

SELECTED HEAVY METAL PROFILES IN FISHES SOLD IN OPEN MARKET, IN RIVERS STATE, NIGERIA

*¹NAFAGHA-LAWAL, M. O., ²V. O. ABIMBOLA, AND ²F. D. SIKOKI

¹National Center for Marine Pollution Monitoring, University of Port Harcourt, Rivers state.

²Department of Animal and Environmental Biology, University of Port Harcourt.

*Corresponding Author: magdalene_lawal@uniport.edu.ng; Tel: +2348037248442

Abstract

Pollution and food safety have become issues of concern in recent years. It is on this premise that the present investigation was carried out to determine the levels of heavy metals (Lead, Cadmium, and Arsenic) in five commonly consumed fish (*Clarias gariepinus*, *Oreochromis niloticus*, *Mugil cephalus*, *Sardinella maderensis*, and *Lutjanus goreensis*) and compare the values with international permissible limit. The fish were procured from Choba market, Nigeria. Analysis of heavy metals in fish was carried out using Atomic Absorption Spectrophotometer. Mean concentrations of Lead in *M. cephalus*, *S. maderensis*, *L. goreensis*, *C. gariepinus* and *O. niloticus* were 0.4894 ± 0.047 mg/kg, 0.95 ± 0.039 mg/kg, 1.036 ± 0.108 mg/kg, 0.75 ± 0.038 mg/kg and 0.59 ± 0.33 mg/kg respectively. Cadmium values in *M. cephalus*, *S. maderensis*, *L. goreensis*, *C. gariepinus* and *O. niloticus* were 0.0038 ± 0.0038 mg/kg, 0.0060 ± 0.0019 mg/kg, 0.0064 ± 0.0011 mg/kg, 0.0036 ± 0.0039 mg/kg and 0.0026 ± 0.0037 mg/kg respectively. For Arsenic, mean values for *M. cephalus*, *S. maderensis*, *L. goreensis*, *C. gariepinus* and *O. niloticus* were 0.0032 ± 0.00295 mg/kg, 0.0046 ± 0.00207 mg/kg, 0.0052 ± 0.00164 mg/kg, 0.0032 ± 0.00327 mg/kg, 0.0018 ± 0.00249 mg/kg respectively. The metal concentrations in the fish were in decreasing order of $Pb > Cd > As$. Pb in fish exceeded the permissible limits in fish samples whereas Cd and As were below the permissible limits. The presence of these metals in fish samples, when consumed continuously, may pose a massive health risk for the consumers.

Keywords: Heavy metals; Niger delta; Choba; Permissible Limit, Lead, Cadmium, Arsenic.

INTRODUCTION

The presence of abundant water bodies in the Niger Delta has made fishing an indigenous occupation and fish is a major part of the diet of the people (Wokoma, 2014). Fish is an integral component of a well-balanced diet (Yu *et al.*, 2019) because it contains high-quality protein, omega-3 fatty acids, various vitamins and minerals (Bosch *et al.*, 2016; Dadar *et al.*, 2016; Varol *et al.*, 2019), and thus, beneficial to human health (Al-Busaidi *et al.*, 2011). In contrast to the potential health benefits of dietary intake of fish, is the concern of the risk from exposure to chemical pollutants through frequent fish consumption. The pollution of the aquatic environment is a major concern for public health and the seafood industry (Anandkumar *et al.*, 2017; Salam *et al.*, 2019). This is especially so in the Niger Delta, where most of the fishes are becoming contaminated as most of the fishes consumed are caught in the wild in increasingly polluted water bodies (Izah and Angaye, 2016).

Among the numerous environmental pollutants, heavy metals are of particular concern, due to their vast sources, potential ecological effects, persistence, non-degradability, inherent toxicity to living organisms, ability to bioaccumulate in aquatic ecosystems and food chains, and long biological half-lives (Tochounwo *et al.*, 2012; Le *et al.*, 2016; Jonathan *et al.*, 2017; Ross *et al.*, 2017). There has also been an increasing ecological and global public health concern associated with environmental contamination by these metals. As a result of an exponential increase in their use in a variety of industrial, agricultural, residential, medicinal, and

technical applications, human exposure to heavy metals has risen drastically (Anyanwu *et al.*, 2018; Engwa *et al.*, 2019; Briffa *et al.*, 2020).

Heavy metal pollution has increased in Nigeria as a result of the country's need for agricultural growth and industrialisation, particularly in the Niger Delta region, where oil extraction, transportation, and refining are carried out (Zabbey *et al.*, 2019; Akpokodje and Frank-Briggs, 2020).

Other sources include sewage discharge, accidental chemical waste disposal, oil spills, combustion of fossil fuels, and gasoline from fishing boats (N-ue and Ordinioha, 2016). Within a contaminated environment, through feeding habits and physiological functioning, fishes can bioaccumulate contaminants and toxic substances in their edible tissues (Wu *et al.*, 2016) and pass them on through the food chain (Souza *et al.*, 2018). Commonly encountered heavy metals in the aquatic environment are chromium, cobalt, nickel, copper, zinc, arsenic, selenium, silver, cadmium, antimony, mercury, thallium, and lead (Akoto *et al.*, 2014). All metals can be toxic if levels are too high and above their threshold level resulting in stress and irreversible physiological conditions. Some heavy metals such as Lead (Pb) and Cadmium (Cd) are toxic even at low concentrations and are not known to have any important biological properties in humans (Bosch *et al.*, 2016).

The measurement of heavy metals in fish can be useful to assess potential health risks to humans associated with the consumption of fish (Malakootian *et al.*, 2016). Studies have reported that

dietary intake constitutes a major route of transfer of heavy metals to man (Castro-gonzález and Méndez-Armenta, 2008; Alipour *et al.*, 2014) thus, many local and international monitoring programs have been established to assess the quality of fish for human consumption and to monitor the health of the aquatic ecosystem to assure public safety (Authman *et al.*, 2015; Olgunoğlu *et al.*, 2015; Abarshi *et al.*, 2017). Considering, the amount of industrial activities in the Niger Delta, especially with the quantity of crude oil that is being spilled into the Niger Delta environment (Chinedu and Chukwuemeka, 2018; DPR, 2018) and the fact that most of the fish consumed in the region are caught in the water bodies of the region, it is suspected that most of the local fish species consumed might contain dangerous levels of heavy metals. Hence, a better understanding of the current status of heavy metals of fishes in Choba, a riverine community is important. The aim of this study was therefore to investigate the status of heavy metal: Lead (Pb),

Cadmium (Cd), and Arsenic (As) in five commonly consumed fishes from an open market on the Choba area, and compare the levels with the maximum permissible limits proposed by FAO/WHO and EU to ascertain if they are safe for human consumption.

MATERIALS AND METHODS

Study area

The fishes were bought from the Choba Market located in Obio-Akpor Local Government Area of Rivers State, Nigeria. Most students of the University of Port Harcourt and indigenes purchase their daily consumables including fish from the market. Its coordinates are; Latitude: 5.1012.1°N, Longitude: 7.5334.7°E, and Elevation 148 meters above sea level. Because of its proximity to students and the New Calabar River, most fishmongers are present in the market to sell their fish. The market shares boundary with the University of Port Harcourt in the north and other neighbouring communities.

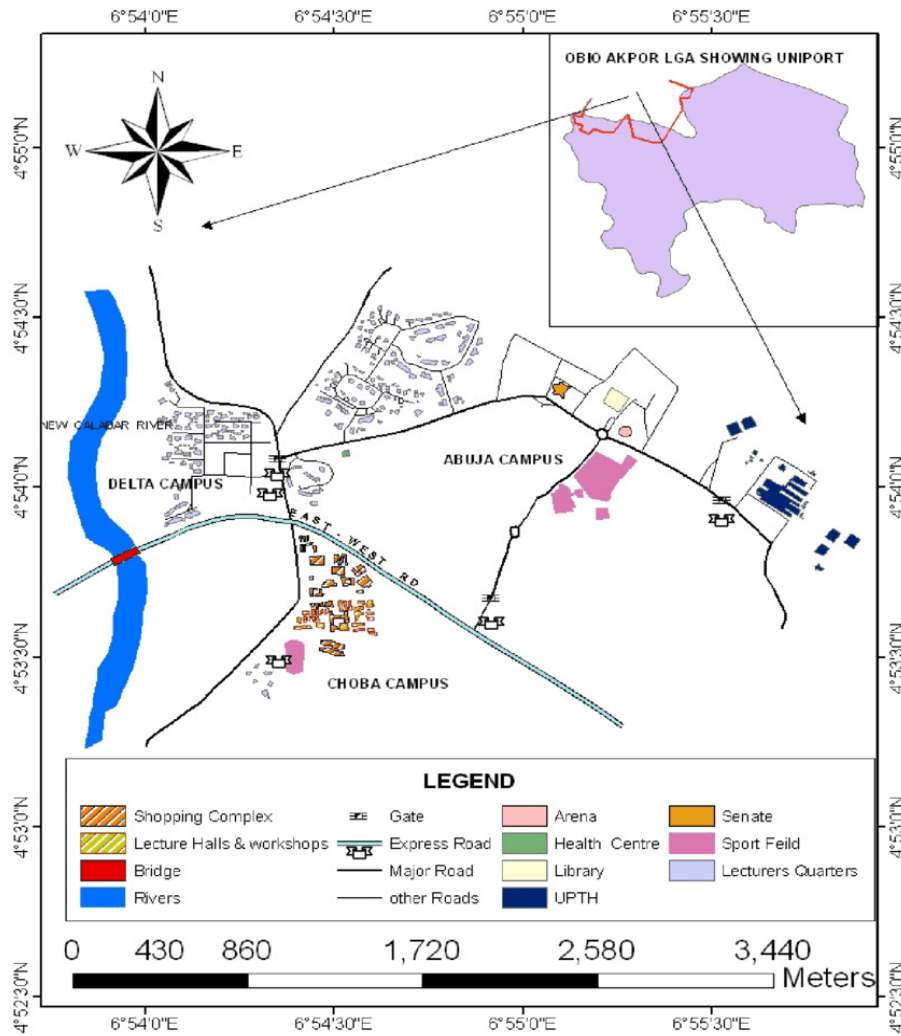


Fig 1 Map of University of Port Harcourt Showing study Area (Choba Market)

Sample collection

Five species of commonly consumed fishes in the Choba community were procured from the Choba market from fishmongers between June and August 2019. The fish samples were transported in an iced cooler to the Animal and Environmental Biology laboratory of the University of Port Harcourt for identification, measurement, preparation, and preservation for further analysis. Identification of the fish species was carried out to

specie level with the aid of species identification sheets for fishery purposes by Sikoki and Francis (2007). The fish species were identified as *Clarias gariepinus*, *Oreochromis niloticus*, *Mugil cephalus*, *Sardinella maderensis*, and *Lutjanus goreensis*. The fish samples were grouped by their species and labelled individually. The length and weight of each fish sample were measured using a ruler and an electric weighing scale respectively as shown in the Table 1.

Table 1: Length and weight of fish samples

Sample	Length (cm)			Weight (g)		
	Min	Max	Mean	Min	Max	Mean
<i>C. gariepinus</i> (n=5)	13.0	19.0	15.66	22.0	48.0	31.2
<i>O. niloticus</i> (n=5)	11.4	14.5	12.28	24.0	54.0	33.8
<i>M. cephalus</i> (n=5)	14.1	16.0	14.98	26.0	37.0	31.8
<i>S. maderensis</i> (n=5)	10.3	11.4	10.82	12.0	17.0	14.8
<i>L. goreensis</i> (n=5)	15.0	18.6	16.12	45.0	85.0	58.4

Fish samples were prepared with the standard methodology ASTM D4698-92 (ASTM, 2013) which involved oven drying, grinding, screening, and overnight digestion (12 hours). The fishes were washed with deionized distilled water, then muscle tissues were removed using stainless knives. The muscles were dried at 1050C until they reach a constant weight. Using a ceramic mortar and pestle, the dry samples were homogenized to a fine powder. One gram of each of the ground fish tissues was transferred to a porcelain basin and kept in a Thermicon P muffle furnace at a temperature of 5500C for 5 h. Samples were digested with a 10 ml tri-acid mixture (HNO₃: HClO₄: H₂SO₄) in a ratio of 6.5:6:2. The samples were then heated at 1050C until a clear colourless solution was obtained. The digested samples were allowed to cool and then diluted to 100 ml with deionized distilled water and then filtered through Whatman filter paper No. 42 and the filtrate was diluted to 100 ml with deionized water for determination of heavy metals (Pb, Cd, and As) concentration by atomic absorption spectrophotometer (Shimadzu Model 6800 with graphite furnace Model GFA 7000) and X-ray fluorescence Spectrophotometer.

For quality assurance, the samples were digested in triplicate along with blanks to minimize error. A set of standard solutions for calibrating the instrument was provided by the manufacturer. Recovery tests were conducted on all of the studied metals in samples by spiking with aliquots of the metal standards and then digesting them. The overall recovery rates (mean \pm SD) of Pb, Cd, and As were 88 \pm 8.1, 90 \pm 2.6, and 94 \pm 6.2% respectively. Since the fish sample preparation was done with fresh fish samples, heavy metal concentrations were represented as mg/Kg wet weight.

STATISTICAL ANALYSIS

The results obtained were recorded as a mean, standard deviation, and subjected to a One-way Analysis of Variance (ANOVA) to test for the significant level. The level of significance was chosen at P < 0.05. Finally mean concentration of heavy metals found in different samples was compared to the recommended accepted value provided by FAO/WHO and EU to check if the present value of heavy metals were within the limits.

RESULTS

The results of the heavy metal analysis in the fish samples from the Choba market are presented in Fig 2. The fish samples were found to contain detectable levels of Lead, Cadmium, and Arsenic in all fish samples. Mean concentration of Lead in *M. cephalus*, *S. maderensis*, *L. goreensis*, *C. gariepinus* and *O. niloticus* were 0.49 \pm 0.047 mg/kg, 0.95 \pm 0.039 mg/kg, 1.036 \pm 0.11 mg/kg, 0.75 \pm 0.038 mg/kg and 0.59 \pm 0.33 mg/kg respectively. The maximum and minimum Pb levels measured was 1.036 \pm 0.11 mg/kg in *L. goreensis* and 0.0026 \pm 0.0037 mg/kg in *M. cephalus* respectively. Statistically significant differences were found in the concentrations of Pb among fish species (p < 0.05).

Cadmium concentrations in *M. cephalus*, *S. maderensis*, *L. goreensis*, *C. gariepinus* and *O. niloticus* were 0.0038 \pm 0.0038 mg/kg, 0.0060 \pm 0.0019 mg/kg, 0.0064 \pm 0.0011 mg/kg, 0.0036 \pm 0.0039 mg/kg and 0.0026 \pm 0.0037 mg/kg respectively. The maximum and minimum Cd level measured were 10.0064 \pm 0.0011 mg/kg in *L. goreensis* and 0.0026 \pm 0.0037 mg/kg in *O. niloticus* respectively. No statistical differences were found in the concentrations of Cd among fish species (p > 0.05).

For Arsenic, mean concentrations for *M. cephalus*, *S. maderensis*, *L. goreensis*, *C. gariepinus* and *O. niloticus* were 0.0032 ± 0.00295 mg/kg, 0.0046 ± 0.0021 mg/kg, 0.0052 ± 0.0016 mg/kg, 0.0032 ± 0.0033 , 0.0018 ± 0.0025 mg/kg respectively. The maximum and minimum Cd level measured were 0.0052 ± 0.0016 mg/kg in *L.*

goreensis and 0.0018 ± 0.0025 mg/kg in *O. niloticus* respectively. No statistical differences were found in the concentrations of Cd among fish species ($p > 0.05$).

The results showed that the order of mean concentration of heavy metal in the fish samples was Lead > Cadmium > Arsenic (Table 2).

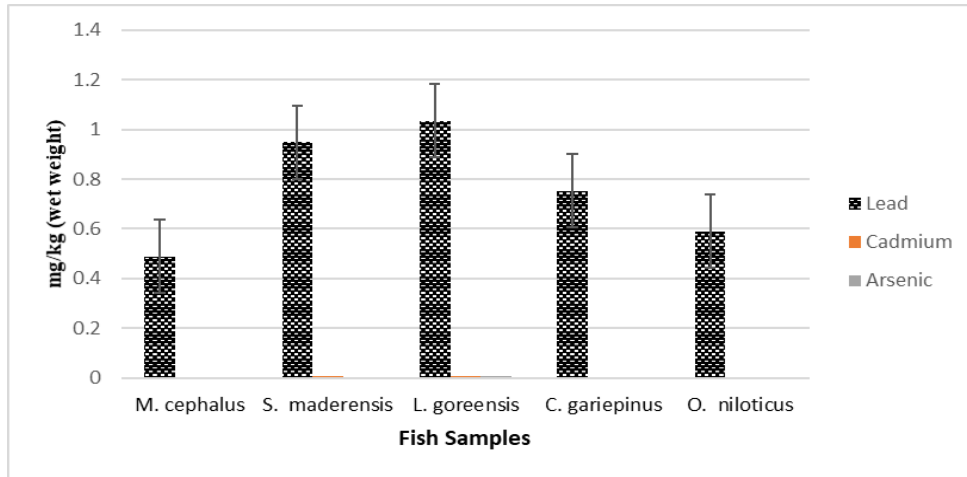


Table 2: Comparison to some international standards

Heavy metal	Average concentration (mg/kg)	Highest concentration (mg)	Average daily intake (mg/kg)	Maximum permissible limit (mg/kg) (FAO- WHO, 2019)	EU (EC, 2006)
Lead	0.7635	1.160	0.00055	0.2	0.3
Cadmium	0.0045	0.010	0.0020	0.1	0.05
Arsenic	0.0036	0.010	0.13	0.01–2.00	-

DISCUSSION

Lead (Pb) is one of the most common metals in the environment and biological systems, despite having no recognized biological function in humans. It is found in all phases of the inert environment and biological systems (Castro-gonzález and Méndez-armenta, 2008). Concentration of Pb in fishes had a range of $0.4894 \pm 0.047 - 1.0356 \pm 0.108$ mg/kg. Lead contents in the literature for fishes in the Niger Delta have been reported in the range of 0.20 - 0.50 mg/kg (Abarshi *et al.*, 2017); 0.00088 – 0.0121 mg/kg (Moslen and Miebaka, 2017); 0.11 - 0.90 (Makinde *et al.*, 2015); 2.60 - 10.11 mg/kg (Ihunwo *et al.*, 2020); 0.380 – 21.555 mg/kg (Aigberua and Tarawou, 2017); 0.73 - 10.6 mg/kg (Osioima and Iniaghe, 2019). Literature on Pb content in fish from some countries in the world have also been reported: 0.000002 – 0.000008 mg/kg in Malaysia (Salam *et al.*, 2019); 3.33 - 10.33 mg/kg in Bangladesh (Shovon *et al.* 2017); 0.01-0.09 Atlantic Coast of Muanda, D R Congo (Suami *et al.*, 2018); 0.083–2.354 mg/ kg (Atique Ullah *et al.*, 2017); BDL - 0.107 mg/kg in fishes in Kahramanmaraş city, Turkey (Varol *et al.*, 2019). The mean concentrations of Pb in the fish samples were about four times the FAO-WHO permissible limit of 0.2 mg/kg (FAO-WHO, 2019), whereas the

European Community (EC, 2006) established the maximum levels of lead in fish as 0.3 mg/kg. The high concentration of Pb in the fishes could be a result of frequent discharge of industrial and domestic effluents into the New Calabar River and most likely incessant oil spills. Lead typically accumulates in muscles, bones, blood, and fat (Nussey *et al.*, 2000). Possible adverse effects caused by lead include damage to the liver, kidneys, brain, and nerves, reproductive disorders, increase in heart disease, high blood pressure, anaemia, behavioural disorders as well as learning deficits (EFSA, 2012; Mason *et al.*, 2014). In young children, it causes hormonal imbalance of metabolite of vitamin D and reduced intelligence quotient (Govind and Madhuri, 2014).

Cadmium is a highly toxic element capable of causing severe toxicity even when it is present at a very low concentration (Bosch *et al.*, 2016). Cadmium was detected in all the fish samples analyzed with a concentration of a range of $0.0026 \pm 0.0037 - 0.0064 \pm 0.0011$ mg/kg, however, they were below the recommended guidelines set by FAO-WHO (2019) of 0.1 mg/kg and EC (2006) of 0.05 mg/kg. Variations in cadmium concentrations in fish have been documented in several investigations. Cd contents in the literature have been reported for fishes in the Niger delta. BDL – 0.00145 mg/kg

(Moslen and Miebaka, 2017); 0.00 – 1.50 mg/g (Abarshi *et al.*, 2017); 0.57 - 2.02mg/kg (Makinde *et al.*, 2015); 3.86 - 24.66 mg/kg (Ihunwo *et al.*, 2020); 0.002 - 0.78 mg/kg (N-ue and Ordinioha, 2016). Literature on Cd content in fish from some countries in the world have also been reported: 0.16 - 0.49mg/kg in Bangladesh (Shovon *et al.*, 2017); 0.015–0.020 mg kg in Dhaka city, Bangladeshi (Atique Ullah *et al.*, 2017); ND-0.59 from Atlantic Coast of Muanda, DR Congo (Suami *et al.*, 2018); ND - 0.0092 mg/kg in fishes in Kahramanmaraş city in Turkey (Varol *et al.*, 2019); 0.008 – 0.01 mg/kg from Tigris River, Baghdad (Mensoor and Said, 2018). Cadmium (Cd) exposure is regarded as being sub lethal and capable of producing chronic lung disease and testicular degeneration (Stancheva *et al.*, 2013); reduced birth weights and premature labour (Henson and Chedrese, 2004); induction of kidney dysfunctions, osteomalacia (Satarug *et al.*, 2017); damage to the central nervous system and produce psychological disorder (EFSA 2012); and even death (Authman *et al.*, 2015).

Arsenic is a potentially dangerous heavy metal that can be found in the environment due to both natural and man-made processes (Saha *et al.*, 2016). Arsenic had the lowest concentrations of the metals in the fish tissues that were analysed with a range of 0.0018±0.0025 - 0.0052±0.0016mg/kg. They were below the recommended limits set by FAO-WHO (2019) of 0.1mg/kg. Only a few studies regarding Arsenic concentrations in fish have been performed in the past in the Niger delta. They are in the range of 1.85 – 7.53 mg/kg in freshwater fish species (N-ue and Ordinioha, 2016); below are Detectable Limits in fishes from the Woji creek (Ihunwo *et al.*, 2020). Reports on As content in fish from some countries in the world have also been reported: 0.42–5.97 mg/g for fishes from the Yellowknife, Northwest Territories, Canada (Tanamal *et al.*, 2020); 0.143–0.501 mg/kg for fishes in Dhaka city, Bangladeshi (Atique Ullah *et al.* 2017); 0.24 - 50.34 mg/kg from fishes in Kahramanmaraş city in Turkey (Varol *et al.*, 2019). According to USFDA (2020), about 90 percent of total human exposure to Arsenic is from fish and seafood consumption. Arsenic (As) exposure to the human body causes cardiovascular, integumentary, pulmonary, and endocrine effects, and can lead to cancer in multiple organs (IARC, 2014; Tanamal *et al.*, 2020).

CONCLUSION

The study indicated a significant accumulation of heavy metals (especially Lead) in the fishes due to the gradual build-up of toxic pollutants in the aquatic environment of the Niger delta which could be attributed to the incessant oil spills. The presence of heavy metal pollutants in fish diets could create serious health problems if continuously consumed over a long period. There is,

therefore, a need for caution while consuming these fishes especially *L. goreensis* which recorded the highest level of Lead because of their potential to cause severe adverse health effects. Therefore, it may be imperative that appropriate regulatory agencies strictly ensure the activities leading to possible water contamination and the relative bioaccumulation of heavy metals in fish tissues is reasonably controlled to forestall further deleterious effects via biomagnification across the food chain. As a result of the significant levels of lead in the fish, more research into source tracing is highly suggested.

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