Physico-chemical Parameters and Level of Toxicity in the Skin and Liver of Some Commercial Fish Forcados River, Okwagbe Waterside, Delta State

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Abstract- The physico-chemical parameters of the water and the toxicity levels of metals in the skin and liver of some commercially important fish from Forcados River, Okwagbe waterside were evaluated to determine their suitability for consumption and assess toxicity levels. The study was conducted bi-monthly in July and August 2022, monitoring a total of eight physico-chemical parameters (temperature, pH, turbidity, biological oxygen demand, dissolved oxygen, nitrate, phosphate, and potassium) and four toxic metals (cadmium, chromium, lead, and nickel). The results indicated no significant differences (P>0.05) in physico-chemical parameters across the months, except for dissolved oxygen and phosphate. The order of toxic metal concentrations in the skin was Pb > Ni > Cd > Cr, while in the liver it followed Pb > Ni > Cd > Cr. Statistical analysis showed no significant differences (P>0.05) in metal concentrations between the liver and skin, except for chromium, which was significantly higher (P<0.05) in the liver than in the skin. The study concluded that most of the assessed physico-chemical parameters were within WHO permissible limits, and the toxic metal concentrations in the liver and skin of the fish were negligible.

Indexed Terms- Physico-chemical parameters, Forcados River, toxicity level, skin, liver, metals

I. INTRODUCTION

The assessment of water body pollution is commonly conducted through the analysis of biological and physico-chemical parameters. Water is inherently impure, as it acquires contaminants from its environment, including inputs from human activities, animal interactions, and various biological processes (Abida *et al*., 2008). Water pollution presents a significant threat to both terrestrial and aquatic ecosystems. The presence of hazardous chemicals can lead to health issues, degrade water quality, exert physiological stress on biotic communities, generate unpleasant odors, and severely impede economic activities. Previous limnological studies, such as those by Omoigberale *et al*. (2010), Ogbeibu *et al*. (2013), and Erhenhi and Omoigberale (2020), have systematically evaluated the water quality of flowing bodies using a range of physico-chemical parameters.
Toxic metals are introduced into aquatic ecosystems through various pathways, including direct atmospheric deposition, climatic influences, and runoff from rainfall. Increased human activities—such as domestic waste discharge, mining, industrial processes, and agricultural practices—substantially contribute to pollution in natural environments (Sulieman and Suliman, 2019). The accumulation of toxic metals in the skin and liver of aquatic organisms can frequently surpass established environmental standards. Toxic effects arise when the rate of metal uptake exceeds the capacity for metabolism, storage, and detoxification within these organisms (Ali *et al*., 2011). Toxic metal accumulation in fish occurs via two primary mechanisms: direct exposure through the consumption of contaminated water and food via the digestive system (primarily the liver) and indirect exposure through the skin (Baki *et al*., 2018).

Numerous studies, including those by Rahman *et al*. (2012), Yousif *et al*. (2016), and Rajeshkumar and Li (2018), have documented the contamination of aquatic

environments by toxic metals. These investigations consistently identify cadmium, chromium, lead, and nickel as the predominant metals contributing to aquatic pollution. The bioaccumulation of toxic metals in fish presents substantial risks to human health upon consumption, potentially leading to serious health consequences (Alinor and Obiji, 2010). Furthermore, toxic metals can disrupt molecular components within aquatic ecosystems, adversely affecting fish behavior, physiological processes, circulatory dynamics, cellular integrity, ionic balance, liver function, and carbohydrate metabolism (Abarshi *et al*., 2017).
Continuous bioaccumulation of these toxic metals in the human body can result in severe health issues, ultimately leading to mortality due to contaminated drinking water and fish consumption. In light of these concerns, the objective of this study is to evaluate the physico-chemical parameters and metallic concentrations in the skin and liver of selected fish species.

II. MATERIALS AND METHODS

- Description of Study Area

Okwagbe waterside along Forcados River is located in Ughelli south, Delta state. Forcados Rivers connects Warri and runs into the river Niger through Patani and other popular towns in Delta state. The major tributaries of Forcados River is the River Niger and River Nun. Okwagbe water-side lies between latitude of 5° 31’ 43” N (5. 5285) to 5° 47’ 23” E (5.7898). The climate is equatorial and is marked by two distinct seasons (Dry and rainy season).The Dry season lasts from November to April and is marked by the cool dusty haze from the north-east winds. Although the rainy season spans May to October. The area is characterized by mean annual temperature of 32.8°C and annual rainfall amount of 2673.8mm. Human activities include boating activities, fishing, run-off from abattoir and agrochemicals, washing, and dredging.

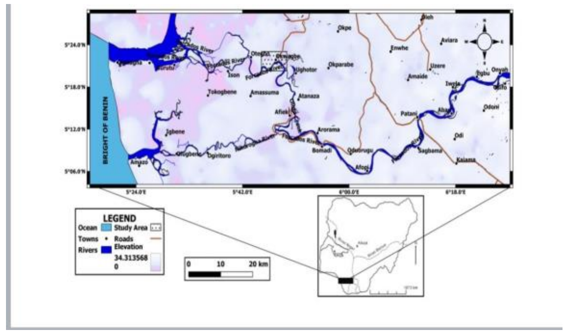

Figure 1: map of study area

- Collection of water samples

The study was carried out for a bi-monthly between July and August 2022 by collecting water sample. Water samples were collected using one litre plastic can and transparent reagent bottle used to collect water samples for dissolved oxygen analysis. BOD bottle was used to collect water samples for Biological oxygen demand analysis. The water samples were determined according to (ASTM 2008; AOAC 2019).

- Collection of fish samples

Synodontis nigrita, *Bagre marinus*, *Malapterus electricus and Synodotis schall* were collected bi-monthly between the months of July and August 2022. During the eight (8) weeks of the study, four (4) distinct fish species were sampled. Each fish species had two grams of skin and three grams of liver measured and digested. The digests were left to cool before being transferred to 100ml volumetric flasks and topped up with 1% nitric acid. The digests were stored in plastic bottles, and toxic metal concentrations were determined afterward with an atomic absorption spectrophotometer (AAS). This analysis was validated by diluting the metal salt solutions in different concentrations of 0.2, 0.4, 0.6, 0.8, and 1.0 ppm were passed through the spectrophotometer to measure the metals from fish and water samples (ASTM 2008; AOAC 2019). Bi-monthly, fish samples were collected from fishermen along the riverbank and dissected in the laboratory using a clean dissecting blade to remove the skin and liver that would be used for the study. The concentration of toxic metals in the sample was analyzed using the following equation

Ig/ =ppm x V
W x 103

Where ppm is mg/l (AAS)
(V) represents the volume of the digest sample

(W) is the weight of the sample used for digestion. The four different metals analyzed were Cadmium, Chromium, Lead and Nickel. The concentrations of toxic metals in the samples were then measured and recorded.

Figure 1: A - *Synodontis nigrita* (Valenciennes, 1840), B - *Bagre marinus* (Mitchill, 1815), C - *Malapterus electricus* (Gmelin, 1789) and D - *Synodotis schall* (Bloch and Schneider, 1801)

III. DATA ANALYSIS

The data collected were evaluated using Paleontological Studies (PAST) v3.4 to test the level of siginificant differences in the physico-chemical parameters between months, level of metals between the skin and the liver. Charts are drawn with Microsoft word (2007).

IV. RESULTS AND DISCUSSION

The result of the physico-chemical parameters of water in Forcado River for the month of July and August, 2022 is presented in Table 1. Dissolved oxygen and phosphate showed high level of significant difference but all other physico-chemical parameters indicated no significant differences between July and August.

Table 1: Summary of the physicochemical properties evaluated in Okwagbe water-side along Forcados River

Data	July	August	Minimum	Maximum	t-cal	p – value	WHO limit
Temperature (℃)	27.50 ± 1.73	25.0 ± 1.15	24	29	2.402	0.59	30
pH	6.90 ± 0.08	6.67 ±0.29	6.42	6.92	1.552	0.21	6.5-8.5
Turbidity (NTU)	19.00 ± 2.31	15.56 ± 0.54	15.09	21.00	2.906	0.06	5.00
BOD (mg/l)	18.30 ± 0.81	16.57 ± 0.62	17.03	19.00	1.445	0.20	50
DO (mg/l)	5.38 ± 0.72	6.92 ± 0.57	4.75	7.14	3.346	0.02	>5

Nitrate (mg/l)	0.06 ± 0.03	0.06 ± 0.02	0.03	0.08	0.000	1.00	<10
Phosphate (mg/l)	0.03 ± 0.01	0.07 ± 0.01	0.02	0.07	5.442	0.004	1.00
Potassium (mg/l)	0.47 ± 0.49	0.49 ± 0.05	0.41	0.98	0.100	0.93	3.00

The mean pH values observed in Okwagbe waterside along Forcados River, ranged from 6.90± 0.08 in July and 6.67 ± 0.29 in August as shown in Table 1. The values from this present study were lower than 8.1 ± 0.11 and 8.7 ± 0.08 reported by (Ahmed *et al.*, 2019) from spring water sources in Amediye District. The mean pH values observed in the present study is higher than the report of (Erhenhi and Omoigberale, 2020) whose pH values ranged from 5.41±0.14 to 5.56±0.13 when evaluating water Quality Index and Principal Component Analysis for the assessment of water Quality of Ethiope River, Delta State Nigeria. These variations could be due to the variation in the sampling area. However, the pH of the sampling area falls within WHO recommended value (6.5 – 8.5) for freshwater organisms.

Observed temperature for this study recorded mean values for 27.50 ± 1.73 in July and 25.0 ± 1.15 in August. Similar findings were also reported by (Erhenhi and Omoigberale, 2020) whose range values were 24.5±0.45 to 26.82±0.34 when evaluating water Quality Index and Prinicipal Component Analysis for the assessment of water Quality of Ethiope River, Delta State Nigeria. The findings of (Abarshi *et al.,* 2017) however, did not concur to this study as they recorded a slightly higher temperature 27°C - 29°C in Sombrero River. This variation could be attributable to the different in sampling season and sampling site.

This study revealed high value of turbidity ranging from 17.00 - 21.00 NTU, with mean values of 19.00 ± 2.31 NTU in July and 15.09 -16.02 NTU and mean values 15.56 ± 0.54 NTU in August. Similarly, Onyegeme-Okerenta *et al.,* (2016) recorded a range mean values 15.5 ± 0.21 and 10.07 ± 0.01 in Otamiri-oche River in Etche, River state, Nigeria. Titilawo *et al.,* (2017) also reported high range mean values 6.5 ±0.8 and 9.46 ±0.3 in some selected rivers in Osun State. The high turbidity values recorded in this study showed high organic matter release of wastewater the abattoir and sand dredging; which could lead to poor vision, respiration and reproduction of aquatic organisms

The Biological oxygen demand (BOD) mean values were 18.30 ± 0.81 mg/l in July and 16.57 ± 0.54 in August. Contrary to this study, this contradicts the report of (Erhenhi and Omoigberale, 2020) who recorded low BOD mean values across five study stations with values ranging from 2.05± 0.14 to 2.71± 0.19 in Ethiope River. The high values recorded in the study indicates increased organic pollution, which may stress, suffocate and finally kill aquatic organisms The mean values of Dissolved oxygen (DO) for this study is 5.38 ± 0.72mg/l in July and 6.92 ± 0.57mg/l in August with a p - value of 0.017. Similar findings were reported by Erhenhi and Omoigberale, (2020) revealed a significant difference $p<0.01$ across the studied stations in Ethiope River. This DO is satisfactory for growth and survival of aquatic organisms and falls within the permissible limit (>5.0) by WHO

The mean values of Nitrate were 0.06 ± 0.03 mg/l in July and 0.06 ± 0.02 mg/l in August. The findings of (Adeogun *et al.,* 2014) revealed higher mean values when compared to this present study, whose values were 43.4 ± 7.59 and 113.4 ± 8.88 in River Ogun, Ogun State, Nigeria. Moreso, higher mean values for nitrate were also reported by (Erhenhi and Omoigberale, 2020) 1.42±0.17 to 9.14±8.22 in Ethiope River. The low nitrate value recorded in this study is an indication that the water is safe for growth and survival of aquatic organisms.

The mean values of Phosphate recorded were 0.03 ± 0.01 mg/l in July and 0.07 ± 0.01 mg/l in August. The values were slightly higher in August an indication of nutrient and use of detergents in the study area. Adeosun *et al.* (2014) reported 0.7 ±0.09 and 0.4 ± 0.02 in River Ogun, Ogun State. Adeosun *et al.* (2014) 0.083± 0.09 and 0.285 ± 0.09 in River Ogun, Ogun State. The high value obtained in this study is greater than 0.035mg/l recommended by WHO which can cause harm to aquatic life.

The mean values of potassium obtained in this study were 0.47 - 0.49 mg/l in July and 0.49 ± 0.05 mg/l in August. These values were within the WHO standard for potassium (3mg/l) in drinking water. These mean values are slightly higher than that of (Erhenhi and Omoigberale, 2020) who recorded lower mean values of potassium 0.00 to 0.04mg/l in Ethiope River. Similarly, [21] recorded lower mean values of potassium (0.083±0.09 and 0.285±0.09) in the lower reaches of Ogun River, Akomoje, Ogun. Whereas, higher values (111-535 mg/l) were reported by Iloba and Shomule (2020) in tropical River in Aragba, Delta state, Nigeria. The variations in the different literatures could be attributed to the geochemical impact of the different study areas.

The concentration of Cd, Cr, Pb and Ni in the skin and the liver of all the sampled fish are presented in Table 2.

Table 2: Metal concentration comparison between the skin and liver of all the fish species

Metal	Mean (skin)	Mean (liver)	SD (skin)	SD (liver)	t-cal	P-value	WHO
Cadmium	0.05	0.11	0.02	0.07	1.799	0.160	0.05
Chromium	0.03	0.10	0.01	0.02	5.139	0.004	0.10
Lead	0.54	0.89	0.34	0.49	1.190	0.284	0.30
Nickel	0.33	0.31	0.17	0.07	0.236	0.825	0.60

Cadmiun, Chromium and Nickel in the sampled fish were below World Health Organization Limit for skin, whereas health risk were observed in the liver for as Chromium and Nickel were above WHO limit (Table 2). These toxic metals are neurotoxin that cause behavioral deficits in fishes thereby decreasing the survival, feeding habitats and grow rate and thus, can be used as biomarker (Wang *et al.*, 2017). Lead content was the highest among all the metals assessed in both skin and liver. Similar finding was reported by Rayeshkumar (2018) where Lead content was highest in the study of fishes of *Cyprinus carpio* and *Pelteabagius fluvidraco* whose values were 0.706±0.056 (liver) in summer and 0.502±0.003 (liver) in winter.

The concentration of toxic metals in *Synodontis nigrita* from Forcados River, Okwagbe waterside is presented in Figure 2. All toxic metals in *Synodontis nigrita* are higher in the liver than in the skin

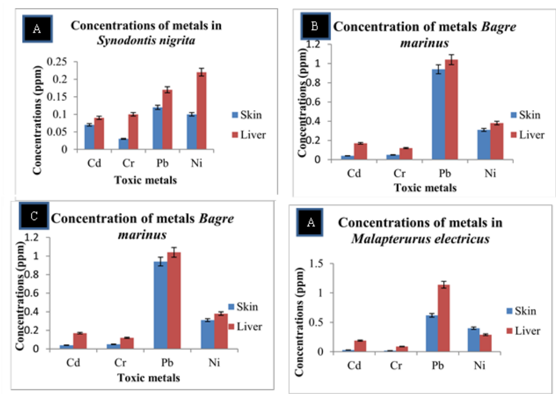

Figure 2: A - Concentrations of metals in *Synodontis nigrita* found in Forcados River, Okwagbe waterside. B - Concentrations of metals in *Bagre marinus* found in Forcados River, Okwagbe waterside. C - Concentrations of metals in *Malapterurus electricus* found in Forcados River, Okwagbe waterside. D - Concentrations of metals in *Synodontis schall* found in Forcados River, Okwagbe waterside

The concentration of toxic trace metals in *Synodontis nigrita* (Figure 2A) in an descending order Ni>Pb>Cr>CD in the liver and PB>Ni>CD>Cr in the skin. The elevated amount of nickel could be that the concentration pattern of metals were higher in the discharge point of the river channels entering the main creek which may be due to the industrial complexes right on the banks of the river channels. The Cd, Cr, Pb and Ni concentrations reported in the skin and liver of *Synodontis nigrita* for this study was lower than 0.8-1.2ppm reported by Overah *et al.* (2012) in Ase Creek, Niger Delta.

Cadmium is mutagenic metal occurring as a result of anthropogenic contamination in aquatic environment that can lead to severe toxicity, adverse effects on growth, reduced reproduction rate of aquatic organisms, affect physiological and biochemical processes in fish tissues and organs (skin and liver) to carcinogenic effect in human when it exceeds required limit.

This study showed no significant difference (P>0.05) in the mean value of cadmium among all fish species. Concentration of cadmium was higher in the liver 0.11mg/l when compared to the skin 0.05mg/l (Table 2), of the selected fish species. Rajeshkumar and Li (2018) reported a lower mean concentration of cadmium at 0.025 mg/l for bioaccumulation of toxic metals in *Cyprinus carpio* and *Pelteobagrus fluvidraco* from Melilang Bay, Taihu lake China. The concentration of cadmium obtained in the fish liver and skin could be as a result of the bioaccumulation of superphosphate fertilizers used in the nearby farmlands seeping into the water body and transferred via nutrient cycle aquatic food webs.

Exposure to Chromium in fish may show different behavioral changes like uneven swimming, mucus discharge, changes in body color and loss of appetite, physiological abnormalities, DNA damage, microscopic lesions, osmoregulatory and respiratory dysfunction. This study showed significant difference (P<0.05) in the mean concentration of Chromium in the liver and the skin of the evaluated fish. The concentration of Chromium in the liver and skin of the evaluated fish is 0.1mg/l and 0.03mg/ l respectively (Table 3). Jyotsna and Manda (2015) recorded a higher value of chromium 15.40 mg/l in bioaccumulation of toxic metals in *Tilapia mossambicus* from an industrially polluted Patalganga River, India. The concentration of chromium in this study is above the permissible limit of 0.491µ g/g, set by USEPA while EUROPA chromium limit is 0.100µ g/g. The high concentration may be attributed to leaching from hazardous waste site from the upper reaches of the river and disposal of metal products of fishing gears in the river.

Lead discharge from various industries, agricultural field, lead dust and municipal waste that directly comes to the aquatic environment causes toxicity for aquatic life. Exposure to lead in fishes causes behavioral changes, impotence, collapsing of blood vessels, oxidative stress and retarded growth. This study indicated no significant difference (P>0.05) in the values of lead in liver 0.89 mg/l and skin 0.54 mg/l (Table 2). This falls within EPA standards limit (15 µg/L) for drinking water. Rajeshkmar *et al.* (2018) recorded a lower mean concentration of lead 0.21 and 0.50 mg/l in the bioaccumulation of toxic metals in fish species *Cyprinus carpio* and *Pelteobagrus fluvidraco* from Melilang Bay, Taihu lake. Moreso, Hany and Elwoa (2012) recorded lower values 0.14 and 0.42 mg/l in *Oreochromis niloticus* and *Clarias angullaris* bioaccumulation of toxic metals in River Nile, Egypt. The low concentration of lead in the study area is an indication that the water is not toxic for the healthy status of the aquatic dwellers.

Nickel is released into the aquatic environment from both natural and anthropogenic sources. Nickel is discharged from industries during nickel mining, waste incineration and oil burning power plant. Exposure of nickel to fishes in an aquatic environment may result in abnormal swimming behaviors, respiratory disorder, lesions in skin, rapid opercula movement, blood vessels degeneration, loss of body equilibrium, behavioral changes like surfacing, rapid mouth and operculum movement before death. The result from this study showed that there was no significant difference (P> 0.05) in the value of nickel in liver 0.31 mg/l and skin 0.33 mg/l (Table 2). On the contrary, Hany and Elwoa (2012) recorded higher concentration of nickel 1.1 and 1.67 mg/l in bioaccumulation of toxic metals in River Nile, Egypt. Sahar *et al*. (2014) recorded a higher mean concentration of nickel 1.42 and 1.96 mg/l in the analysis of trace metals in tissues of *Pampus argenteus* and *Platycephalus indicus* in Hara reserve, Iran. The low values of nickel recorded in this study may be due to from weathering of minerals and rocks which associated with particulate matter of sediments.

Previous studies of Ahmed *et al*., (2019) and Huang *et al*., (2019) showed that liver and intestine absorbed more metal than other tissue, the result observed in this study were in good agreement with the above consensus. This study concurred also with previous studies of Yu *et al*., 2012, Jayaprakash *et al*., 2015 and Rajeshkumar(2018) that bioaccumulation of heavy metal in fish skin is significantly correlated with fish species. Bioaccumulation prone strongest in opportunistic feeders; *Bagre marinus* and *Malapterurus electricus* followed by *Synodontis* *schall* and *Synodontis nigrita* which are bottom living fishes; where bioaccumulation tend to be strong and associated to their feeding items such as fish scales, diptera insects, defoliate macrophytes that bioaccumulate over a long period of time

CONCLUSION

The physicochemical parameters in this study showed high values of Turbidity, Biological oxygen demand (BOD) were above the WHO standard thereby reducing the aesthetic water quality. All toxic metals evaluated were within the WHO permissible limit in the skin and liver of the fish species. This serves as an indication of a good water body with most physicochemical parameters falling within the acceptable limit and metal concentrations at a negligible level.

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