HEAVY METAL CONTENT IN A SMOKE-DRIED CLARIID FISH SPECIES FROM SELECTED MARKETS IN ABA, ABIA STATE, NIGERIA, WEST AFRICA

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Abstract – The research specifically determined the concentrations of Lead (Pb), Cadmium (Cd), Zinc (Zn) and Copper (Cu) in smoke-dried Clariasgariepinusfrom selected markets in Aba city, Nigeria, employing Atomic Absorption Spectrophotometric technique in order to ascertain its suitability for human consumption against the backdrop of the dearth of information regarding the heavy metal content in this particular fish species. The summary statistics for heavy metals in fish ranged from 0.0078 mg/kg (Cd) to 17.96 mg/kg (Zn) while the summary statistics for metals in fish by market ranged from 0.001 mg/kg (Cd) at NkwoNgwa market to 24.58 mg/kg (Zn) in the same market with significant ($p<0.05$) differences in the mean concentrations of Pb and Zn in fish between all markets. The toxic quotient (TQ) values ranged from 0.06 for Cu to 0.35 for Zn. The mean concentrations of Pb, Zn, and Cu in fish were below their respective maximum threshold limits with the exception of Cd. Consumers must, therefore, eat such fish with caution owing to the possibility of exposure to Cd poisoning over time.

Keywords: Heavy metals, toxic quotient, fish, poisoning

INTRODUCTION

Heavy metals are chemical elements that have a relatively high density and are toxic to living organisms at low concentrations; hence their inclusion and importance in ecotoxicological studies(Ibangaet al. 2019). Worldwide, it has been recognized that heavy metal pollution from anthropogenic sources impact negatively on the resources of natural aquatic media (Perera et al. 2015). The situation is further compounded with industrialization and urbanization as human populations increase from continent to continent (Du et al. 2013). Consumption of fish laden with heavy metals may produce health hazards in man through biomagnification of such metals (Agrahariet al. 2017). All heavy metals become toxic when threshold levels are exceeded and can bioaccumulate in fish throughfurthercontamination (Shovonet al. 2017; Pei et al. 2019).Aba is a popular commercial city in Abia state, Nigeria. The dearth of information regarding the heavy metals in smoke-dried Clariasgariepinus (Burchell, 1822) from markets in the city warranted this research. C. gariepinus is the most common fish species applied in aquaculture practices in Nigeria owing to its hardy nature, omnivorous habit, air-breathing ability and it'spotential to attain maximum table size within a short period of time. It is also known as the African sharp tooth catfish belonging to the family Clariidae. This fish species is widely available in its smoke-dried form in markets in Aba city, hence its adoption in this research. Smoke-drying,is a form of post-harvest processing technology which has the principal aim of extending shelf life as fish are prone to spoilage once harvested from their host water media (Wangboje and Oghenesode 2017). The heavy metals investigated were Lead (Pb), Cadmium (Cd), Zinc (Zn) and Copper (Cu). These metals were purposely selected from the wide plethora of heavy metals portrayed on the periodic table of chemical elements owing to their persistence in urban and semi-urban settlements. The aforementioned heavy metals occur naturally in the environment but the anthropogenic impact has often raised natural background levels of such metals to hazardous levels of concern (Wangboje 2015). Data generated from this research is expected to guide both current and potential consumers of smoke-dried C. gariepinusin Aba, Abia State, Nigeria, in order to safeguard public health ultimately.

MATERIALS AND DETAILS

Description of research area

Abia state (Longitude 5º 25' N and Longitude 7º 30' E) is located within the south eastern part of Nigeria while Aba (Longitude 5º 07' N and Longitude 7º 22' E) is the major commercial heart nerve of the state and lies along the west bank of Aba River (Fig. 1). The city has a population of 1,586, 287 people (Wikipedia 2019). The climate is Tropical, with an average annual temperature of 26.4ºC and an average annual precipitation of 2333 mm.Rain falls between April and October while there is a dry spell between November and March.The driest month is January while precipitation is highest in September. Vegetation is typical of the tropical rainforest belt (Climate-Data 2019).

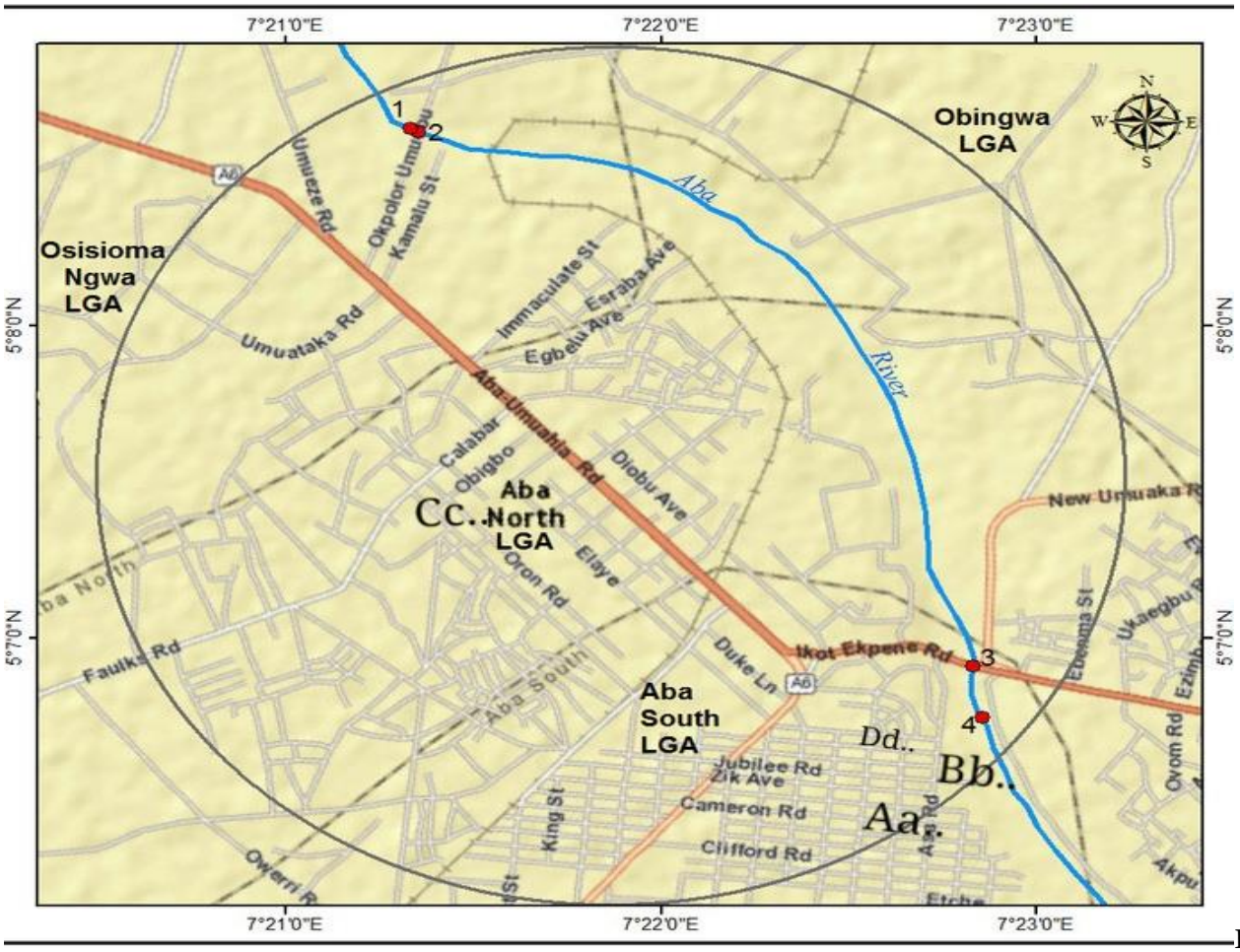

Fig. 1: Map of research area

Four markets were purposely selected for the research based on the availability of smoked-dried *C. gariepinus* (Plate 1). These markets are located within areas characterized with heavy human and vehicular traffic. Their details are presented in Table 1. Fish samples (n=48) were purchased from these markets between June and

November, 2019. Samples of fish were placed in newly purchased polythene bags, labeled, sealed and transported to the laboratory within 24 hours.

Table 1: Details of sampledmarkets

MARKET CODE ON MAP	NAME	GPS COORDINATES
Aa	Ngwa road market	5^0 6'5'N, 7^0 22'21'E
Bb	Cemetary market	5^0 6'8'N, 7^0 21'28'E
Cc	Ariaria International market	5.11806^0 N, 7.33250^0 E
Dd	Nkwongwa market	5. 0901^0 N, 7.3598^0 E

Table 2: Mean length and weight of smoke- dried *C. gariepinus*

Months	Total Length (cm)	Weight (grams)
June	30.8	25.03
July	31.2	22.02
August	29.6	29.01
September	20.7	38.04
October	29.9	30.00
November	35.6	28.09
Mean	29.63	28.7

Laboratory procedure

Smoke-dried fish samples were weighed whole in grams using an ATOM A-110C® electronic compact scale while their total lengths were recorded using a length of cotton thread and a translucent ruler (Table 2). After preliminary drying of whole samples using a Surgifield-Uniscope® SM 9023 model laboratory oven and milling, acid digestion was carried out (Wangboje and Oghenesode 2017).Fish digests were analyzed for Pb, Cd, Zn and Cu by means of an Atomic Absorption Spectrophotometer (Unicam® 696 series) equipped with solar software using air acetylene flame as oxidant. Concentrations of metals in fish were expressed in mg/kg. Blanks, spiked samples and duplicate analyses were performed for all analytes as part of the quality assurance procedures. All reagents used were of analytical grade (BDH, Poole, England).

Theoretical maximum daily intake (TMDI) for heavy metals

The TMDI is used for making a first estimate of heavy metal residue intake. It is calculated by multiplying the established maximum limit by the estimated average daily regional consumption for each food item and then summing the products (World Health Organisation 1997).
TMDI = Σ ML1* F1
Where: ML = Maximum limit for a given food;
F = Per capita/ regional food consumption.

Total toxicity of mixtures (TTM) index for heavy metals

Whether or not a mixture of metals in a particular medium exceeds the quality guideline value for that medium, can be determined by applying the TTM index (ANZECC/ARMCANZ 2000)
TTM = Σ (C1/GV1)
Where**:** C1 = Concentration of the 'ith' component of mixture;
GV1= Guideline value for the 'ith' component; TTM >1= The mixture has exceeded the Guideline value

Toxicity/hazard quotient (TQ) for heavy metals

The Toxicity/hazard quotient (TQ) for chemical elements is a ratio between the measured concentrations of chemical elements in fish samples with specific health-based criteria (Newsteadet al. 2002).
TQ =

$$Concentration\ of\ chemical\ element\ in\ fish\ sample / Health\ based\ criteria$$

Statistical procedure

Statistical software (GENSTAT® version 13.3 for Windows) was used for analyzing data. One-way analysis of variance (ANOVA) was used to test for significant differences between mean values of heavy metals at 5% level of probability while Duncan Multiple Range Test was used to separate significant means. Microsoft Excel (for Windows 2010), was used for all graphical presentations

RESULTS

The summary statistics for heavy metals in smoke-dried *C. gariepinus*for the research period ranged from 0.0078 mg/kg (Cd) to 17.96 mg/kg (Zn) as shown in Table 3 while the summary statistics for metals in fish by market ranged from 0.001 mg/kg (Cd) at NkwoNgwa market to 24.58 mg/kg (Zn) in the same market with significant ($p<0.05$) differences in the mean concentrations of Pb and Zn in fish between markets (Table 4).

Table 3: Summary statistics for heavy metalconcentrations (mg/kg) in smoke-dried *C.gariepinus*

Metals	Mean	Minimum	Maximum	Threshold	Threshold Source
Pb	0.053	0.01	0.26	0.30	Commission Regulation, 2008
Cd	0.0078	0.000	0.031	0.05	Commission Regulation, 2008
Zn	17.96	11.85	32.03	50	FAO, 1983
Cu	1.73	0.016	3.47	30	FAO, 1983

Table 4: Summary statistics for heavy metals (mg/kg) in smoke-dried *C.gariepinus* by market

Market	Pb	Cd	Zn	Cu
Ngwa Road	0.019^{a}	0.0017^{a}	14.67^{a}	1.30^{a}
Cemetary Market	0.055^{ab}	0.0085^{a}	19.02^{b}	1.60^{a}
NkwoNgwa	0.11^{b}	0.001^{a}	24.58^{c}	2.22^{a}
Ariaria	0.026^{a}	0.011^{a}	13.54^{a}	1.78^{a}

Means with similar superscripts are not significantly different ($P>0.05$). Verticalcomparisons only.

Table 5: Mean heavy metal concentration (mg/kg) in smoke-dried *C. gariepinus* by month

Month/Year	Pb	Cd	Zn	Cu
June, 2019	0.032^{a}	0.001^{a}	17.64^{a}	1.89^{a}
July, 2019	0.085^{a}	0.0092^{a}	19.33^{a}	2.25^{a}
August, 2019	0.035^{a}	0.0055^{a}	18.14^{a}	1.29^{a}
September,	0.027^{a}	0.0067^{a}	18.26^{a}	1.60^{a}

October, 2019	0.071[a]	0.005[a]	17.53[a]	1.54[a]
November, 2019	0.068[a]	0.010[a]	16.83[a]	1.78[a]

Means with similar superscripts are not significantly different (P>0.05). Vertical comparisons only

As shown in Table 5, the mean concentrations of metals in fish by month ranged from 0.001 mg/kg (Cd) in June to 19.33 mg/kg (Zn) in July, with no significant differences (p>0.05) in the mean concentrations of metals in fish between months. As presented in Figure 2, the calculated TMDI value from the research was 3214 mg/person/day while the calculated TTM value was 0.74 (Fig. 3). The TQ values ranged from 0.06 for Cu to 0.35 for Zn as presented in Figure 4 while the percentage quota of heavy metals in fish ranged from 0.04% for Cd to 90.93% for Zn (Fig. 5). The total heavy metal load in fish by market ranged from 15.36 mg/kg at Ariaria market to 26.91 mg/kg at NkwoNgwa market as shown in Figure 6.

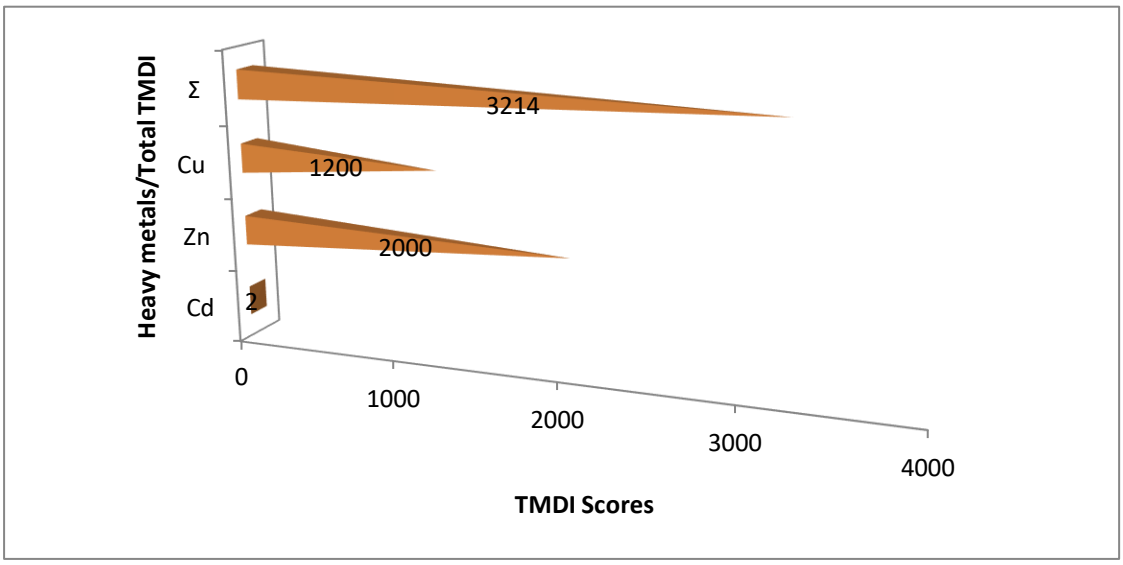

Fig. 2: TMDI value for heavy metals in smoke-dried *C. gariepinus*

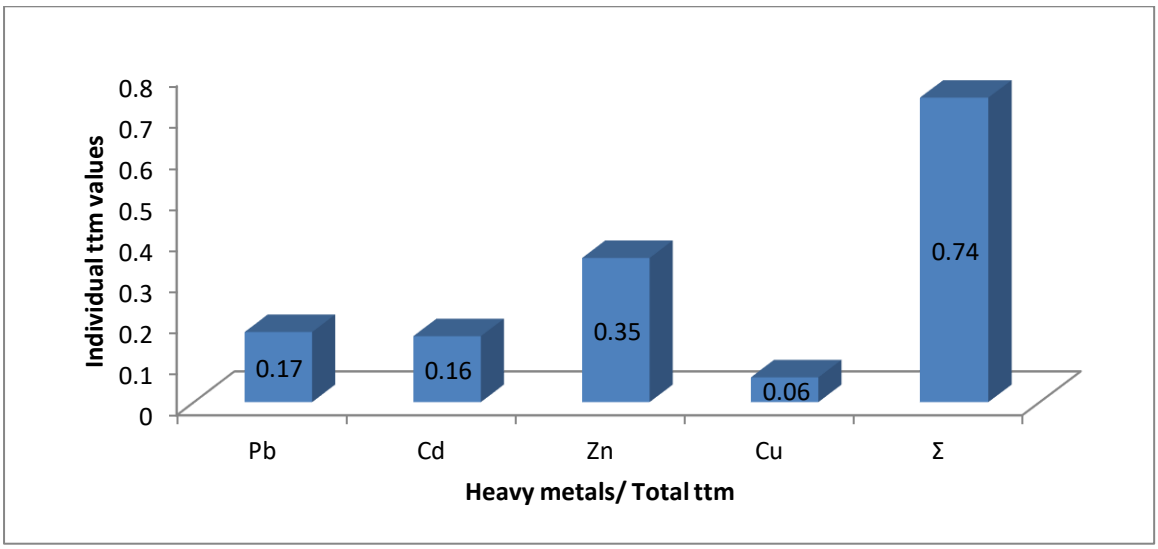

Fig. 3: TTM value for heavy metals in smoke-dried *C. gariepinus*

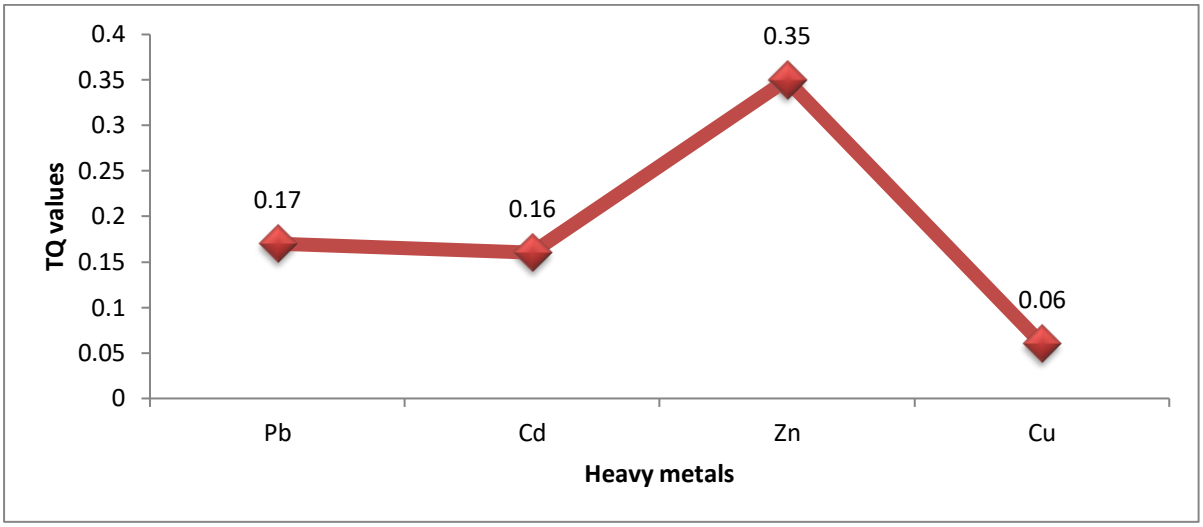

Fig.4: TQ values for heavy metals in smoke-dried *C. gariepinus*

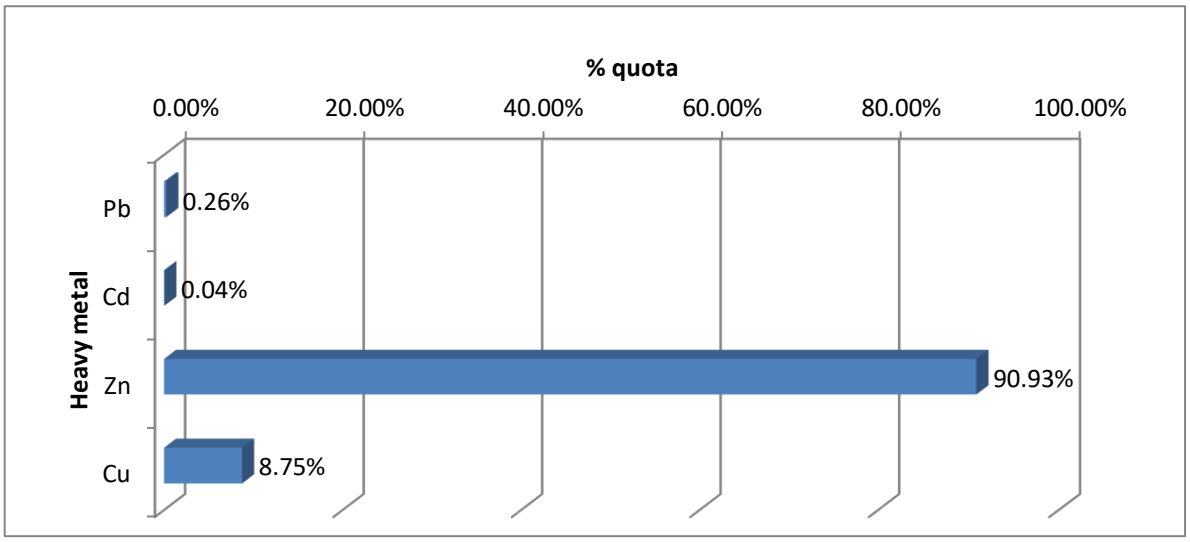

Fig. 5: Percentage quota of heavy metals in smoke-dried *C. gariepinus*

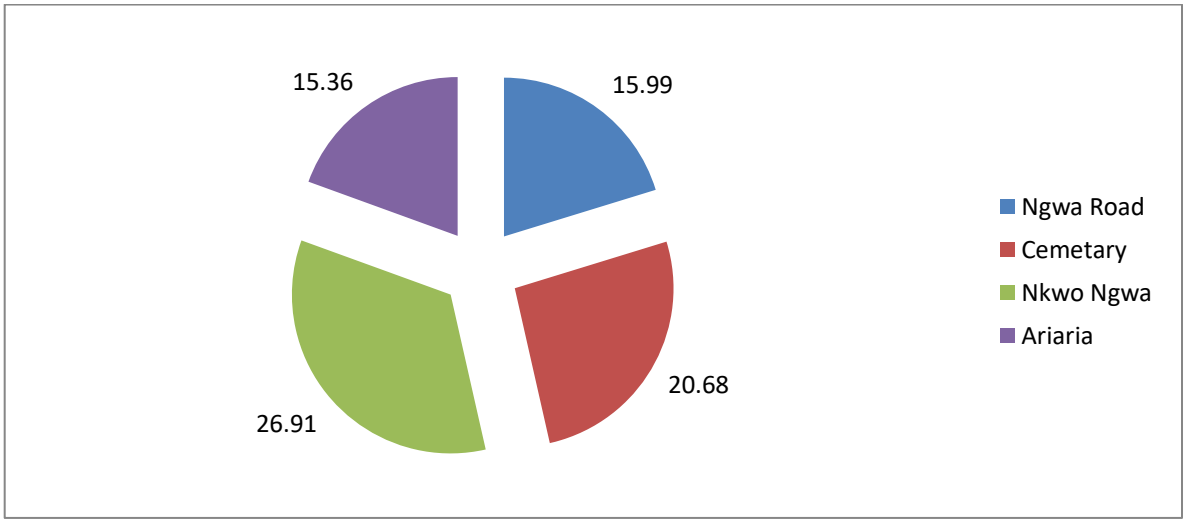

Fig. 6: Total heavy metal load (mg/kg) in fish by market

Plate 1: A sample of smoke-dried *C. gariepinus*

DISCUSSION

In ascending order, the profile of heavy metals in smoke-dried *C. gariepinus* was Zn>Cu>Pb>Cd, giving a clear indication that Zn was the dominant metal in the investigated fish species. This dominance was buttressed by a percentage quota of 90.93% for Zn in fish. The opposite scenario was obviously the case for Cd. Since the fishes were smoke-dried, it was not possible to carry out bioaccumulation calculations and to apply the Fulton condition factor to assess the general well-being of fish. However, it can be posited that Zn may have been bioaccumulated more by this fish species compared to the other heavy metals.Fishes are known for their ability to bioaccumulate heavy metals in their bodies from their surrounding ambient aquatic medium especially when the rate of uptake is greater than the rate of depuration (Heidaryet al. 2012; Opasolaet al. 2019).Such metals which could be sourced from paint, diverse industrial processes e.g. stabilizers for PVC and agricultural activities such as the use of pesticidesultimatelypass into the human body whenaquatic species like finfish and shellfish are consumed (Salaam et al. 2019).It was observed that between markets, the mean concentrations of Pb and Zn in fish were significantly different ($p<0.05$), indicating that the smoke-dried fishes may have come from different processors and distributors. It was also observed that the total heavy metal load in fish was highest at NkwoNgwa market and lowest at Ariaria market, indicating that buyers of such fish should patronize the latter market owing to the seemingly overall lower metal content in such fish. This assertion is in tandem withthe findings of some researchers who investigated the heavy metal content in some frozen marine fish species form markets in Warri, Delta state, Nigeria (Wangbojeet al. 2019).It was also observed that between months, there were no significant differences ($p>0.05$) in the mean concentrations of all the investigated metals in fish, indicating a non-seasonal variation in the levels of these metals in fish. This finding could be attributed to the fact that five (June, July, August, September and October) out of the six months were wet months. The TMDI value calculated for the research was 3214 mg/person/day. This figure takes into cognizance the maximum acceptable concentration of metals in fish along with the per capita consumption rate. The per capita consumption rate adopted in this research was 40 g/person/day (Anyakoraet al. 2008). It is worthy to note that Zn and Cu contributed the most to the TMDI value owing to their higher maximum limits of 50 mg/kg and 30 mg/kg respectively. A TTM value of 0.74 was recorded in this research. This value was kept below unity as the mean concentrations of Pb, Zn and Cu were below their respective thresholds of 0.30 mg/kg, 50 mg/kg and 40 mg/kg.The applied thresholds were the Commission Regulation limits of the European Union and theFood and Agriculture Organisation of the United Nations (FAO) limits.The scenario was different for Cd, whose mean concentration in fish exceeded the limit of 0.05 mg/kg for Cd.According to the International Programme on Chemical Safety (IPCS), Cd has been reported to exert toxic effects on the kidney, skeletal and respiratory system and has also been classified as a human carcinogen (World Health Organisation 2019). The TQ values for all the metals were below unity, indicating that presently the consuming public is not at risk however Cd is the metal that remains of immediate concern for obvious reasons. The TQ values recorded forsome selected aquatic species in Cameroon showed that Zn was likely to have a toxic risk to the health of potential consumers as

unity was surpassed. The workers in the aforementioned researchinvestigated Cd, Pb, Fe, Mg, Cu and Zn (Mbehet al. 2019).

CONCLUSION

The research successfully provided the profile of some heavy metals in smoke-dried *C. gariepinus*. Although the mean concentrations of 75% of the metals (Pb, Zn and Cu) in fish were below their respective maximum allowable limits, Cd was the only exception. The consuming public must therefore eat such fish with caution owing to the possibility of exposure to Cd poisoning over time. It is suggested that the public be enlightened on the dangers associated with prolonged exposure to heavy metals via smoked fish consumption. This task could be jointly carried out by Monitoring Officers from the Ministries of Health and Environment with the ultimate view to save lives.

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