia, holds substantial commercial value in Nigeria and across Africa due to its rapid growth, adaptability, and high market demand. Its presence in Ureje Reservoir contributes significantly to local fisheries and the livelihoods of surrounding communities (Food and Agriculture Organization, 2022). Changes in their haematological and biochemical parameters can reflect the impact of environmental stressors and pollutant exposure (Adesina *et al.*, 2020).

Moreover, studies have highlighted the significance of monitoring these parameters to understand the health implications for both aquatic organisms and human consumers. For instance, a study conducted by Obayemi *et al.* (2023) in Osu Reservoir assessed heavy metal concentrations in *C. zillii* and *Parachanna obscura*, revealing that while metal levels were below recommended limits, continuous consumption could pose health risks over time. Furthermore, Adegoke *et al.* (2024) in Ureje River examined the effects of environmental pollution on catfish,

focusing on water quality, heavy metal contamination, and fish health. Findings indicated significant biochemical alterations and organ damage in fish from polluted areas, underscoring the detrimental impact of pollution on aquatic life.

Despite these findings, there is a notable lack of studies focusing on the biochemical and haematological responses of *Coptodon zillii* and *Oreochromis niloticus* to these environmental stressors. Investigating these physiological parameters can provide early indicators of sub-lethal stress and overall fish health, offering valuable insights into the ecological impacts of pollution in the reservoir. Therefore, this study evaluated the haematological and biochemical properties of two economically important fish species, *C. zillii* and *O. niloticus* to fill existing knowledge gaps,

inform conservation and management strategies, and contribute to safeguarding the health of aquatic ecosystems and the communities that depend on them.

Materials and Methods

Study Area

This study was conducted at Ureje Reservoir, Ado-Ekiti, in Ekiti State, Nigeria (latitude 7° 37' N and longitude 5° 13' E). The reservoir is a man-made reservoir constructed primarily for water supply, irrigation, and aquaculture purposes (Balogun *et al.*, 2025). The study area lies between latitude 7° 37' N and longitude 5° 13' E (Figure 1). The climate of the study area is divided into two seasons: dry and wet seasons. The dry season lasts from November to March with a high temperature, sometimes reaching above 30°C, the wet season lasts from April to late October with an average temperature of 30°C (Oso *et al.*, 2024).

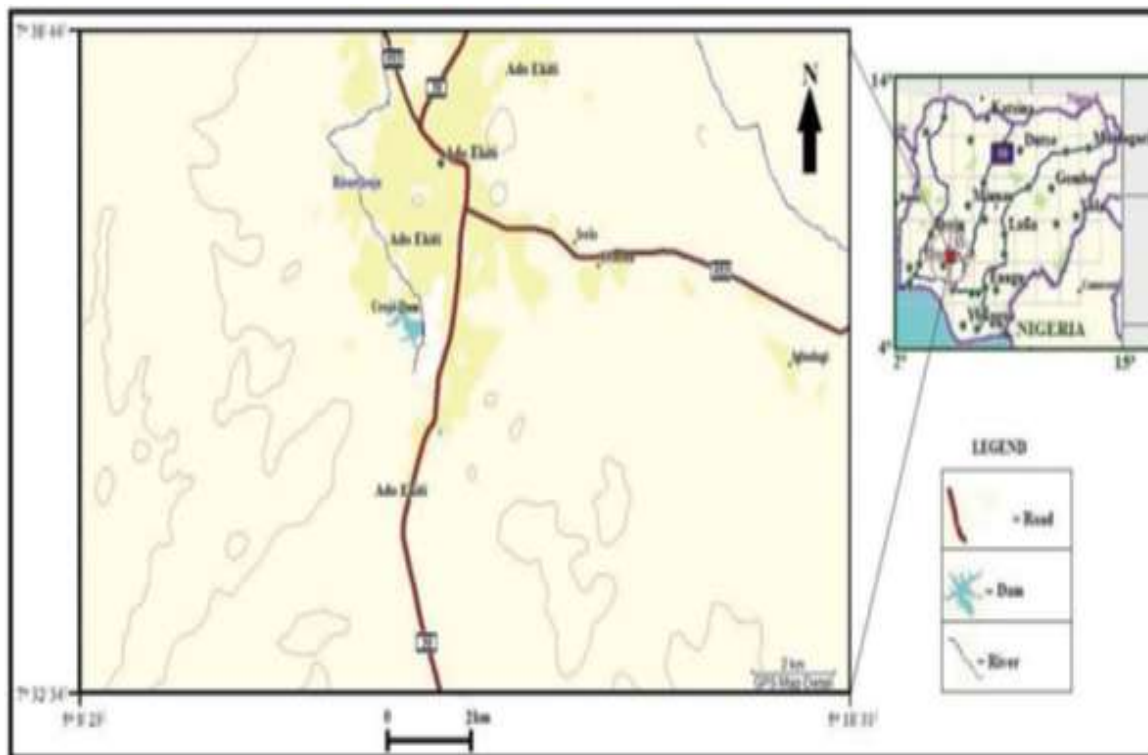


Figure 1: Ureje Reservoir (Balogun *et al.*, 2025)

Sample Collection

Adult specimens of *Coptodon zillii* and *Oreochromis niloticus* were identified using the taxonomic guide by Olaosebikan and Raji (2013) and were collected monthly from October to December using local fishing gear. Immediately after capture, the fish were transported in aerated containers to the laboratory for blood sampling following the procedure described by Owolabi *et al.* (2021). A total of 144 *C. zillii* and 152 *O. niloticus* specimens were collected during the study period. In October, 40 *C. zillii* and 48 *O. niloticus* samples were obtained, while 48 and 56 samples were collected for both species in November and December, respectively. The October to December sampling period was chosen due to its ecological significance as the transition from the wet to dry season, a time when environmental stressors such as reduced water levels, increased pollutant concentration, and lower dissolved oxygen can influence fish health, making it ideal for assessing physiological responses (Ogunfowokan *et al.*, 2017 and Balogun *et al.*, 2025).

Blood Sampling and Analysis

Blood was drawn from the caudal vein using heparinized syringes. Haematological parameters (PCV, RBC, WBC, platelet count, Hb, MCV, MCHC, lymphocytes, monocytes, and neutrophils) were determined using standard methods (Nwani *et al.*, 2010). For biochemical analyses, serum was separated by centrifugation and analyzed for ALP, ALT, AST, albumin, creatinine, and urea using a spectrophotometer according to Adesina *et al.*, (2022).

Statistical Analysis

All values are expressed as mean \pm standard

deviation. Differences across months were analyzed using multivariate analysis of variance on the statistical package for social scientists (SPSS 20.0), with significance set at $p < 0.05$.

Results

Haematological Parameters

The haematological parameters of *Coptodon zillii* and *Oreochromis niloticus* as presented in Table 1 revealed that *C. zillii* showed higher PCV (29.83%) and Hb (9.72 g/100ml) levels compared to *O. niloticus* (24.20% and 9.04 g/100ml, respectively). The table further revealed that WBC counts were similar, with *C. zillii* slightly higher at 21.03×10^9 /ml. RBC counts were also higher in *C. zillii* (3.40×10^{12} /ml) than in *O. niloticus* (2.92×10^{12} /ml), indicating better oxygen-carrying capacity. Platelet counts were similar across species, while differential counts such as neutrophils and lymphocytes showed minor variations.

The table further revealed that most hematological parameters (PCV, RBC, WBC, Hb, Platelet count, MCV, and MCHC) in *Coptodon zillii* showed significantly higher values ($P < 0.05$) in October, with a gradual decline through November and December (which suggests better physiological status in October, likely due to more favorable environmental or ecological conditions during that period). Whereas, in *Oreochromis niloticus*, most parameters remained relatively stable across the three months, with no significant differences ($P > 0.05$) observed for PCV, RBC, WBC, Hb, Platelets, and leukocyte differentials. However, MCHC showed a progressive and significant increase ($P < 0.05$) from October to December, indicating possible adaptive hematological responses.

Table 1: Haematological parameters of *C. zillii* and *O. niloticus* collected from Ureje reservoir

Species	Parameter	October	November	December	Mean
<i>C. zillii</i>	PCV (%)	31.09±0.91 ^b	29.57±0.16 ^a	28.82±0.40 ^a	29.83±1.12
	RBC(x10 ¹² /ml)	4.67±0.92 ^a	3.13±0.14 ^b	2.40±0.40 ^a	3.40±1.13
	WBC(x10 ⁹ /ml)	22.30±0.90 ^b	20.77±0.16 ^a	20.03±0.40 ^a	21.03±1.12
	Platelet(x10 ⁹ /ml)	172.90±0.90 ^b	171.37±0.16 ^a	170.63±0.40 ^a	171.63±1.12
	Hb (gm/100ml)	10.99±0.91 ^b	9.47±0.15 ^a	8.71±0.40 ^a	9.72±1.12
	MCV(fl)	1346.90±0.90 ^b	1345.37±0.16 ^a	1344.63±0.40 ^a	1345.63±1.12
	MCHC (gm/100ml)	31.92±0.89 ^b	30.42±0.13 ^a	29.68±0.40 ^a	30.67±1.10
	Lymphocytes (gm/100ml)	68.20±0.90 ^b	66.67±0.16 ^a	65.93±0.40 ^a	66.93±1.12
	Monocytes (gm/100ml)	2.01±0.89 ^b	0.51±0.12 ^a	0.57±0.40 ^a	1.03±0.88
	Neutrophils (gm/100ml)	19.62±0.89 ^b	18.12±0.13 ^a	18.18±0.40 ^a	18.64±0.88
<i>O. niloticus</i>	PCV (%)	24.87±2.27 ^a	24.71±1.10 ^a	23.02±0.12 ^a	24.20±1.54
	RBC(x10 ¹² /ml)	2.29±1.23 ^a	4.07±1.10 ^a	2.39±0.09 ^a	2.92±1.20
	WBC(x10 ⁹ /ml)	19.42±0.84 ^a	20.92±1.10 ^a	19.27±0.08 ^a	19.87±1.05
	Platelet(x10 ⁹ /ml)	178.08±7.67 ^a	183.61±1.10 ^a	181.93±0.12 ^a	181.21±4.59
	Hb (gm/100ml)	8.47±1.11 ^a	10.17±1.10 ^a	8.49±0.09 ^a	9.04±1.15
	MCV(fl)	1258.75±73.18 ^a	1217.61±1.10 ^a	1215.93±0.12 ^a	1230.76±42.19
	MCHC (gm/100ml)	28.77±0.66 ^a	31.29±1.10 ^b	33.39±0.09 ^c	31.15±2.10
	Lymphocytes (gm/100ml)	62.01±2.25 ^a	61.87±1.10 ^a	60.19±0.09 ^a	61.36±1.53
	Monocytes (gm/100ml)	1.68±0.56 ^a	1.67±1.10 ^a	0.55±0.45 ^a	1.30±0.86
	Neutrophils (gm/100ml)	21.60±1.82 ^a	22.72±1.10 ^a	21.07±0.08 ^a	21.79±1.29

Biochemical Parameters

The biochemical parameters of *C. zillii* and *O. niloticus* as presented in Table 2 revealed notable species-specific trends. *O. niloticus* exhibited higher alanine aminotransferase (49.28 mg/dl), aspartate aminotransferase (21.60 mg/dl), and urea (43.15 g/100ml) compared to *C. zillii* (38.32 mg/dl, 18.49 mg/dl, and 38.43 g/100ml, respectively),

suggesting potential stress or liver dysfunction. Albumin levels, which are indicators of nutritional and hepatic health, were higher in *C. zillii* (45.60 g/100ml) than in *O. niloticus* (37.63 g/100ml), reinforcing the trend that *C. zillii* may be experiencing less physiological stress compared to *O. niloticus*, whereas creatinine values were relatively similar across species.

Table 2 further revealed that the biochemical parameters of *Coptodon zillii* and *Oreochromis niloticus* exhibited statistically significant monthly variations ($P < 0.05$) between October and December. In *C. zillii*, levels of ALP, ALT, and AST were significantly higher in October compared to November, with a partial rebound observed in December. Similarly, albumin, creatinine, and urea levels were significantly lower in November but increased markedly in December, indicating possible

physiological adjustments to changing environmental conditions. Conversely, *O. niloticus* displayed relatively stable biochemical values, though significant increases ($P < 0.05$) were noted in December for ALP, ALT, AST, albumin, creatinine, and urea when compared to October and November. Despite these changes, the magnitude of variation in *O. niloticus* was less pronounced than in *C. zillii*, indicating a comparatively steadier physiological state across the study period.

Table 1: Biochemical parameters of *C. zillii* and *O. niloticus*

Species	Parameter	October	November	December	Mean
<i>C. zillii</i>	ALP (mg/dl)	26.98±1.80 ^b	24.13±0.77 ^a	26.44±1.26 ^{ab}	25.85±1.75
	ALT (mg/dl)	39.47±1.80 ^b	36.62±0.78 ^a	38.89±1.22 ^{ab}	38.32±1.74
	AST (mg/dl)	19.62±1.80 ^b	16.77±0.74 ^a	19.08±1.23 ^{ab}	18.49±1.74
	Albumin (g/100ml)	46.07±0.80 ^{ab}	44.22±0.77 ^a	46.50±1.21 ^b	45.60±1.33
	Creatinine (g/100ml)	15.93±0.80 ^{ab}	14.08±0.73 ^a	16.38±1.22 ^b	15.46±1.34
	Urea (g/100ml)	38.89±0.80 ^{ab}	37.04±0.75 ^a	39.35±1.25 ^b	38.43±1.34
<i>O. niloticus</i>	ALP (mg/dl)	31.91±0.28 ^a	31.66±0.57 ^a	32.79±0.11 ^b	32.12±0.60
	ALT (mg/dl)	49.08±0.28 ^a	48.81±0.60 ^a	49.97±0.11 ^b	49.28±0.62
	AST (mg/dl)	21.39±0.28 ^a	21.15±0.56 ^a	22.27±0.11 ^b	21.60±0.60
	Albumin (g/100ml)	37.42±0.28 ^a	37.17±0.57 ^a	38.29±0.11 ^b	37.63±0.60
	Creatinine (g/100ml)	17.87±0.28 ^a	17.60±0.60 ^a	18.73±0.11 ^b	18.07±0.61
	Urea (g/100ml)	42.95±0.28 ^a	42.69±0.59 ^a	43.81±0.11 ^b	43.15±0.61

Discussion

The observed variations in haematological and biochemical profiles between *Coptodon zillii* and *Oreochromis niloticus* highlight species-specific physiological responses to environmental conditions in the Ureje Reservoir. These differences may be linked to factors such as dietary preferences, habitat use, tolerance to pollutants, or genetic variability. The normal physiological ranges for key hematological parameters in *Coptodon zillii* and *Oreochromis niloticus* have been well-documented. The packed cell volume (PCV) typically ranges between

20–40% (Akinrotimi *et al.*, 2010; Fazio, 2019), while red blood cell (RBC) counts fall between $1.0\text{--}3.5 \times 10^{12}/\text{ml}$ (Oyelese, 2006; Olayemi and Akinyemi, 2009). White blood cell (WBC) counts are reported within $20\text{--}150 \times 10^9/\text{ml}$ (Gabriel *et al.*, 2004; Fazio, 2019), and platelet counts generally range from $30\text{--}250 \times 10^9/\text{ml}$ (Tavares-Dias and Moraes, 2007; Fazio, 2019). Hemoglobin (Hb) concentration normally lies between 5–15 g/100 ml (Olayemi and Akinyemi, 2009; Akinrotimi *et al.*, 2010). Additionally, mean corpuscular volume (MCV) values are usually within 100–250 fl (Fazio, 2019), and mean

corpuseular hemoglobin concentration (MCHC) is found between 25–35 g/100 ml (Gabriel *et al.*, 2004). Regarding leukocyte differentials, lymphocytes account for 50–90% of total WBCs (Fazio, 2019), neutrophils for 5–20% (Gabriel *et al.*, 2004), and monocytes for 2–10% (Tavares-Dias and Moraes, 2007). These values, however, may fluctuate depending on environmental conditions, age, nutritional status, and exposure to pollutants (Fazio, 2019; Akinrotimi *et al.*, 2010).

The haematological parameters observed in both species fall within the established normal physiological ranges (Akinrotimi *et al.*, 2010; Fazio, 2019). Notably, *C. zillii* exhibited greater monthly fluctuations in hematological indices than *O. niloticus*, indicating a higher sensitivity to seasonal or environmental changes. The lower RBC count ($2.92 \times 10^{12}/\text{ml}$), hemoglobin concentration (9.04 g/100ml), and packed cell volume (24.20%) recorded in *O. niloticus* may reflect exposure to hypoxic conditions or stressors that suppress erythropoiesis. In contrast, *C. zillii* showed higher RBC ($3.40 \times 10^{12}/\text{ml}$), Hb (9.72 g/100ml), and PCV (29.83%) values, suggesting a more robust oxygen transport capacity and potentially lower physiological stress (Akinsanya *et al.*, 2023). Conversely, the relatively lower values of these parameters in *O. niloticus* may indicate anaemia or reduced erythropoiesis, possibly due to sub-lethal exposure to pollutants such as heavy metals, pesticides, or organic waste. Anaemia in fish is commonly linked to environmental stressors that affect blood formation or cause red cell lysis (Fazio, 2019). Chronic exposure to sublethal pollutants such as ammonia, heavy metals, or pesticides may damage hematopoietic tissues, reduce oxygen-carrying capacity, and compromise fish vitality (Gabriel *et al.*, 2004). The elevated WBC levels in both

species though slightly higher in *C. zillii*, are indicative of immune system activation in response to stress or pathogen exposure in the aquatic environment (Adeyemo *et al.*, 2019). Similar findings were reported in Osu Reservoir, where heavy metal concentrations in *C. zillii* and *Parachanna obscura* were assessed, indicating potential health risks from continuous consumption (Obayemi *et al.*, 2023). Increased WBC is a common response to infection or stress in fish and is often used as a biomarker for environmental pollution (Akinsanya *et al.*, 2023).

Biochemical markers such as liver enzymes (ALT, AST, and ALP), albumin, creatinine, and urea serve as essential indicators of physiological and organ function in fish. In both *C. zillii* and *O. niloticus*, the normal physiological range for alkaline phosphatase (ALP) is reported to be between 104 and 130 U/L, alanine aminotransferase (ALT) between 65 and 130 U/L, and aspartate aminotransferase (AST) between 135 and 205 U/L (Akinsanya *et al.*, 2023). For albumin, *O. niloticus* typically exhibits a mean value of approximately 3.06 ± 0.65 g/100ml (Akinrotimi *et al.*, 2010). However, normal reference values for creatinine and urea are less clearly defined and may vary significantly depending on the fish's environmental exposure and physiological state (Obayemi *et al.*, 2023). In this study, *O. niloticus* displayed higher ALT and AST levels than *C. zillii*, suggesting potential hepatocellular damage. These enzymes are released into the bloodstream when liver tissues are damaged due to toxicant exposure (Adeyemo *et al.*, 2019). Elevated levels of ALT and AST are commonly associated with exposure to agricultural runoff, heavy metals, and industrial waste—pollution sources prevalent in many parts of southwestern Nigeria.

Biochemical indicators of liver function, particularly ALT and AST, were notably higher in *O. niloticus*, suggesting hepatic

damage or increased metabolic activity related to detoxification processes. These enzymes are commonly elevated in fish exposed to pollutants such as organophosphates, heavy metals, and hydrocarbons (Nwani *et al.*, 2010). Urea and creatinine levels, which are markers of kidney function and nitrogen metabolism, were also higher in *O. niloticus*, pointing to potential renal stress or inefficient nitrogen excretion mechanisms under environmental pressure. A study on catfish in Ureje River reported similar findings, with fish from polluted areas exhibiting higher liver enzyme levels and oxidative stress markers, indicating liver damage (Adegoke *et al.*, 2024). Creatinine and urea levels were also higher in *O. niloticus*, indicating possible renal impairment or increased protein catabolism, which may be a result of environmental contamination or metabolic stress (Obayemi *et al.*, 2023). Albumin levels were higher in *C. zillii*, reflecting better liver function and protein metabolism. Since albumin is synthesized by the liver, reduced levels in *O. niloticus* may indicate impaired hepatic function or protein loss due to gill or kidney damage (Adegoke *et al.*, 2024). These findings align with previous research showing that fish exposed to polluted water bodies exhibit decreased albumin concentrations (Iyora and Ueezi, 2024).

From an ecological perspective, these physiological disturbances in fish can indicate poor water quality and ecosystem imbalance. As fish are integral to aquatic food webs, their impaired health can affect population dynamics, reduce reproductive success, and alter predator-prey relationships. Furthermore, consumption of fish with bioaccumulated toxins poses serious risks to human health, including organ toxicity, endocrine disruption, and carcinogenic effects (Owolabi *et al.*, 2021; Iyora and Ueezi, 2024). Bioaccumulation of

pollutants in fish tissues poses risks to consumers, especially in communities relying heavily on these fish for protein. Chronic exposure to contaminants such as heavy metals and pesticide residues can lead to kidney and liver damage, neurological issues, and carcinogenic effects in humans (Setia *et al.*, 2020). Therefore, evaluating fish health using biochemical and haematological markers, is crucial for early detection of environmental degradation and guide interventions to safeguard both ecological and public health.

Conclusion

The biochemical and haematological assessments conducted in this study provide valuable insight into the physiological health of *Coptodon zillii* and *Oreochromis niloticus* in Ureje Reservoir. The findings suggest that *O. niloticus* may be more physiologically stressed, as evidenced by elevated liver enzymes, urea, and creatinine levels, as well as lower haematological values. These changes are indicative of potential exposure to environmental pollutants that can compromise organ function and overall fish health. In the broader context of aquatic ecology, these findings raise concerns about the ecological status of the Ureje Reservoir. Persistent exposure of fish populations to pollutants can reduce biodiversity, disrupt ecological balance, and impair the reservoir's function as a sustainable resource. Additionally, the implications for human health are significant, as contaminants in aquatic organisms can bio-accumulate and be transferred to humans through fish consumption, leading to serious health effects. Regular biomonitoring of fish health should be institutionalized to detect early signs of environmental stress.

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