Scientia Africana, Vol. 19 (No. 2), August, 2020. Pp 1-14
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BIOINDICATION POTENTIAL OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*) FROM OTTO RIVER IN UNALE, IBAJI LOCAL GOVERNMENT AREA, KOGI STATE

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Received: 08-08-2020
Accepted: 17-08-2020

ABSTRACT

The aim of the study was to assess the bio-monitoring potential of Nile Tilapia (Oreochromis niloticus) from Otto River in Unale, Ibaji L.G.A, Kogi State, Nigeria.Fifteen samples of Nile Tilapia together with water samples were collected from Otto River in Unale. Oreochromis niloticus and water samples were also collected from unpolluted river of Ebocho in Odeke in the same LGA to serve as control for the study. Heavy metals (i.e., Pb, Cd, Cu and Zn) concentrations, length-weight relationship and condition factor were determined on the fish samples. Nitrate, nitrite, Dissolved Oxygen (DO) and salinity were determined for the water samples.The concentration of lead and cadmium was above the WHO permissible limits while copper and zinc were below WHO permissible limits. Decreasing order of heavy metals concentration was Pb>Cd>Cu>Zn. The water quality parameters were within the permissible limits. The isometric growth pattern observed in this study is an indication that the fishes are in good health conditions. The condition factor values (>1) of the studied fish samples suggests that the physico-chemical quality of river Otto favours the well-being of fish samples studied. The high accumulation of lead and cadmium in the fish samples suggests that anthropogenic activities are going on around the river.

Keywords: Bio-monitoring, Heavy Metal, Condition Factor, Anthropogenic

INTRODUCTION

According to Wilkomirski (2013) several organisms have been used as markers suitable for monitoring the constituents of the environment. Fish is one of such animals used for the monitoring of pollutions in the biosphere. (Benaduce *et al*., 2008; Sucman *et al.*, 2010). Fish reflects the state of the pollution very well because of their limited ability to eliminate contaminants (Sucman *et al.*, 2010). Fish is an inexpensive source of proteins and an important cash crop in many regions of the world, and water is the physical support by which they carry out their life functions such as feeding, swimming, breeding, digestion and excretion (Bronmark and Hansson, 2005). So, good water quality is very essential for the survival and growth of fish (Bhatnagar and Devi, 2013). Water quality is defined in terms of its chemical, physical and biological contents. Some important physical and chemical parameters influencing the aquatic environment are temperature, pH, salinity, and dissolved oxygen. Others are total suspended and dissolved solids, total alkalinity and acidity and heavy metal contaminants. These

parameters in the opinion of Sucman *et al*., (2010) are some of the factors militating against the survival of aquatic organisms (flora and fauna) in aquatic environments. Natalia *et al*., (2015) reported that the use of fish as biological agents of monitoring the quality of water is now gaining the required recognition. Fish did not only offer the advantages of describing the natural characteristics of the environment but also assess changes to the habitats (Sucman *et al*., 2010). In addition, fish are located at the end of the aquatic food chain and may accumulate metals and pass them to human beings through food causing chronic or acute diseases (Limbo *et al*., 2009).Mendil *et al*., (2005) and Agbozu *et al*.,(2007) stated that fishes are often at the end of aquatic food chain and many concentrate large amount of heavy metals from polluted water that build up by ingestion, ion-exchange of dissolved metals across lipophilic membranes and absorption on tissue and membrane surface.

In recent years, pollution of the aquatic environment with heavy metals has become a worldwide problem, because they are non-biodegradable and most of them have hazardous effects on organisms (MacFarlane and Burchett,2000) Among environmental pollutants, heavy metals pollutions are of particular concern due to their potential toxic effects and ability to accumulate in aquatic ecosystems(Censi *et al*.,2006).Heavy metals pollution in aquatic environment has become a worldwide problem during the past few decades. This fact is mainly attributed to their persistent stability and toxic effect to aquatic as well as terrestrial organisms (Mendil *et al*., 2005).Thus, heavy metals acquired through the food chain as a result of pollution are potential chemical hazards that can affect the consumers of such organisms. At low concentrations, some heavy metals such as copper and zinc are essential for enzymatic activity and many biological processes (Levent *et al*., 2012).

Despite the fact that metal bio magnifications is influenced by metal assimilation, pollutants can still move through the various trophic levels in an eco system (Wang, 2002) and could result in higher concentrations of the substance than would be expected if water were the only exposure mechanism. At the highest trophic level, the increased concentrations in tissues may become toxic (Ismaniza and Idaliza, 2012).Since fishes live and feed in the aquatic environments they are particularly vulnerable to pollution because it is difficult for them to escape the detrimental effects of pollutants (Yarsan and Yipel, 2013). Sediments have been reported by Wang (2002) as another important sink of a variety of pollutants, particularly heavy metals and may serve as an enriched source of these contaminants for benthic organisms. The occurrence of elevated levels of heavy metals in sediments found at the bottom of the water column can be a good indicator of anthropogenic pollution rather than natural enrichment of the sediment by geological weathering (Balirwa *et al*., 2003; Nzomo, 2005; Limbo *et al*., 2009).Thus, the need for an effective biological systems of monitoring pollution is imperative.

Maintaining factors like salinity, dissolved Oxygen (DO), ammonia, nitrite, nitrate, inorganic nitrogen total dissolved Solid (TDS), within the internationally recommended levels is germane for optimizing a healthy aquatic environment for optimum production of aquatic products. Therefore, there is the need to

Scientia Africana, Vol. 19 (No. 2), August, 2020. Pp 1-14
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ensure that these environmental factors are properly managed and regulated for the survival of aquatic organisms(Anita and Pooja, 2013).Length-weight relationship of fish is widely recognized as an important tool in fisheries science especially in ecology population dynamic and stock management (Abdoli and Rasooli,2008). The condition factor is an index reflecting interactions between biotic and abiotic factors in relation to the physiological conditions of fishes. Therefore, the condition factor may vary among fish species at different locations(Blackwell *et al*.,2000).Thus, condition factor is important in understanding the life cycle of fish species and it contributes towards maintaining the equilibrium in the ecosystem (Imam *et al*., 2010). This study was therefore to assess the bio-monitoring potential of Nile Tilapia (*Oreochromis niloticus*) from Otto River in Unale, Ibaji L.G.A, Kogi State, Nigeria.

MATERIALS AND METHODS

Description of the Study Area

Fish samples were collected from Otto River in Ibaji Local Government Area. Ibaji is located between Latitude 6°52'00"N 6°87'00"N of the equator, and Longitude 6°48'00"E6°80'00"E of the Greenwich Meridian. It is located at the Eastern part of Kogi State and occupies an area of 1,377km^2. Ibaji shares boundary with Edo State (with River Niger separating them) and Delta State located at its Southern border. The town is located between 300m and 490m above sea level and naturally drained by River Niger. The River and fertile land of Ibaji play significant role in fishing and agricultural activities of the dwellers. The map is shown in Fig 1.

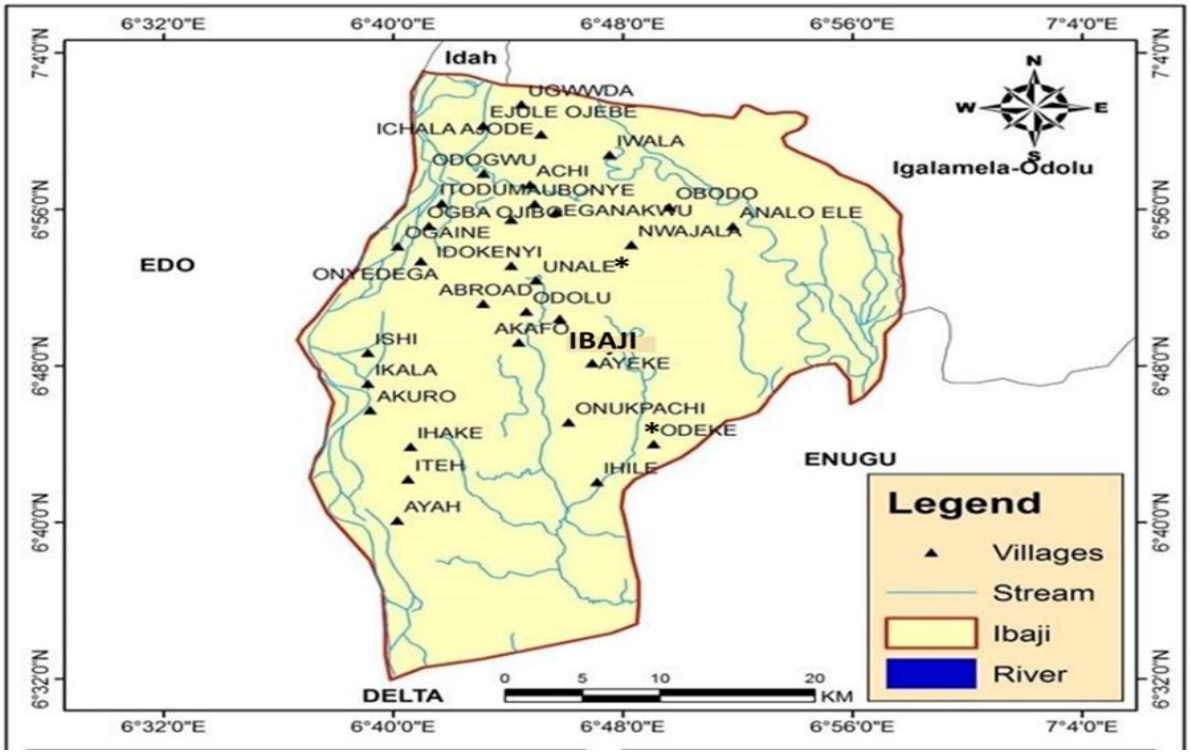

Fig. 1: Map of Ibaji L.G.A of Kogi State

Sample Collection

Fifteen *Oreochromis niloticus* samples and one control sample used for this study were sourced from local catches by the fishermen at the point of pollution at Otto River in Ibaji Local Government Area and the unpolluted river of Ebocho in Odeke from the same LGA . They were transported live to the Laboratory of Biological Sciences, Kogi State University Anyigba for analysis. Water samples were also collected in sterilized plastic bottles from the polluted and unpolluted sites at 7:45am.

Determination of Length-Weight Relationship and Condition Factor

The total length of each fish was measured according to the method described by Lagler (1970), while the weight was measured using AND GF.3000 weighing balance. The condition factor (K) was calculated with the formula, $K=100 * BW * TL^{-3}$. Where K is the condition factor, BW is the Body Weight and TL is the Total length(cm).

Determination of Nitrate (NO_3^-)

Activated aluminum (Aluminum oxides): Riedel-de Haen (Aluminum oxides, neutral), for column chromatography: 30 cm length, and 2 cm in diameter. Nitrate reagent: HI93728-0, for nitrate determination. NAD reagent: N-(1-naphthyl) ethylenediamine and 2HCl: SIGMA. Sulfanilamide reagent: Sulfanilamside (P-Aminobenzenesulfonamide):
SIGMA.Other reagents used were: $NaNO_2$, and CH_3COOH. 3.2. Instruments: Nitrate meter: HANNA Instrument, HI 93728-0. UVPC spectrophotometer device: Schimadzu, UV-1601PC, UV-Visible spectrophotometer.

Preparation of Reagents and Standard Solution for NO_3^- Determination

NED reagent: 0.2 g N-(1-naphthyl) ethylenediamine.2HCl were dissolved in 150 ml 15% of (V/V) CH_3COOH. Filtered when it is necessary, and stored in glass-stoppered brown glass bottle. Sulfanilamide reagent: 0.5 g sulfanilamide were dissolved in 150 ml of 15% CH_3COOH (V/V). Filtered if necessary and stored in glass-stoppered brown glass bottle. Sodium nitrite standard solution: (1) stock solution (1000 ppm $NaNO_2$): 1 g $NaNO_2$ was dissolved in H_2O and diluted to 1L. (2) Intermediate solution (100 ppm $NaNO_2$): 100 ml of the stock solution was diluted to 1L with H_2O. (3) Working solution (1 ppm $NaNO_2$): 10 ml of the intermediate solution was diluted to 1L with H_2O

Quantitative Determination of NO_3^-

10ml of the transparent, clear solution was analyzed for the nitrate content using "HANNA Instrument" which gives the sample content of nitrate as NO_3^-. 0.05ml solution containing nitrite was transferred into a 25 ml volumetric flask. Then 2.5 ml sulfanilamide was added, followed by addition of 2.5 ml NAD. The volume was completed with water and left for 15 minutes in order to give time for color development. The absorbance was measured at 545 nm against a blank solution. The nitrite (NO_2^-) concentration was determined using the 40 calibration curve prepared as follows: 10, 20, 30, and 40 ml of nitrite working standard solution was transferred into 50 ml volumetric flasks in order to prepare standard solutions of 0.2, 0.4, 0.6, and 0.8 ppm $NaNO_2$.Then 2.5 ml

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of sulfanilamide reagent was added to each flask followed by 2.5 ml NAD reagent. The volumes were completed to the marks. The absorbance was measured after 15 minutes at 545 nm. The calibration curve was constructed by plotting the absorbance vs. the concentration (Amr and Hadidi, 2001). NO_3 - -N in the extracts was removed with ion exchange resins (the mixture of Amberlite IR120 and Amberlite IRA410). Absorption spectra of each extract within 200 nm to 300 nm was measured by a spectrophotometer (Shimadzu UVmini-1240). Ratio of the absorbance calculated at 220nm to that at 260nm in each extract was used as the mean value of the ratio in the following nitrate estimations. The absorbance at 220nm was measured (Cataldo *et al.,* 1975; Kaneko *et al.,* 1968).

Determination of Dissolved Oxygen and Salinity

Hanna Conductivity meter was used to measure Dissolved Oxygen (DO) and salinity in water by dipping the meter in water and reading taken after 1-2 Minutes.

Analysis of Heavy Metals in the Fish Samples

Four heavy metals (Cadmium, Copper, Lead and Zn) was analyzed from the tissues, gills and flesh of each of the fifteen samples using the spectrophotometer method described by Schachter and Boyer (1980).0.50g of tissues, gills and flesh from each fish sample was weighed into a clean ceramic crucible. These samples were oven-dried at 500°C for 2 hours. Ashes from each of the oven-dried samples were poured into 5ml of distilled water in clean centrifuge tube. The samples were thereafter centrifuged at 3000rpm for 10mins. The supernatant were used for determination of heavy metal contents using atomic absorption spectrophotometer.

Data Analysis.

Data obtained in this study was subjected to Analysis of Variance (ANOVA) and means with significant differences were separated using Duncan Multiple Range Test (DMRT). Pearson correlation analysis was used to check the associations between Length-Weight and Condition Factor. All analyses were carried out using SPSS Version 23 software package.

RESULTS

Table 1 shows the weight (cm), standard length (cm), total length (cm) and condition factor (K) values for the fifteen *Oreochromis niloticus* samples and the control. The heaviest fish (97.82cm), longest standard length (15.50cm), total length (19.50) were recorded in sample 6 but also had the lowest condition factor (1.32). Sample 15 was the lightest fish (32.86cm) and shortest standard length (10.00cm) while shortest total length of 13.30cm was recorded in samples 12 and 13 while the highest condition factor of 2.93 was recorded for sample 5.

Table 1: Length-Weight Relationship and Condition Factor of Nile Tilapia (*Oreochromis niloticus*)

Samples	Weight(g)	Standard length (cm)	Total length(cm)	K=Condition Factor
1	63.10	13.50	17.50	1.18
2	63.02	13.00	16.50	1.40

3	39.46	11.00	14.00	1.44
4	40.03	11.50	14.20	1.40
5	80.51	14.00	18.00	2.93
6	97.82	15.50	19.50	1.32
7	97.77	14.60	18.60	1.52
8	78.80	13.20	16.80	1.79
9	82.77	13.20	16.40	1.88
10	50.49	11.00	14.40	1.69
11	63.90	13.20	16.30	1.48
12	47.03	10.70	13.30	1.99
13	87.05	14.00	13.30	1.74
14	45.56	10.90	17.10	1.53
15	32.86	10.00	14.40	1.53

Table 2 shows Pearson correlation among weight, standard length and total length. A significant positive correlation was observed between weight and standard length (r=0.941, p=0.000), weight and total length (r=0.639, p=0.010). There is also a significant positive association between standard length and the total length (r=0.703, p=0.003).

Table 2: Pearson Correlation Among Length, Weight and Condition Factor of Nile Tilapia (*Oreochromis niloticus*)

Correlations		Weight (g)	Standard length (cm)	Total length (cm)	K=condition factor
Weight (g)	Pearson Correlation	1			
	Sig.(2-tailed)				
	N	15			
Standard length (cm)	Pearson Correlation	.941**	1		
	Sig. (2-tailed)	.000			
	N	15	15		
Total length (cm)	Pearson Correlation	.639*	.703**	1	
	Sig. (2-tailed)	.010	.003		
	N	15	15	15	
K=condition factor	Pearson Correlation	.202	.075	.008	1
	Sig. (2-tailed)	.471	.792	.977	
	N	15	15	15	15

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Scientia Africana, Vol. 19 (No. 2), August, 2020. Pp 1-14
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Figures 2 and 3 shows Length-Weight Relationship: Fish total length (cm) was measured using measuring board as described by Lagler (1970), while weight (g) was measured using AND GF.3000 weighing balance.

The Length-weight relationship (LWR) was estimated by using the equation:

W = aLb

Where

W = The weight (g) of fish in grams

L = The Total length of fish in centimeters

a = Exponent describing the rate of change of weight with length (= the intercept of the regression line on the Y axis)

b = The slope of the regression line (also referred to as the Allometric coefficient)

The log transformed data gave a regression equation.

Log w = log a + b log L

Where;

a = Constant b = the regression co-efficient (Lagler, 1970).

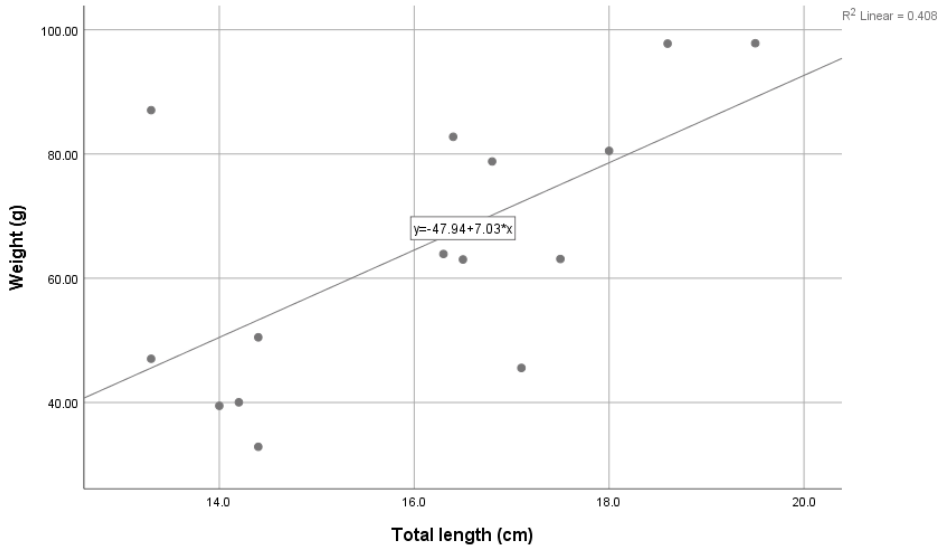

Figure 2: Length-Weight Relationship
W = aLb
W = 7.0298L - 47.939
R^2 = 0.408

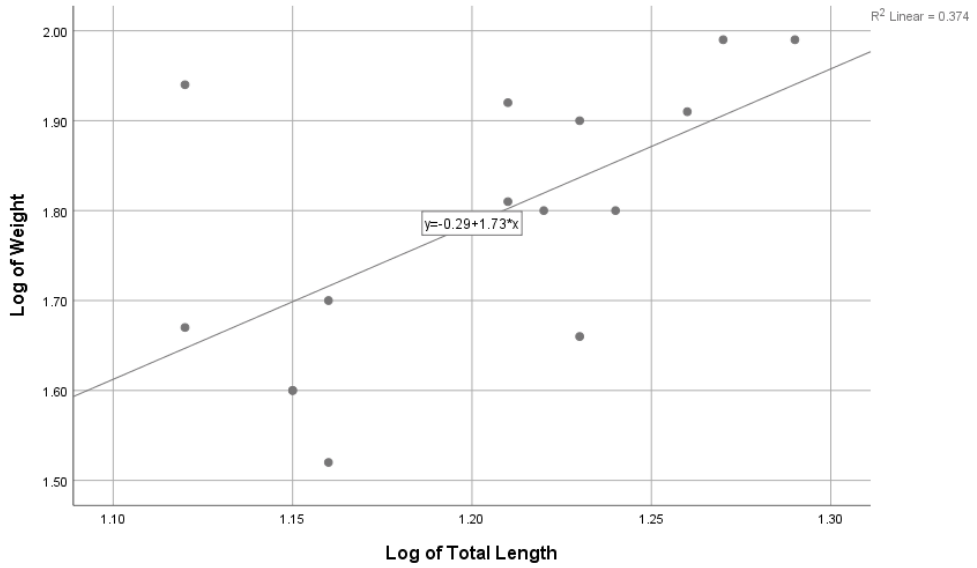

Figure 3: Length-Weight Relationship
y = 1.73x - 0.29
R^2 = 0.374
Log W = log a + b log L

The nitrate, nitrite, dissolved oxygen and salinity contents of the river are shown in Table 3. All the four water quality parameters studied (i.e., nitrate, nitrite, dissolved oxygen and salinity) were within the World Health Organization Standard.

Table 3: Water Quality Parameters of the River

Sample	Nitrate (mgL-1)	Nitrite (mgL-1)	Dissolved oxygen(mgL-1)	Salinity(ppt)
Control	0.045	0.002	1.38	0.01
Water	0.319	0.072	6.20	0.04
WHO (2008) standard	45	1.0	5.0-7.0	----

Table 4 shows heavy metals concentration of the fish samples from the polluted site and the control. It was observed that the fish sample from the unpolluted river (control) showed significantly lower heavy metal values compared to samples from the polluted river for the four heavy metals studied (Cd, Cu, Pb and Zn). The lowest Cd, Cu, Pb and Zn contents were recorded in control with 0.212±0.001, 0.024±0.001, 1.315±0.007 and 0.003±0.001 respectively. The highest concentrations of Cadmium (0.478±0.001mg/g), Copper (0.263±0.001mg/g), Lead (2.145±0.007mg/g) and Zinc (0.278±0.001mg/g) were recorded for samples 12, 4 (and 9), 6 and 3respectively. Decreasing order of heavy metals concentration is described as Pb>Cd>Cu>Zn.

Scientia Africana, Vol. 19 (No. 2), August, 2020. Pp 1-14
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Table 4: Heavy metal concentration (mgk^{-1}) of Nile Tilapia (*Oreochromis niloticus*)

Fish Samples	Cd (mg/g)	Cu (mg/g)	Pb (mg/g)	Zn (mg/g)
Control	0.212±0.001^{a}	0.024±0.001^{a}	1.315±0.007^{a}	0.003±0.001^{a}
1	0.486±0.001^{o}	0.226±0.001^{e}	1.855±0.007^{g}	0.259±0.001^{j}
2	0.438±0.001^{l}	0.219±0.001^{d}	1.775±0.007^{f}	0.278±0.001^{k}
3	0.396±0.001^{h}	0.209±0.001^{b}	1.655±0.007^{c}	0.235±0.001^{g}
4	0.418±0.001^{i}	0.263±0.001^{k}	1.955±0.007^{j}	0.229±0.001^{e}
5	0.388±0.001^{g}	0.236±0.001^{g}	2.020±0.014^{k}	0.248±0.001^{i}
6	0.365±0.001^{d}	0.218±0.001^{d}	2.145±0.007^{l}	0.233±0.001^{f}
7	0.457±0.001^{n}	0.226±0.001^{e}	1.875±0.007^{h}	0.218±0.001^{c}
8	0.376±0.001^{e}	0.248±0.001^{i}	1.855±0.007^{g}	0.206±0.001^{b}
9	0.436±0.001^{k}	0.263±0.001^{k}	1.675±0.007^{d}	0.218±0.001^{c}
10	0.424±0.001^{j}	0.255±0.001^{j}	1.775±0.007^{f}	0.236±0.001^{g}
11	0.359±0.003^{c}	0.239±0.001^{h}	1.925±0.007^{i}	0.225±0.001^{d}
12	0.478±0.001^{n}	0.216±0.001^{c}	1.675±0.007^{d}	0.239±0.001^{h}
13	0.455±0.001^{m}	0.225±0.001^{e}	1.585±0.007^{b}	0.248±0.001^{i}
14	0.385±0.001^{f}	0.218±0.001^{d}	1.675±0.007^{d}	0.226±0.001^{d}
15	0.349±0.001^{b}	0.232±0.001^{f}	1.725±0.007^{e}	0.238±0.001^{h}

Mean ± SD values with the same superscript across the column are not significantly different at $p < 0.05$.

DISCUSSION

This study showed that all the fifteen fish samples exhibited isometric growth patterns that is, the longer the fish the heavier they are.This finding supported the isometric growth pattern reported for *Alburnoides eichwaldii* and *Oxynoemacheilus bergianus* by Mazaher *et al.*, (2015). Paiboon and Kriangsak (2015) reported that isometric growth pattern is enhanced by the availability of food and reduced anthropogenic activities in control and natural environment of fish. In contrast to the finding, negative allometric growth pattern was reported by Obasohan *et al.*, (2012) and Arup *et al.*, (2018).

In this study the condition factor (K) which is the assessment of the wellbeing or health status of fish was greater than 1. This indicated that the fish samples were in good health condition. These condition factor also revealed isometric growth among the studied fish samples. Olapade and Tarawallie (2014) reported factors like sex, data puling, sorting into classes, states of stomach and stages of development as those that could affect the wellbeing of fish. The condition factor range of 1.32 to 2.93 is in consonance with the1.17 to 3.45 reported by Damytro and Hanna, (2017) for *Abramis brama*. In contrary to the findings in this result, Obasohan *et al.*, (2012) reported some fish samples with condition factor less than 1.

The presence of nitrate may be as a result of complete oxidation of Ammonia in water or a nitrate reduction reaction. .The concentrations of nitrate, nitrite, dissolved oxygen and salinity reported in this study

were within the permissible concentration recommended by WHO (2008). This indicates that although the water may be polluted, the level of pollution can still support aquaculture. The ranges obtained for nitrate, nitrite, dissolved oxygen and salinity in this study are consistent with the ranges reported by Santhosh and Singh (2007) and OATA (2008) and Bhatnagar *et al.*,(2004) for fish culture. The low salinity observed in this study may be due to continuous inflow of less contaminated rivers into the studied river. The concentration of salinity recorded in this study was within the < 0.05 reported by EPA (2006).

The fact that fish samples from the unpolluted water (Control) had significant reduction in the concentrations of Cadmium (Cd), Copper (Cu), Lead (Pb) and Zinc (Zn) indicates that Otto river has been receiving pollutions from anthropogenic activities. The higher concentration of Cadmium (Cd) in the fifteen fish samples from Otto River compared to the sample from less polluted rissver of Ebocho could be as a result of heavy application of phosphate fertilizers by farmers around the river, traffic emission from vehicles, dumping of wastes such as children's toys, irons, electric and electronic materials, the use of agrochemicals like pesticides, herbicides and insecticides, rain water runoff from the domestic environment and farmlands into the river.

In this study, the concentration of Cadmium was higher than 0.05 $mgkg^{-1}$ recommended permissible limit (WHO 2001).The values of Cadmium obtained in this study was higher than the 0.008 $m\mu g^{-1}$, 0.014 $m\mu g^{-1}$ and 0.00116 $m\mu g^{-1}$recorded for tilapia fish samples obtained from Kiri, Bare and Mada rivers respectively (Orosun *et al.*, 2016). High cadmium intake according to Yujun *et al.,* (2011) can lead to hypertension and kidney damages in humans while NAS-NRCC (1982) attributed the incidence of shock and acute renal failure in humans to consumption of cadmium above 350mg.The quantity of copper obtained in this study was less than the values of 3.0 $mgkg^{-1}$recommended by WHO (2001), 2.0 $mgkg^{-1}$ recommended by USEPA (1998) and WPCL (2004). This finding indicated that the concentration of copper in the fish samples is not toxic to humans.

The concentration of lead was observed to be higher than the recommended concentration of 0.2 $mgkg^{-1}$ for food fish by European Union (2002), 2.0$mgkg^{-1}$ recommended by Media of International Standard (Senarathne and Pathiratne, 2007), 0.1$mgkg^{-1}$ recommended by WHO (2001) and 0.11 $mgkg^{-1}$ of USEPA, (1976).Lead according to Izah *et al.,* (2015) is one of the toxic heavy metals which have no known metabolic use. Lead accumulation in the opinion of Naseem and Tahir (2001) and Izah *et al.,* (2015) could lead to loss of alteration, delusions and hallucinations, irritability (mostly in children), mental incapability, difficulties in learning, growth reduction, anemia, severe stomach ache, weakness of muscle and brain damage.

The concentration of zinc in this study was lower than the permissible level of 5.0 $mgkg^{-1}$ specified by WHO (2003). The value was also lower than the 4.25 $mgkg^{-1}$ by WPCL (2004), 4.25 $mgkg^{-1}$recommended by Median International Standard (Senarathne and Pathiratne,2007) and Anim-gyampo *et al.,* (2013), 5.0 $mgkg^{-1}$ recommended for food fish by USEPA (Anim-gyampo *et al.*, 2013) The significantly low zinc content of the fish

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samples reported in this study compared to the regulatory standard indicates that the concentration of zinc in the fish samples is not toxic to humans.

CONCLUSION

This study revealed that the weight of the studied fish samples increases as their length increases (Isometric growth). The condition factor values of the studied fish samples suggest that the physico-chemical quality of river Otto favours the well-being of fish samples studied. The quantities of Lead and Cadmium in the fish samples were higher than the permissible level recommended by WHO. The study established some levels of anthropogenic activities around river Otto.

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