International Journal of Applied Research 2023; 9(1): 155-161

ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor: 8.4
IJAR 2023; 9(1): 155-161
www.allresearchjournal.com
Received: 15-11-2022
Accepted: 18-12-2022

Okpanachi MA
Department of Animal and Environmental Biology, Kogi State University Anyigba, P.M.B. 1008, Anyigba, Kogi State, Nigeria

Egbeja TI
Department of Animal and Environmental Biology, Kogi State University Anyigba, P.M.B. 1008, Anyigba, Kogi State, Nigeria

Wintola HU
Department of Animal and Environmental Biology, Kogi State University Anyigba, P.M.B. 1008, Anyigba, Kogi State, Nigeria

Onoja EA
Department of Animal and Environmental Biology, Kogi State University Anyigba, P.M.B. 1008, Anyigba, Kogi State, Nigeria

Isah GO
Department of Animal and Environmental Biology, Kogi State University Anyigba, P.M.B. 1008, Anyigba, Kogi State, Nigeria

Corresponding Author:
Okpanachi MA
Department of Animal and Environmental Biology, Kogi State University Anyigba, P.M.B. 1008, Anyigba, Kogi State, Nigeria

Health risk assessment and heavy metal levels in *Trachurus murphyi* and *Clupea harengus* purchased from anyigba main market, Anyigba, Kogi State, Nigeria

Okpanachi MA, Egbeja TI, Wintola HU, Onoja EA and Isah GO

Abstract
This study investigated the Health risk assessment and heavy metal levels in tissues (gill, bone, muscle and liver) of *Trachurus murphyi* and *Clupea harengus* purchased from Anyigba main market, Anyigba, Kogi State, Nigeria. Three (3) samples each of *Trichurus murphi* and *Clupea harengus* species were used. Heavy metal analysis was done using a Virian Atomic Absorption Spectrophotometer. The results obtained were subjected to descriptive (mean and standard deviation) and inferential (ANOVA) statistics. Means were separated using Duncan multiple range Test (DMRT). Statistical Analysis system (SAS) version 9.0 portable was used. The grand mean concentration of metals determined ranged from 3.29±0.5–34.55±5.56 mgkg^{-1}. The metals determined were Pb, Cd, Hg, Cu and Ni with grand mean concentrations of 22.34±3.79, 7.15±1.24, 7.21±2.6, 34.55±5.56 and 3.29±0.5 (mgkg^{-1}) respectively for *Trichurus murphi*. While, in *Clupea harengus*, the grand mean concentration of metals determined for Pb, Cd, Hg, Cu and Ni were 23.21±3.39, 2.94±0.13, 1.58±1.02, 18.88±1.04 and 2.28±0.05 (mgkg^{-1}) respectively. The concentration of metals was in this order: Copper >Lead >Cadmium>Mecury>Nickel. Result revealed that all the metals determined were above the maximum allowable limits set by regulatory bodies. Hence, there is need to enlighten people on the need to reduce anthropogenic activities leading to excessive presence of heavy metals in our water bodies.

Keywords: Cancer, frozen fish, heavy metals, risk assessment

Introduction

Pollution remains one of the most challenging problems facing societies around the world (Yahya *et al*., 2018) [33]. This is as a result of advancement in industrialization and increase in human population (Matouke *et al*., 2020) [22]. Controlled and uncontrolled disposal of waste, run-offs from agricultural activities, mining and smelting of metal ores, accidental and process spillage are routes through which contaminants in the form of dust and leachates pass onto non-contaminated areas spreading contamination across the ecosystem (Ghosh and Singh, 2005) [16].

Many inorganic and organic compounds of contamination include heavy metals, substances of combustion and putrefaction, hazardous wastes, explosives and petroleum products, Phenol and textile dyes amongst others (Khayatzadeh and Abbasi, 2010) [19].

Globally, pollution of aquatic environments is of immense concern due to the deposit of toxicants and heavy metals (Egbeja *et al*., 2019) [10]. According to Khayatzadeh and Abbasi (2010) [19], heavy metals have been defined: as metals with atomic number 23 (i.e. vanadium) and above except Rb, Y, Cs, Ba, and Fr; as metals possessing a density above 5; and as metals which are toxic to man and other living organisms when found in the environment. Although, heavy metals exist as natural trace components of the aquatic environment, their recent levels are reported to be on the increase due to pollution from industrial wastes, agricultural waste, changes in geochemical structure, mining activities and other anthropogenic activities (Singh *et al*., 2007) [28].

More severe is the problem of surface and groundwater heavy metal contamination in developing countries due to inadequate monitoring of the water sources (Tay *et al*., 2019) [31]. Because of potential effect of toxic levels to bioaccumulate in marine ecosystems, heavy metals have attracted global interest.

The World Health Organization (WHO) has listed As, Pb, Hg and Cd in its chemicals watch-list of major public health concern (Tay *et al*., 2019) [31].

Some examples of heavy metals are lead (Pb), arsenic (As), cadmium (Cd), mercury (Hg) and nickel (Ni), chromium (Cr), and thallium (Tl) (Ekpo *et al*., 2008) [12]. Although, some heavy metals like zinc, iron and copper contribute to normal body development at trace levels, intakes higher than the daily dietary requirement have proven to be adverse to health (Gonzalez and Mende-Arementa 2008) [17]. Other heavy metals such as Nickel (Ni), Cadmium (Cd), Chromium (Cr) and lead (Pb) are hazardous at even trace amounts and are termed as non-essential (Storelli *et al*., 2005; Bassey and Chukwu, 2019) [30, 5].

Studies show that aquatic animals such as fish are capable of heavy metals accumulation (Egbeja *et. al*., 2021) [11]. Heavy metals enter the food chain when organisms consume water or food and bio-accumulate in living organisms, biomagnifying across trophic levels whereby pollutants travel within food chains (Canpolat, 2013) [6]. Humans are therefore exposed through consumption of fishes. Since, heavy metals cannot be metabolized by the human body, they tend to bio-accumulate in the liver, muscles and the bones of man, thus could be poisonous to the health of man when ingested in sufficient quantities. (Ekpo *et al*., 2008) [12].

Long-term exposure via ingestion, inhalation and skin contact to toxic heavy metals and chemicals in the environment may be risky to human health (Tay *et al*., 2019) [31]. Hence, risk assessment is used to assess the potential risk of exposure.

Risk assessment is a scientific procedure used to identify, analyze and measure hazards and ascertain their possible routes of exposure in order to estimate their potential health risks and possible control measures (Bassey and Chukwu, 2019) [5]. According to Bassey and Chukwu (2019) [5], elements are classified by health risk assessment as carcinogenic and non-carcinogenic. The non-carcinogenic elements have a threshold limit and are observed at a dose below the threshold level to have no adverse health effects

In Nigeria, fish is a major source of protein, and frozen fish is a delicacy for most Nigerians. Fishes sold in an open market are obtained from several sources, including both fresh water (ponds, streams lakes and rivers) and sea water.

These fishes could come from already polluted sources or their contamination could arise during handling and processing. Therefore, this study attempts to determine the level of some heavy metals (Cd, Pb, Mn, Cu, Hg, Zn, Ar) in *Trachurus murphyi* and *Clupea harengus* and the associated health risk of consuming these fishes sold at Anyigba main market, Anyigba, Kogi State, Nigeria.

Materials and Methods

Study Area

Anyigba Located in Dekina local government area of Kogi state Nigeria, is found between longitude 7^{o}12^1 East of the Greenwich meridian and latitude 7^o 36^1 North of the Equator (7.30^o N, 6.42^o E) (7.500^o N, 6.700^o E) is located in the central region of Nigeria. Kogi is characterized by rain and dry seasons, rainy season and dry season lasting from April to October and November to March respectively. Anyigba is known to have local steppe as its prevailing climate, characterized with guinea savannah type of vegetation and mean annual rainfall of about 747mm. The average maximum temperature is 33.2 °C and average minimum temperature is 22.8 °C while the rainy season lasts from April to October.

Sampling

Three (3) samples each of *Trachurus murphyi* and *Clupea harengus* species respectively, were purchased from Anyigba main market, Kogi State. These samples were placed in a polythene bags before taken to the laboratory for pre-treatment and subsequent analysis. Different body parts (gill, muscle, liver, and bone) of *Trachurus murphyi* and *Clupea harengus* were used in this study.

Sample Pre-treatment

The collected samples were washed with de-ionised water, deboned and then oven dried at 40^{o}c for three days. The dried samples were impoverished using mortar and pestle (Aremu *et al*., 2007) [2].

Sample Digestion

The heavy metal content was determined using computerized Varian Atomic Absorption Spectrophotometer (model Spectra AA-240FS) at university of Ibadan Central Laboratory.

Statistical Analysis

The results obtained were subjected to descriptive (mean and standard deviation) and inferential (ANOVA) statistics. Means were separated using Duncan multiple range Test (DMRT). Statistical Analysis System (SAS) Version 2.0 portal was used.

Results

Table 1 shows the mean heavy metal residual concentration and grand mean of heavy metals in the body parts (gills, bone, muscle, and liver) of frozen fish (*Trachurus murphyi*) measured in mgkg^{-1}. The grand mean concentration of metals determined ranged from 3.29 ± 0.5–34.55 ± 5.56 mgkg^{-1}. The metals determined were Pb, Cd, Hg, Cu and Ni with grand mean concentrations of 22.34±3.79, 7.15±1.24, 7.21 ± 2.6, 34.55 ± 5.56 and 3.29 ± 0.5 (mgkg^{-1}) respectively.

Table 1: Result of heavy metal residual concentration in the examined *Trachurus murphyi* tissue samples sold in Anyigba main market

Samples	Pb	Cd	Hg	Cu	Ni
Gill	6.32±1.12^{bc}	1.56±0.24^{d}	1.78±0.62^{bc}	7.99±2.01^{b}	1.07±0.40^{g}
Bone	9.71±0.97^{e}	1.94±0.90^{e}	1.96±0.39^{bc}	8.66±1.30^{bc}	0.27±0.01^{b}
muscle	5.44±1.02^{b}	1.34±0.02	1.01±0.60^{ab}	7.63±0.95^{b}	0.72±0.04^{d}
Liver	0.87±0.60^{a}	2.31±0.08^{f}	2.46±0.99^{c}	10.27±1.30^{c}	1.23±0.05^{h}
Grand mean	22.34±3.79	7.15±1.24	7.21±2.6	34.55±5.56	3.29±0.5

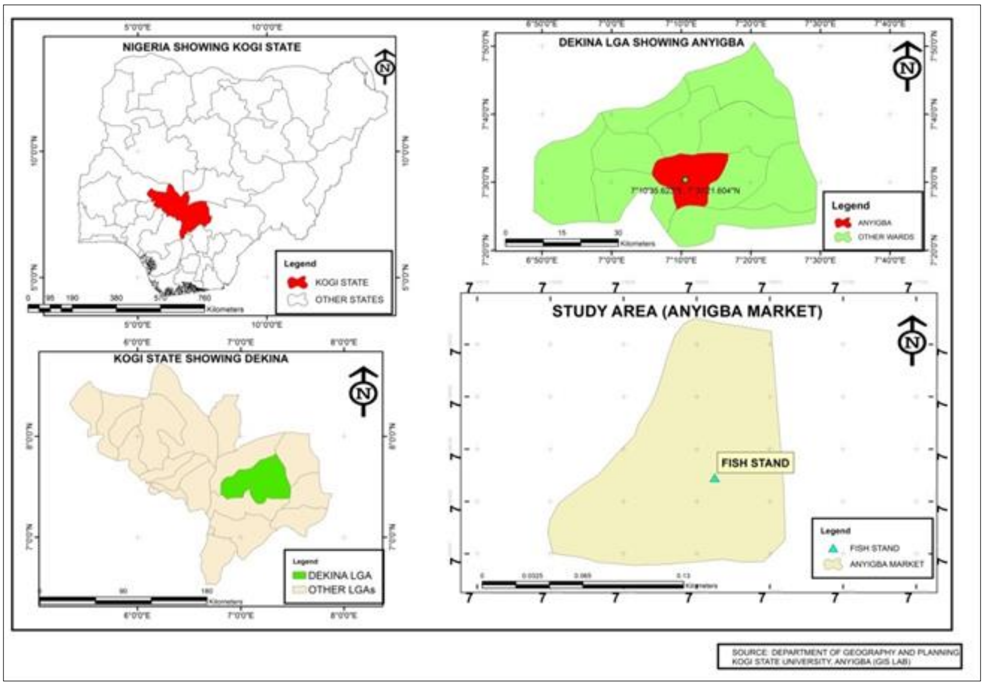
Table 2 shows the mean heavy metal residual concentration and grand mean of heavy metals in the body parts (gills, bone, muscle, and liver) of frozen fish (*Clupea harengus*) measured in mgkg^{-1}. The grand mean concentration of metals determined ranged from 1.58±1.02-23.21±3.39 mgkg^{-1}. The metals determined were Pb, Cd, Hg, Cu and Ni with grand mean concentrations of 23.21±3.39, 2.94±0.13, 1.58±1.02, 18.88±1.04 and 2.28±0.05 (mgkg^{-1}) respectively.

Table 2: Result of heavy metal residual concentration in the examined *Clupea harengus* tissue samples sold in Anyigba main market

Samples	Pb	Cd	Hg	Cu	Ni
Gill	2.36 ± 0.26^{a}	0.62 ± 0.03^{b}	0.08 ± 0.01^{a}	3.11 ± 0.12^{a}	0.82 ± 0.01^{e}
Bone	7.36 ± 1.08^{cd}	0.23 ± 0.02^{a}	0.10 ± 0.08^{a}	0.10 ± 0.08^{a}	0.11 ± 0.01^{a}
Muscle	8.66 ± 1.14^{de}	0.75 ± 0.03^{b}	0.06 ± 0.02^{a}	3.45 ± 0.11^{a}	0.42 ± 0.01^{c}
Liver	4.83 ± 0.91^{b}	1.66 ± 0.05^{d}	1.34 ± 0.91^{b}	8.64 ± 0.49^{bc}	0.93 ± 0.02^{f}
Grand mean	23.21 ± 3.39	2.94 ± 0.13	1.58 ± 1.02	18.88 ± 1.04	2.28 ± 0.05

Values are mean± SD of three replicates. Different superscript in the same column indicate significant difference at $p<0.05$ (DMRT)

Table 3 shows the mean estimated daily intake (EDI) and grand mean of heavy metals in the body parts (gills, bone, muscle, and liver) of frozen fish (*Trachurus murphyi*) measured in $mgkg^{-1}$. The grand mean concentration of metals determined ranged from 0.2533-1.5301 $mgkg^{-1}$. The metals determined were Pb, Cd, Hg, Cu and Ni with grand mean concentrations of 0.9893, 0.3166, 0.3192, 1.5301 and 0.2533 ($mgkg^{-1}$) respectively.



Map source: Department of Geography, Kogi State University, Anyigba

Fig 1: Map showing study area

Table 3: Estimated daily intake (EDI) in *Trachurus murphyi* of different metals tested

Samples	Pb	Cd	Hg	Cu	Ni
Gill	0.279	0.0691	0.0788	0.3538	0.0473
Bone	0.4300	0.0859	0.0868	0.3836	0.1196
Muscle	0.2409	0.0593	0.0447	0.3379	0.0319
Liver	0.0385	0.1023	0.1089	0.4548	0.0545
Grand mean	0.9893	0.3166	0.3192	1.5301	0.2533

Table 4. Shows the mean estimated daily intake (EDI) and grand mean of heavy metals in the body parts (gills, bone, muscle, and liver) of frozen fish (*Clupea harengus)* measured in $mgkg^{-1}$. The grand mean concentration of metals determined ranged from 0.0699-1.0278 $mgkg^{-1}$. The metals determined were Pb, Cd, Hg, Cu and Ni with grand mean concentrations of 1.0278, 0.1444, 0.0699 and 0.8361 and 0.1007 ($mgkg^{-1}$) respectively.

Table 4: Estimated daily intake (EDI) in *Clupea harengus* of different metals tested

Samples	Pb	Cd	Hg	Cu	Ni
Gill	0.1045	0.0275	0.0035	0.1377	0.0363
Bone	0.3259	0.0102	0.0044	0.1630	0.0047
Muscle	0.3835	0.0332	0.0027	0.1528	0.0186
Liver	0.2139	0.0735	0.0593	0.3826	0.0411
Grand mean	1.0278	0.1444	0.0699	0.8361	0.1007

Table 5 shows the mean metal concentrations and grand mean percent in the body parts (gills, bone, muscle, and liver) of frozen fish (*Trachurus murphyi*) measured in $mgkg^{-1}$. The grand mean concentration of metals determined ranged from 0.0127-0.3432 $mgkg^{-1}$. The metals determined were Pb, Cd, Hg, Cu and Ni with grand mean concentration of 0.2473, 0.3432, 0.1597, 0.0308, 0.0127 and 0.7937 ($mgkg^{-1}$) respectively.

Table 5: Result of target hazard quotient (THQ) analysis due to consumption of *Trachurus murphyi* sold in Anyigba main market

Samples	Pb	Cd	Hg	Cu	Ni	HI
Gill	0.0700	0.0691	0.0394	0.0088	0.024	0.1897
Bone	0.1075	0.0859	0.0434	0.0022	0.0060	0.245
Muscle	0.0602	0.0859	0.0224	0.0084	0.0016	0.1785
Liver	0.0096	0.1023	0.0545	0.0114	0.0027	0.1805
Grand mean	0.2473	0.3432	0.1597	0.0308	0.0127	0.7937

Table 6 shows the mean metal concentrations and grand mean percent in the body parts (gills, bone, muscle, and liver) of frozen fish (*Clupea harengus)* measured in $mgkg^{-1}$. The grand mean concentration of metals determined ranged from 0.0050 – 0.2569 $mgkg^{-1}$. The metals determined were Pb, Cd, Hg, Cu and Ni with grand mean concentrations of 0.2569, 0.1442, 0.0351, 0.0195 and 0.0050 ($mgkg^{-1}$) respectively.

Table 6: Result of target hazard quotient (THQ) analysis due to consumption of *Clupea harengus* sold in Anyigba main market

Samples	Pb	Cd	Hg	Cu	Ni	HI
Gill	0.026	0.0275	0.0018	0.0034	0.0018	0.0606
Bone	0.0815	0.0102	0.0022	0.0041	0.0002	0.0982
Muscle	0.0959	0.033	0.0014	0.003	0.0009	0.1352
Liver	0.0535	0.0735	0.0297	0.009	0.0021	0.1684
Grand mean	0.2569	0.1442	0.0351	0.0195	0.0050	0.4624

Table 7 shows the estimated cancer risk in the body parts (gills, bone, muscle, and liver) of frozen fish (*Trachurus murphyi*) measured in mgkg-1. The metals determined were Cd, and Ni. Cadmium range from 1.0 100 in gills to 4.1 10-1 in Liver, while Nickel range from 1.1 10-1 in bone to 5.0 10-2 in liver.

Table 7: Result of the estimated cancer risk due to consumption of *Trachurus murphyi* sold in Anyigba main market

Samples	Cd	Ni
Gill	1.0×10^{0}	4.3×10^{-2}
Bone	1.3×10^{0}	1.1×10^{-1}
Muscle	8.9×10^{-1}	2.9×10^{-2}
Liver	4.1×10^{-1}	5.0×10^{-2}

Table 8 shows the estimated cancer risk in the body parts (gills, bone, muscle, and liver) of frozen fish (*Clupea harengus*) measured in $mgkg^{-1}$. The metals determined were Cd, and Ni. Cadmium range from 1.1×10^{0} in liver to 5.0×10^{-1} in Muscle, while Nickel range from 1.7×10^{-2} in liver to 4.3×10^{-3} in bone.

Table 8: Result of the estimated cancer risk due to consumption of *Clupea harengus* sold in Anyigba

Samples	Cd	Ni
Gill	4.1×10^{-1}	3.3×10^{-2}
Bone	1.5×10^{-1}	4.3×10^{-3}
Muscle	5.0×10^{-1}	1.7×10^{-2}
Liver	1.1×10^{0}	3.7×10^{-2}

Table 9: Shows the regulatory standard for Word Health Organization (WHO) recommended permissible limits of heavy metals

Metals	Fish ($mgkg^{-1}$)
	WHO
Lead	2.0
Mercury	1.0
Cadmium	0.5
Nickel	2.0
Copper	0.6

Discussion

This study was aimed at assessing the health risk and heavy metal level in *Trachurus murphyi* and *Clupea harengus* purchased from Anyigba main market, Kogi State. Heavy metal has been on the increasing rate in recent research development as a result of pollution from industrial wastes, agricultural waste, changes in the geochemical structure, mining activities according to Sprocati *et al*. (2006) [29] and Singh *et al*. (2007) [28].

In regards to this study, Diop *et al*. (2017) [9] have done investigations on some heavy metals and their risk assessment in fish species namely: Lead (Pb), cadmium (Cd), copper (Cu), Nickel (Ni), and Mercury (Hg).

The statistical analysis of heavy metals like cadmium, lead, mecury, nickel and copper (Cd, Pb, Hg, Ni, Cu) concentrations (mgkg-1) in the various tissues and organs (Gills, Muscle, Liver and Bone) of *Trachurus murphyi* and *Clupea harengus* in this study, recorded copper with the highest residual concentrations in *Trachurus murphyi* liver (10.27 mgkg-1) as shown in Table 1 compared to other metals examined. This may be as a result of its presence in fish feed formulation, as copper is necessary for growth and metabolism of all living organism including fish. It also represent parts of many enzymes and glycoprotein and also important for nervous system function and necessary for haemoglobin synthesis (Nordberg *et al*., 2007) [25].

It could also be as a result of its abundance in fresh and marine water because they are the principal receptor of industrial and urban wastes water, surface water runoff and atmospheric disposition according to Davis *et al*. (2001) [8]. *Trachurus murphyi* has the highest residual concentration of copper (Cu) in liver which is also the highest among the two species of fishes examined as shown in Table (4.1); (10.27 mgkg-1). *Clupea harengus* in Table 2 has the least heavy residual concentration of Cu in bone (0.10±0.08 mgkg-1).

The result of cadmium concentration shown in Table 1, indicated that the concentration recorded in the tissues of *Trachurus murphyi* fish species ranges from 1.34±0.02 mgkg-1 to 2.31±0.08 mgkg-1 as shown for muscle and liver tissues respectively. So also, cadmium concentration in *Clupea harengus* as shown in Table 2, ranges between 0.23 mgkg-1 and 1.66 mgkg-1 as indicated for the bone and liver respectively. The *Trachurus murphyi* liver and *Clupea harengus* species liver accumulates the highest concentration of Cd, 2.31 mgkg-1 and 1.66 mgkg-1 respectively. This concentration of cadmium shown in the liver tissues was far below what was recorded from the report found in many fish species. The findings of Bashir *et al*. (2013) [4], which indicated that 13.35 mgkg-1 was in the liver tissue of Arius thalassinus species sample collected from Mersing region. Abdullahi *et al*. (2015) [1] in a related experiment has shown that 19.758 mgkg-1 was in the liver of Scomber scombrus species sold in Nigeria and Storelli *et al*. (2005) [30] has shown that 19.81 mgkg-1 was found in the liver of Sphyrna zygaena fish species.

From the background of fish studies, different report was seen corresponding with the higher level of cadmium. Cd is usually accumulated in the liver tissue (Uzairu *et al*., 2009 and Abolfazl *et al*., 2012) [32]. According to this study, comparing cadmium accumulation of *Trachurus murphyi* and *Clupea harengus* with other fish species from other locations presented greater differences in concentration. However, *Trachurus murphyi* and *Clupea harengus* sold in Anyigba presented the lowest level of cadmium in the liver, which shows that the cadmium contamination is less in the *Trachurus murphyi* and *Clupea harengus* sold in Anyigba compared to the level in the study carried out on Scomber scombrus in Zaria (Abdulahi *et al*., 2015).

The enormous level of cadmium shown in the liver in comparison to the other tissues may be due to the fact that liver is the ultimate organ responsible for the detoxification, storage of toxic substances and transportation (Yazkan *et al*., 2002) [34]. According to Copat *et al*. (2013) [7] relatively, liver tissue that acts as the major storage organ of cadmium was reported in different species of fish studied in the Mediterranean sea and Northeast the Mediterranean sea. The liver is also an active site of pathological effects. The studies of fish according to Frazli *et al*. (2009) and Kalay and Canli (2000) [18] it was also known that adoption of cadmium from the gills or gastrointestinal tract mainly pile up in the liver and kidney.

Table 1 shows that the lead mean concentration in the tissue of *Trachurus murphyi* fish species range between 0.87±0.60 mgkg-1 and 9.71±0.97 mgkg-1 as indicated in the liver and bone tissue respectively and the lead concentration in *Clupea harengus* fish species as shown in table 4.2 range between 2.36 ±0.26 mgkg-1 in the gills and 8.66±1.14 mgkg-1 in the muscle respectively. Lead concentration in the case of *Trachurus murphyi* and *Clupea harengus* was highly recorded in the bone tissue with concentration of 9.71± 0.97 mgkg-1 *Trachurus murphyi* and 8.66±1.14 mgkg-1 in the muscle of *Clupea harengus* fish species, comparing the level of lead concentration in *Trachurus murphyi* bones is higher than the lead concentration in muscles of *Clupea harengus* fish species.

This shows that *Trachurus murphyi* sold in Anyigba is contaminated with lead than the *Clupea harengus* species and this may be as a result of the contamination from their sources. Table 1 and Table 2 has shown that bones and muscles tissue of *Trachurus murphyi* and *Clupea harengus* has the highest concentration of lead 9.71±0.97 mgkg-1 and 8.66±1.14 mgkg-1 respectively. This result is in contrast with the study done by Asante *et al*. (2014) which reported that inactive tissues such as muscles and bones of fish lack the ability to store heavy metals to such level that can reflect the metal concentration of the environment. Noik Hasyimah *et al*. (2011) [24], according to the study, injection of lead and other metals happens through oral routes by eating, drinking and absorption by gills or skin before moving to other parts of the body, this part are often called target organs where bio accumulation of lead can occur in the face of mucus and metallothionein protein. Lead has been grouped among the most heavy metals which its biochemical importance to animals and humans have not been known yet (Singh *et al*., 2007) [28].

According to El-Ghasham *et al*. (2008) [13], Lead threat to human health is on the increase on the daily bases both children and adult are seriously threatened by heavy lead presence in our water and soil due to some anthropogenic activities. Lead is capable of inciting the oxidative damage to brain, heart, kidneys and reproductive organs. The recent epidemiology and toxicological research have indicated that disease such as hypertension, cognitive impairment and neurodegenerative disease (FAO, 2003) [14]. The metal concentration of lead in *Trachurus murphyi* and *Clupea harengus* is below the lead reported from Scomber scombrus frozen fish species sold in Nigeria; a case study in Zaria metropolis (Abdullahi *et al*., 2015) [1].

According to the result shown in Table 1, nickel concentrations in the tissue of *Trachurus murphyi* fish species ranges from 0.27±0.01 mgkg-1 and 1.23±0.05 mgkg-1 as indicated for the bone and liver respectively, and 0.11±0.01 mgkg-1 and 0.93±0.02 mgkg-1 as indicated for bone and liver of *Clupea harengus* in table (4.2) respectively. Liver tissues of *Trachurus murphyi* in Table 1 shows higher level of nickel accumulation (1.23 mgkg-1) compared to other parts examined. The high level of nickel may be attributed to the high coordination of metallothionein protein with nickel (Uzairu *et al*., 2009) [32] and also the liver is the principal organ responsible for the detoxification, transportation and storage of toxic substances (Uzairu *et al*., 2009) [32] whereas, the low level of nickel in the bone tissues of *Trachurus murphyi* fish species assessed in this study, is far below the level of nickel in the bones of Scomber scombrus fish species gotten from Russia and Europe; 6.767 mgkg-1 and 8.167 mgkg-1 respectively (Abdullahi *et al*., 2015) [1]. On the other hand, *Trachurus murphyi* liver possesses higher concentration of Nickel (1.23 mgkg-1) while the bone possesses lower concentration (0.27 mgkg-1) and liver of *Clupea harengus* also possesses higher concentration of nickel in liver (0.93 mgkg-1 and bone accumulated lesser nickel (0.11 mgkg-1).

Mercury is a natural occurring metallic element, which can be present in food stuffs by natural phenomenon. Fish ingests contaminated metallic food which passes through the gastrointestinal tract and get distributed, accumulated or detoxified by the liver (Mieiro *et al*., 2011) [23]. The concentration of mercury level range from 1.01 mgkg-1 to 2.46 mgkg-1 in muscle and liver of *Trachurus murphyi* respectively as shown in table (4.1), while *Clupea harengus* ranges from 0.06 mgkg-1 to 1.34 mgkg-1 in muscle and liver respectively in Table 2. This metal is absorbed by the gills and carried by the bloodstream to the liver where it is detoxified as bile before it gets to the flesh (Romeo *et al*., 1999). *Trachurus murphyi* fish recorded the highest concentration of Hg in liver (2.46 mgkg-1) of the two fish species examined, whereas, *Clupea harengus* had the lowest concentration in muscle (0.06 mgkg-1).

The cancer risks which are associated with exposure to a measured dose of chemical pollutants can be estimated using the incremental lifetime cancer risk (ILCR). According to Li and Zhang (2010) [21], the latter is the incremental probability of an individual developing any kind of cancer over a lifetime due to a 24hour/day carcinogenic exposure to a given daily dose of a chemical for 70 years. One in a million (1 10-6) cancer risk means that if a million people are exposed, one additional cancer case would be expected. The US EPA cancer risk considered as acceptable for regulatory purposes is within the range of 1 10-6 to 1 10-4 (Li *et al*., 2014) [20].

From Table 7, the cancer risk pose by cadmium in *Trachurus murphyi* liver examined (4.1 10-1) which has the highest level of cancer risk in *Trachurus murphyi*, is above the accepted level for regulatory purpose (Parsa, 2012). While 8.9 10-1 of Cd in the muscle of *Trachurus murphyi* is the lowest which is still higher compared to the minimum level of cancer risk (as recommended by United States Environmental Protection Agency; US EPA), 1 10-4 (Li *et al*., 2014) [20]. Also from the same Table 7, the cancer risk pose by Nickel in *Trachurus murphyi* bone (1.1 10-1) is the highest level of cancer risk, while 2.9 10-2 in the muscle is the lowest which is still higher than the recommended level by US EPA. From table (4.8), the cancer risk posed by Cadmium in *Clupea harengus* liver examined (1.1 100) which is the highest level of cancer risk in *Clupea harengus* parts is above the minimum accepted level, while 1.5 10-1 of Cd in bone of *Clupea harengus* is the lowest which is still higher compared to the minimum level of cancer risk (as recommended by US EPA), 1 10-4. Table (4.8) also shows the cancer risk posed by Nickel in *Clupea harengus* liver (3.7 10-2) is the highest level of cancer risk, While 4.3 10-3 in the bone is the lowest which is still higher than the acceptable level by the US EPA.

Conclusion

In this study, human health risk assessment with respect to contamination by heavy metals (Cd, Pb, Hg, Cu and Ni) in frozen *Trachurus murphyi* and *Clupea harengus* fish species sold in Anyigba main market Kogi State, Nigeria was evaluated. Result showed that the risk for human exposure to heavy metal contamination through fish consumption was significant. The two fish species studied varied greatly in terms of the amount of heavy metal concentration present in the various tissues examined. The heavy metal residues in the tissues of both species exhibited different methods of accumulation and distribution among the selected tissue parts.

Since the levels of the studied heavy metals in all the analyzed tissues were above their corresponding permissible limits recommended by FAO/WHO, the health risk from consumption of fish tissues shows that the chance of exposure were higher for copper and lead than mercury, cadmium and less with nickel. However, individuals consuming fish gill, bone, muscle, and livers, may face considerable risk from ingestion of toxic metals at unacceptable concentrations. Finally, this work may provide valuable database for continuing research on frozen fish in Nigeria.

References

1. Abdullahi A, Uzairu A, Ekwumemgbo PA, Oluwole JO. Risk Assessment of Heavy Metals in Frozen Fish Scomber scombrus species sold in Nigeria: case study in Zaria Metropolis. Advances in Toxicology; c2015. p. 1-11. http://doi.org/10.1155/2015/303245
2. Aremu MO, Atolaiye BO, Shagye D, Moumouni A. Determination of trace metals in Tilapia zilli and Clarias lazera fishes associated with water and soil sediment from River Nasarawa in Nasarawa State, Nigeria, India J Multi. Res. 2007;3(1):159-168.
3. Asante F, Agbeko E, Addae G, Quainoo AK. Bioaccumulation of heavy metals in water, sediments and tissues of some selected fishes from the Red Volta, Nangodi in the upper east region of Ghana. British Journal of Applied Science & Technology. 2014;4(4):594-603.
4. Bashir FH, Othman MS, Mazlan AG, Rahim SM, Simon KD. Heavy metal concentration in fishes from the coastal waters of Kapar and Mersing, Malaysia. Turkish Journal of Fisheries and Aquatic Sciences. 2013;13(2):375-382. http://doi.org/10.4194/1303-2712-vi3_2_21
5. Bassey OB, Chukwu LO. Health Risk Assessment of Heavy Metals in Fish (Chrysichthys nigrodigitatus) from Two Lagoons in Southwestern Nigeria. Journal of Toxicology and Risk Assessment. 2019;5(2):27. DOI: 10.23937/2572-4061.1510027
6. Canpolat O. The Determinatin of Some Heavy Metals and Minerals in the Tissues and Organs of the Capoetaumbla Fish Species in Relating to Body Size, Sex, and Age. 2013;22:64-72.
7. Copat C, Arena G, Fiore M. Heavy metals concentrations in fish and shellfish from eastern Mediterranean Sea: consumption advisories. Food and Chemical Toxicology. 2013;53:33-37.
8. Davis AP, Shokouhian M, Ni S. Loading estimates of lead, copper, cadmium and zinc in urban runoff from specific sources. Chemosphere. 2001;44(5):997-1009.
9. Diop M, Net S, Michael H, Lencel P, Watier D, Grard T, *et al*. Concentrations and potential human health risks of trace metals (Cd, Pb, Hg) and selected organic pollutants (PAHs, PCBs) in fish and seafood from the Senegalese coast. International Journal of Environmental Research. 2017;11(3):349-358.
10. Egbeja TI, Onoja AO, Kadiri JU, Samson MO. Assessment of heavy metals in tissues of dried Clarias gariepinus and Oreochromis niloticus purchased from Anyigba major market, Kogi state, Nigeria. International Journal of Fisheries and Aquatic Studies. 2019;7(5):14-18.
11. Egbeja TI, Olubiyo CK, Olubiyo GT. Assessment of heavy metals and physic chemical parameters in water from Kpata River, Lokoja, Nigeria. International Journal of Applied Research. 2021;7(5):237-240.
12. Ekpo KE, Asia IO, Amayo KO, Jegede DA. Determination of lead cadmium and mercury in surrounding water and organs of some species of fish from Ikpob river in Benin city, Nigeria. International Journal of Physical Sciences. 2008;3(11):289–292.
13. El-Ghasham A, Mehanna EE, Abdel-Reheem M. Evaluation of lead and cadmium levels in fresh water fish farms at Qassim region, Journal of Agricultural and Veterinary Sciences. 2008;1(2):59-77.
14. FAO. Heavy Metals Regulations: Part 1. Legal Notice, 2003, 66. http://www.faolex.fao.org/docs/pdf/eri42405.pdf
15. Fazli H, Zhang CI, Hay DE, Lee CW. Stock assessment and management implications of anchovy kilka (Clupeonella engrauliformis) in Iranian waters of the Caspian Sea," Fisheries Research. 2009;100(2):103-108.
16. Ghosh M, Singh SP. Review on phytoremediation of heavy metals and utilization of its byproducts: Applied Ecology Research. 2005;3(1):1-18.
17. Gonzalez MI, Mende-Arementa. Heavy metals: Implication associated to fish consumption. Environmental Toxicology and Pharmacology. 2008;26(3):263-71.
18. Kalay M, Canli M. Elimination of essential (Cu and Zn) and non-essential (Cd and Pb) metals from tissues of a fresh water fish, Tilapia zillii," Tropical Journal of Zoology. 2000;24(1):429–436.
19. Khayatzadeh J, Abbasi E. The Effects of Heavy Metals on Aquatic Animals. The 1st International Applied Geological Congress, Department of Geology, Islamic Azad University - Mashad Branch, Iran, 26-28 April 2010.
20. Li Z, Ma Z, Kuijp TJ, Yuan Z, Huang L. A review of soil heavy metal pollution from mines in China: pollution and health risk assessment. Science of the Total Environment, 2014, 486-469.
21. Li S, Zhang Q. Risk assessment and seasonal variations of dissolved trace elements and heavy metals in the Upper Han River, China, Journal of Hazardous Materials. 2010;181(1-3):1051-1058. doi:10.1016/j.jhazmat.2010.05.120
22. Matouke MM, Abdullahi KL. Assessment of Heavy Metals Contamination and Human Health Risk in Clarias gariepinus [Burchell, 1822] Collected From Jabi Lake, Abuja, Nigeria. Scientific African Journal. 2020. https://doi.org/10.1016/j.sciaf.2020. e00292.

23. Mieiro CL, Pereira ME, Duarte AC, Pacheco M. Brain as a critical target of mercury in environmentally exposed fish (Dicentrarchus labrax)-bioaccumulation and oxidative stress profiles, Aquatic Toxicology. 2011;103(3-4): 233–240.
24. Noik Hasyimah AK, James Noik V, Teh YY, Lee CY, PearlineNg HC. Assessment of cadmium (Cd) and lead (Pb) levels in commercial marine fish organs between wet markets and supermarkets in KlangValley, Malaysia, International Food Research Journal. 2011;18:795-802.
25. Nordberg GF, Fowler BA, Nordberg M, Friberg LT. Handbook on the toxicology of metals, 3rd edition Academic Press. 2007.
26. Parsa N. Environmental factors inducing human cancers. Iranian Iran J. Public Health. 201241:1.
27. Roméo M, Siau Y, Sidoumoun Z, Gnassia-Barelli M. Heavy metal distribution in different fish species from the Mauritania coast. Science of the Total Environment. 1999;232:169-175.
28. Singh RK, Chavan SL, Sapkale PH. Heavy metal concentrations in water, sediments and body tissues. 2007;129:471-481.
29. Sprocati AR, Alisi C, Segre L, Tasso F, Galletti M, Cremisini C. Investigating heavy metal resistance, bioaccumulation and metabolic profile of a metallophile microbial consortium native to an abandoned mine. Journal of Science Total Environment. 2006;366:649-658.
30. Storelli MMA, Storelli R, Dddabbo C, Marano R, Bruno, Marcotrigiano GO. Heavy elements in loggerhead turtles (Caretta caretta) from the eastern Mediterranean Sea, overview and evaluation. Environmental Pollution. 2005;135:163-170.
31. Tay CK, Dorleku M, Doamekpor LK. West African Journal of Applied Ecology. 2019;27(1):23-41.
32. Uzairu A, Harrison GFS, Balarabe ML, Nnaji JC. Concentration levels of trace metals in fish and sediment from Kubanni River, Northern Nigeria. Bulletin of the Chemical Society of Ethiopia. 2009;23(1):9-17.
33. Yahya AN, Mohamed SK, Mohamed AG. Environmental Pollution by Heavy Metals in the Aquatic Ecosystems of Egypt. Open Access Journal of Toxicology, 2018, 3(1). OAJT.MS.ID.555603 DOI: 10.19080/OAJT.2018.03.555603
34. Yazkan MO. Zedemir F, Golukcu M. Cu, Zn, Pb and Cd content in some fish species caught in the Gulf of Antalya, Turkish Journal of Veterinary and Animal Sciences. 2002;26(6):1309-1313.