

Assessment of Heavy Metals in Some Marine Fish Species Relevant to their Concentration in Water and Sediment from Coastal Waters of Ondo State, Nigeria

Olusola JO* and Festus AA

Department of Chemistry, Federal University of Technology, Akure, Nigeria

Abstract

Due to oil exploration activities and urbanization as well as continuous industrial and agricultural growth in Ondo State, Nigeria. The coastal water has been heavily impacted by a number of pollutants originating from different sources including heavy metals. This investigation assessed and monitored accumulation levels of (Cr, Cd, Pb, Cu, Zn, and Ni) in different organs (Gill, Head, Bone, Muscle and Eye) of five fish species (*Pentanemus quinquarius*, *Pseudotolithus senegalensis*, *Trichirus lepturus*, *Plectorhynchus mediterraneus* and *Pseudotolithus typus* together with water and sediment collected from the ocean shoreline in the coastal waters of Ondo State, Nigeria. Heavy metals concentrations in fish tissues, water and sediment samples were analyzed after treatment using atomic absorption spectrophotometer. Dissolve total metal in water (in mg/l) Zn 0.12-0.22 , Cu 0.26-0.27 and Ni BDL-0.01 recorded in the water samples in this study were low and within the maximum permissible level (MPL) recommended by WHO and USEPA, while higher concentrations above the MPL were recorded for Cr 0.31-0.34 Cd 0.08 -0.21 and Pb 0.57-0.79. The concentrations of these metals in sediment (in mg/kg) were in the range Cr (0.16-4.19, Cd 0.35-0.38, Pb 0.9-1.00, Cu 0.24-1.44, Zn 2.12-3.11 and Ni BDL-0.01. They are all lower than their probable effect concentrations (PEC) in sediment. Mean Concentrations of the heavy metals in fish species were of the order: Zn>Cu>Cr>Cd>Pb>Ni. Levels of heavy metals varied depending on different tissues in the fish species. Correspondingly, high concentrations of the metals were found in gills and eye compared to other tissues. While the concentration of Zn (0.34 mg/kg-1.29 mg/kg), Cu (BDL-1.88 mg/kg), Ni (BDL-0.01 mg/kg) , and Cr (BDL-1.28) in the fish tissues were within the maximum allowable level (MAL) for a food source, the findings of this study shows higher value above the allowable limit for Cd(BDL-1.14 mg/kg) and Pb (BDL-0.71 mg/kg), thus constituting potential health hazard to consumers of these fish species.

Keywords: Heavy metals; Fish; Sediment; Concentration factor; Coastal water

Introduction

The aquatic environment with its water quality is considered the main factor controlling the state of health and diseases in both cultured and wild fishes. Pollution of heavy metals in aquatic ecosystem is growing at an alarming rate and has become an important worldwide problem [1]. Increase in population, urbanization, industrialization and agricultural practices have further aggravated the situation [2]. As heavy metal cannot be degraded, they are deposited, assimilated or incorporated in water, sediments and aquatic animals and thus causing heavy metal pollution in water bodies [1]. Therefore, heavy metals can be bio accumulated and biomagnified via the food chain and finally assimilated by human consumers resulting in health risks [3]. As a consequence, fish are often used as indicators of heavy metals contamination in the aquatic ecosystem because they occupy high trophic levels and are important food sources [4]. Fishes are major part of the human diet and it is therefore not surprising that numerous studies have been carried out on metal pollution in different species of edible fish [5,6]. Predominantly, fish toxicological and environmental studies have prompted interest in the determination of toxic elements in seafood [7]. Analyzing pollutant in living organisms is more attractive and promising than analyzing pollutants of the abiotic environment, as living organisms provide precise information about the bioavailability of pollutants [8]. This may assist in predicting pollutants transfer exposure and its possible health consequence to humans. In addition, such information is crucial in making accurate risk assessment for seafood safety purposes. Report has shown that heavy metals have the tendency to accumulate in various organs of marine organisms, especially fish, which in turn may enter into the

human metabolism through consumption causing serious health hazards [9]. In many cases, industry has main role in environmental crises especially in civil and energy projects. For example, more than 60 percent of annual greenhouse gas emissions are related to the industrial activities in the world (transportation fuels and distribution 25.3%, power stations 21.3%, industrial process 16.8%). Ondo State coastal water is a brackish water body located in southwestern Nigeria. The water is used by the local community for various purposes including fishery. Water and sediment quality within this coastal waters are increasingly polluted with contaminants especially heavy metals coming from oil spill from shell and chevron companies, sewage and run off-off from agricultural land [10]. Hence the main issue arises on whether the concentration of pollutants in the waters body represents a risk to human and aquatic biota. Generally, in environment field and related science, most previous studies have been carried out using classical methods and only the ways to deal with industrial pollution have been investigated. Researches about deal with challenges and using of new technologies have not been fully dealt with. However,

*Corresponding author: Olusola JO, Department of Chemistry, Federal University of Technology, Akure, Nigeria, Tel: +2348066447549; E-mail: layinkx@gmail.com, demolakt@yahoo.co.uk

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valipour et al used environmental flow diagram to identify pollutants of industrial units, the source of production, transmission and conversion processes, and the recipient thus, making decision about environmental pollution simple. The present study is undertaken to investigate the bioaccumulation potential of six selected heavy metals viz. Cadmium, Copper, Chromium, Nickel, Lead and Zinc in different tissues of the selected fish species, *Pentanemus quinquarius*, *Pseudotolithus senegalensis*, *Trichirus lepturus*, *Plectorhynchus mediterraneus* and *Pseudotolithus typus* from the coastal waters with associated water and sediment samples.

Materials and Methods

Study area

The coastal waters in Ilaje local government area is one of the largest water bodies in ondo state, Nigeria. The research was carried out in the Atlantic Ocean shoreline from the coastal waters in Ilaje local government area. The Local Government Area lies between longitudes 6°12'E and 6°30'E of the Greenwich Meridian and between latitudes 4°10'N and 4°6'N of the Equator. It is bounded in the West by Ogun State, in the East by Irele Local Government Area and Edo State, in the North by Okitipupa Local Government Area and in the South by Bight of Benin and Atlantic Ocean (Figure 1). Due to oil exploration activities and urbanization as well as continuous industrial and agricultural growth in Ondo State, Nigeria. The coastal water has been heavily impacted by a number of pollutants originating from different sources including heavy metals. Such contamination must be an important issue regarding the health of the aquatic ecosystem and its animals and in turn, to human's health.

Sampling and sample analysis

Water and sediment samples were collected from randomly selected three sub location in each main location of the ocean shore

line. Water samples were taken into pre-acid washed polyethene bottles. The water sample were acidified to a pH of less than 2 by adding 2 ml of analar grade conc. HNO₃ and kept in the refrigerator prior to analysis. Representative water sample (100 ml) from the three sub locations in each main location were digested by standard procedure. The concentrations of metals in each sample were determined against those of the blank and standard solutions using Buck scientific AAS. The sediment sample taken concurrently from the bottom surface using a sediment samples from the randomly selected three sub locations of each of the selected location were transported to the laboratory in a polythene bag that has been previously washed and leached with acid, and subsampled to obtain a representative sample for each location. The sediment was drained and kept in safe place for air drying prior to analysis. The air dried samples were ground and sieved through 2 mm aperture. Digestion of sediment samples was carried out by procedure described by Hulya [5]. Heavy metals in sediment sample was analyze using Atomic Absorption Spectrophotometer (AAS) Buck scientific model, 200A. Five to seven pieces each of (*Pentanemus quinquarius*, *Pseudotolithus senegalensis*, *Trichirus lepturus*, *Plectorhynchus mediterraneus* and *Pseudotolithus typus*.) were caught from the water bodies with the assistance of local fisher men. The samples were transported to the laboratory, where the scales were removed where applicable, rinsed with distilled water to remove any adhering substance and each fish separated into eye, head, gills, bones and muscles with dissecting knife. The different fish organs were then separately oven-dried at 105 ± 2°C in a Gallenkamp moisture extraction oven until constant weight was obtained and then ground into powder. Extraction of metals from the fish samples was by mixed acid digestion. Heavy metal concentrations in water samples were determined having digested the samples in accordance with the standard procedure established by Parker [11]. The water samples (100 ml) were digested on a hot plate with the addition of 10 ml concentrated nitric acid. The solution was heated to almost dryness and the residue dissolved with 10% HNO₃. The resulting solution was filtered through Whatman number 1 filter paper into 50 ml standard flask and solution made to the mark. The concentrations of metals in each sample were determined against those of the blank and standard solutions using Buck scientific AAS. The sediment samples were air dried ground and sieved through 2 mm aperture. About two grams of the sediment sample in each case were put into 250 ml beaker and digested with 20 ml of mixed hydrochloric acid and nitric acid in the ratio 3:1 and 2 ml 35% H₂O₂ on hot plate in a fume cupboard for 2 hours [5]. On cooling, the digest was filtered into 50 ml standard flask and made to the mark with distilled water. The resultant solution was analyzed for heavy metals using Atomic Absorption Spectrophotometer (AAS) Buck scientific model, 200 A. Samples of various organs ranging from 0.5 g to 1.09 g were accurately weighed and digested using 10 ml of 65% HNO₃, 5 ml of 37% HCl and 2 ml of 35% H₂O₂ at 80 ± 50°C in a fume chamber until colorless liquid was obtained [12]. The solutions were allowed to cool at room temperature, filtered into a 50 ml standard flask. The filtrate obtained was made up to 50 ml mark with distilled water and used for heavy metals determination against those of the blank and calibration standards using Atomic absorption spectrophotometer, Buck Scientific model.

Result and Discussion

Heavy metal levels in water

Mean concentration and standard deviation of heavy metals level (mg/L) in the two sampled locations are presented in Table 1. The result were compare with federal ministry of Environment

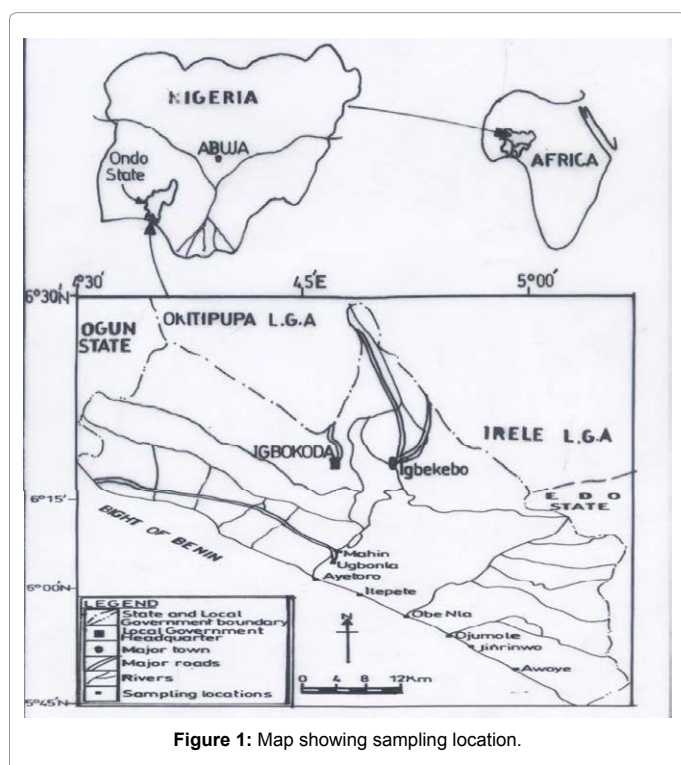


Figure 1: Map showing sampling location.

Metals	Ocean shore L1	Ocean shore L2	USEPA Value	FME Limit	WHO
Cr	0.34 ± 0.001 ^a	0.31 ± 0.001 ^a	0.1	0.02-2.0	0.05
Cd	0.08 ± 0.016 ^b	0.21 ± 0.014 ^a	0.005	0.0002-0.0018	0.003
Pb	0.79 ± 0.001 ^a	0.57 ± 0.142 ^b	0.015(Action level)	0.001	0.01
Cu	0.27 ± 0.018 ^a	0.26 ± 0.001 ^a	1	2.0-4.0	2
Zn	0.22 ± 0.001 ^a	0.12 ± 0.001 ^b	2	50	3
Ni	0.01 ± 0.001 ^a	0.01 ± 0.001 ^a	-	0.0017	0.02

Data are mean of duplicate (2) determination. BDL: Below instrument detection limit. Letters a and b show differences among the different locations. Data shown with different letters are statistically different at P<0.05 level.

Table 1: Mean Concentration of heavy metals in the present studies and some international standard.

water standards for aquatic life fresh (FWA), USEPA and World Health Organization standard for permissible limit of heavy metals in water [13,14]. Heavy metal pollution in the marine environment is determined by measuring its concentration in water, sediment and living organisms. Levels of dissolved metals in water from the two main sampled locations at the Ocean shore line are presented in Table 1. No significant location-related differences were seen with respect to the levels of Cr, Cu and Ni in water. Metals concentrations in water were found in the following order: Pb > Cr > Cu > Zn > Cd > Ni in Location1, whereas they follow the order of Pb > Cu > Cr > Cd > Zn > Ni in Location 2. Of the six metals monitored, Pb and Cr were the most abundant. High concentration of Pb (0.57-0.79 mg/l) observed in the water may be associated to deposit of air born particulate matter as well as spill from fishing boat used as means of transportation. The mean concentrations of the metals in the coastal water were compared with guideline values recommended by USEPA and FME Table 1, Showed compliance with Cu, Zn and Ni, while Cr (0.31-0.34 mg/l) Cd (0.08-0.21 mg/l) and Pb (0.57-0.79 mg/l) were higher than the permissible recommended limits. Similar observation was made with the federal ministry of Environment water standards for aquatic life to which the metal Cr, Cd and Pb were also higher [15]. It is expected that the equilibrium of analyte between particular environmental components depend on the critical parameters responsible for kinetic processes that lead to this state. For the studied system the critic parameter should be as ordered as follows: the composition and physicochemical properties of neighboring rivers flowing into the coastal waters, type of the floated soil/sediment forming bottom sediment, current of flowing streams/rivers, seasonal parameters, and biological ability of particular environmental components for concentration of heavy metals.

Heavy metal levels in sediment

The mean results and standard deviation of heavy metals (mg/kg) in sediment samples from the two sampled locations are presented in Table 2. The results were compared with probable effect concentration of heavy metals in sediment as propose by McDonald et al., [16]. Sediments are essential component of aquatic ecosystem acting as carriers sink and potential sources of contaminants [17]. Heavy metals contamination in sediment can affect the water quality and bioaccumulation of metals in aquatic organisms, resulting in potential long term implication on human health and ecosystem [18]. The mean concentration of heavy metals in sediment has been found to reflect the degree of pollution in an area. The mean results of heavy metals recorded in sediment samples taken from the two sampled locations are presented in Table 2. Total metal concentrations of the bottom sediment varied slightly between the sampled locations especially in the values of Cr, Zn and Cu, but no significant differences (P<0.05)

were observed in Pb, Cd and Ni concentration among the two locations studied. The value of Cr (0.02-4.19 mg/kg) and Zn (2.12- 3.11 mg/kg) was higher than those of other metals, while Ni remained within a relatively narrow range from BDL to 0.01 mg/kg. Cd and Pb were found to share a trend in their level at the two locations. The level of Cd and Pb in sediment of the coastal water could be attributed to industrial and agricultural discharges as well as from possible spill of petrol from fishing boat over the year. High level of metal at the Ocean shoreline could also be attributed to changes in velocity within the ocean which may lead to abundance of heavy metal at the ocean shoreline. Although the pH value of the sediment was not carried out, it has been show from literature that heavy metal are more accumulated in sediments with high pH value, which is one of the characteristics of the coastal water [10]. The order of abundance of these metals in sediments from the two locations were Cr> Zn > Cu > Pb > Cd > Ni (Table 3). Concentration of some metals investigated in the sediment were similar to those reported for River Orogodo in Delta State [17], but were lower compared to previous study on Ondo State Coastal Water (Tables 4a-4e) [18] and those reported for some communities in Ilaje local government area of Ondo State (Table 4.4) [10]. The difference in heavy metals concentrations in sediment may be attributed to seasonal variation due to sampling periods. Also, the constituents of sediment dictate their ability to concentrate heavy metals. Report has shown that

Metals	Ocean shore L1	Ocean shore L 2	PEC*
Cr	0.02 ± 0.001 ^b	4.19 ± 0.038 ^a	111
Cd	0.35 ± 0.021 ^a	0.38 ± 0.025 ^a	5
Pb	0.95 ± 0.023 ^a	1.00 ± 0.025 ^a	128
Cu	0.24 ± 0.007 ^b	1.44 ± 0.028 ^a	149
Zn	3.11 ± 0.110 ^a	2.12 ± 0.035 ^b	159
Ni	0.01 ± 0.003 ^a	0.01 ± 0.007 ^a	-----

Data are mean of duplicate (2) determinations. BDL: Below instrument detection limit.

Letters a and b show differences among the different locations. Data shown with different letters are statistically different at P<0.05 level.

*PEC- Probable effect concentration *L1 - Location One *L2 - Location Two

Table 2: Mean results and standard deviation of heavy metals (mg/kg) in sediment samples from the two sampled locations.

Metal	Present Study	Ondo Coastal water	Ilaje LGA	River Orogodo
Cr	0.02–4.19	9.20–21.20	2.01– 44.09	0.30–0.32
Cd	0.35–0.38	4.10–13.10	0.01–2.99	0.10 - 0.27
Pb	0.95–1.00	1.20–10.10	10.00 -32.06	0.30–0.84
Cu	0.24–1.44	3.20–21.40	1004–2879	0.20–0.84
Zn	2.12–3.11	4.00–26.70	0.02- 0.29	1.20–1.91
Ni	0.01	7.50–38.60	3.40–5.90	0.60–0.65

Table 3: Comparison of heavy metal levels (mg/kg) in Sediment of current and previous studies.

Metal	Muscle	Head	Eye	Gill	Bone	Overall mean
Cr	BDL	BDL	0.48 ^c	1.19 ^a	0.35 ^b	0.4
Cd	0.33 ^b	BDL	0.39 ^b	1.07 ^b	0.33 ^a	0.42
Pb	0.09 ^c	BDL	0.03 ^d	0.18 ^a	0.11 ^b	0.08
Cu	BDL	BDL	BDL	1.86 ^a	0.56 ^a	0.48
Zn	0.25 ^c	0.37 ^b	0.43 ^b	0.01 ^d	0.35 ^a	0.28
Ni	BDL	BDL	0.01 ^b	0.01 ^b	BDL	<0.01

Data are mean of replicate (2) determinations. BDL: Below instrument detection limit. Letters a, b, c and d show differences among the different tissues. Data shown with different letters are statistically different at P<0.05 level.

Table 4a: Level of heavy metal in *Trichurus lepturus* organs (mg/kg).

Metal	Muscle	Head	Eye	Gill	Bone	Overall mean
Cr	BDL	0.32 ^c	0.35 ^b	0.49 ^a	0.35 ^b	0.3
Cd	BDL	0.21 ^c	0.33 ^b	0.48 ^a	0.32 ^b	0.27
Pb	0.09 ^c	0.20 ^a	0.20 ^a	0.15 ^b	0.12 ^c	0.15
Cu	BDL	BDL	BDL	0.87 ^a	0.59 ^b	0.29
Zn	0.34 ^d	0.38 ^c	0.38 ^{bc}	0.51 ^a	0.10 ^b	0.4
Ni	BDL	0.02 ^d	0.04 ^d	0.03 ^d	BDL	0.02

Data are mean of replicate (2) determinations. BDL: Below instrument detection limit. Letters a, b, c, and d show differences among the different tissues. Data shown with different letters are statistically different at P<0.05 level.

Table 4b: Level of heavy metal in *Pentanemius guigarius* organs (mg/kg).

Metals	Muscle	Head	Eye	Gill	Bone	Overall mean
Cr	BDL	0.37 ^c	0.62 ^b	1.28 ^a	0.38 ^c	0.53
Cd	BDL	0.26 ^c	0.49 ^b	1.14 ^a	0.32 ^c	0.44
Pb	0.10 ^e	0.34 ^b	0.14 ^c	0.40 ^a	0.11 ^d	0.22
Cu	0.58 ^b	BDL	BDL	1.88 ^a	0.59 ^b	0.61
Zn	0.35 ^c	0.36 ^c	0.65 ^b	1.29 ^a	0.39 ^c	0.61
Ni	BDL	0.01 ^d	0.01 ^d	0.05 ^d	BDL	0.01

Data are mean of replicate (2) determinations BDL: Below instrument detection limit. Letters a, b, c, and d show differences among the different tissues. Data shown with different letters are statistically different at P<0.05 level.

Table 4c: Level of heavy metal in *Pseudotolithus senegalensis* organs (mg/kg).

Metal	Muscle	Head	Eye	Gill	Bone	Overall mean
Cr	BDL	0.26 ^c	0.32 ^b	0.86 ^c	0.38 ^b	0.38
Cd	BDL	0.27 ^b	0.29 ^b	0.81 ^a	0.31 ^b	0.34
Pb	0.10 ^a	0.71 ^a	0.04 ^a	0.27 ^a	0.12 ^a	0.28
Cu	0.46 ^b	0.38 ^b	0.39 ^b	0.94 ^a	0.39 ^b	0.51
Zn	0.36 ^b	0.38 ^b	0.39 ^b	0.94 ^a	0.39 ^b	0.49
Ni	0.02 ^c	0.12 ^b	0.08 ^c	0.07 ^c	0.02 ^c	0.06

Data are mean of replicate (2) determinations. BDL: Below instrument detection limit. Letters a, b, c, and d show differences among the different tissues. Data shown with different letters are statistically different at P<0.05 level.

Table 4d: Level of heavy metal in *Pseudotolithus typus* organs (mg/kg).

Metal	Muscle	Head	Eye	Gill	Bone	Overall mean
Cr	0.36 ^c	0.23 ^d	0.37 ^{ab}	0.37 ^{bc}	0.37 ^a	0.34
Cd	0.31 ^b	0.28 ^d	0.30 ^c	0.32 ^a	0.32 ^b	0.32
Pb	0.07 ^c	0.16 ^a	0.01 ^d	0.12 ^b	0.11 ^b	0.09
Cu	BDL	BDL	BDL	0.62 ^a	0.59 ^a	0.24
Zn	0.36 ^d	0.38 ^c	0.39 ^b	0.42 ^a	0.38 ^b	0.39
Ni	BDL	0.01 ^c	0.04 ^c	BDL	0.01 ^c	0.01

Data are mean of replicate (2) determinations. BDL: Below instrument detection limit. Letters a, b, bc, and c show differences among the different tissues. Data shown with different letters are statistically different at P< 0.05 level.

Table 4e: Level of heavy metal in *Plectorhynchus mediterraneus* organs (mg/kg).

sediments containing more sand and lower values of organic matter exhibit low metals enrichment. Also, the concentration of heavy metals in sediment increases as the amount of organic material increases [19]. It has also been reported that metals such as Cd, Cu, Pb and Zn have high tendency to binding tenaciously to organic matter contained in the soil, sediment and suspended particles within the water column, while sediment with high clay content has ability to concentrate most heavy metals compared to others such as carbonate which are selective [20,21]. Therefore the variation in heavy metals in the sediment samples analyzed may be due in part to contribution from these factors. By comparing the concentrations of heavy metals analyzed in the water and sediments samples, it can be concluded that heavy metals are highly

accumulated in sediments than water corroborating what has earlier been reported that sediments act as reservoir for all contaminants and dead organic matter [17,22]. Probable effect concentrations (PEC) of sediments metal levels Pb 128, Cd 5, Cr 111, Cu 149, Zn 159 (mg /kg) has been proposed by McDonald et al. [16]. The results of the present study show that the concentrations of Cd, Cu, Cr, Pb and Zn in the sediment samples were much below the probable effect concentration of sediment metals levels. Above this level, metals may have adverse effects on sediment dwelling organisms [16].

Heavy metal concentration in fish

Mean concentrations of chromium, cadmium, lead, copper, zinc and nickel in muscle, head, gill, eye and bone of *Pentanemius quinquarius*, *Pseudotolithus senegalensis*, *Trichirus lepturus*, *Plectorhynchus mediterraneus* and *Pseudotolithus typus* from the coastal waters are shown in Tables 4 (a-e). Measure concentration of the six tested metals in the muscle, gill, eye, bone and head of the five fish species (*Pentanemius quinquarius*, *Pseudotolithus senegalensis*, *Trichirus lepturus*, *Plectorhynchus mediterraneus* and *Pseudotolithus typus*) under investigation are presented in Tables 4a-e. Zinc was the most abundant in all the examined tissues. Tissues specific comparison of the accumulation of the investigated metals showed that the metals concentration were significantly high in the gill tissues compared to the muscle tissues. Jobling [23] attributed the high accumulation of heavy metals in gills tissues to the metallothionein proteins which are synthesized in liver and gills tissues when fishes are exposed to heavy metals and detoxify them. These proteins are thought to play an important role in protecting them from damage by heavy metal toxicants. Also, gills are the site directly exposed to the ambient conditions and also are known for their excretory function [24]. Chromium, copper and Zinc are essential element and are regulated by physiological mechanisms in most organism. However, occurrence of excessive levels of them is regarded as potential hazard which can endanger both animal and human health [25]. The level of these essential metals Cr, Cu and Zn in the muscle, gill, bone, eye and head are presented in Tables 4a-4e. Cr was not detected in the muscle of all examined fish species except *Plectorhynchus mediterraneus* (0.36 mg/kg) this may be associated to their large size and long exposure period. Cr concentration recorded comparable value in most tissues of the examined fish species. The level of Cr in muscle and other organs were lower than USEPA limit 8 mg/kg [14]. The levels of Cu and Zn in edible muscle of the fish species ranged from BDL-0.58 mg/kg and 0.25-0.36 mg/kg respectively. The USEPA limit for Cu and Zn in fish food for human consumption is 120 and 50 mg/kg respectively [14]. The level of Cu and Zn in edible muscle in all fish species were low and below the international limits. Hence, Cu and Zn levels have posed no threat for consumption of the fish muscle from the coastal water. However, because a metal concentration in the aquatic environment is low and considered to be naturally occurring or background does not mean that the concentration could not cause adverse ecological effects [26]. The presence of one metal can significantly affect the impact that another may have on an organism. The effect may be synergistic, additive or antagonistic. The low level of Cu and Zn in muscle could be associated to lower level of binding protein metallothioneins. Metallothioneins are a family of low molecular weight cysteine rich proteins that have been reported in vertebrate and several invertebrate. Their synthesis can be induced by a wide variety of metal ions including Cu, Zn and Cd. Hence metallothioneins has been proposed as biomarkers to indicate the presence of high metals in the environment [8]. Although Cu and Zn play a crucial role in several enzymatic processes, they are tentatively classified as highly toxic metals by Hellawell [27] and are

bioaccumulated in aquatic organism. The concentration of nickel in the tissues of all examined species is relatively low ranges from BDL-0.12 mg/kg. The result confirms that most fish species do not bioaccumulate the metal contrary to what was previously reported by Hulya and Mendil [5,28]. The mean concentration of nickel in different fish species observed in this present study was below the permissible limit of 1.0 mg/kg prescribed by United State Environmental Protection Agency [14]. Lead and cadmium are non-essential elements which are accumulated in human tissue and harmful to human health. Comparison of Cd and Pb accumulation in the various organs shows that the highest concentration of Pb was found in head of *Pseudotolithus typus* (0.71 mg/kg) (Table 4d) and gill of *Pseudotolithus senegalensis* (0.40 mg/kg) (Table 4c). While highest Cd concentration was found in gill of *Pseudotolithus senegalensis* (1.14 mg/kg) (Table 4c) and gill of *Trichirus lepturus* (1.07 mg/kg) (Table 4a). The level of Pd in the edible muscle of the fish species ranges from 0.07-0.10 mg/kg. While Cd was observed only in the muscle of *Plectorhynchus mediterraneus* (0.07 mg/kg) (Table 4e) and *Trichirus lepturus* (0.09 mg/kg) (Table 4a). The accumulation of Pb and Cd recorded in fish bone follows similar pattern in all the species ranging from 0.11-0.12 mg/kg and 0.31-0.33 mg/kg respectively. The accumulation of these metals in gills, bones and head of fish do not directly affect human health because these are not edible parts. Nevertheless, the predatory animals such as birds who consume the whole fish from coastal waters are at risk of excess metal contamination. Moreover, fish head and bone are used in production of food additives for livestock feed. Therefore, its health quality is also very important. The maximum allowable levels of lead and cadmium in fish for human consumption specified by European Union are 0.2 and 0.05 mg/kg respectively. Of the different metals levels detected in edible muscle of all the examined fish species, the level of Cd in *Plectorhynchus mediterraneus* and *Trichirus lepturus* exceed the maximum allowable limit.

Concentration Factor

Concentration factors of the metals in fish relative to superficial water and sediment are presented in the tables below (Tables 5 and 6). Estimated concentration factor of heavy metals from water were greater than from sediment, suggesting bioaccumulation of the metals by the fish from water column. Fish has been reported to accumulate metals from water by diffusion via skin and gills as well as oral consumption/drinking of water [29]. Similar observation has been reported by many

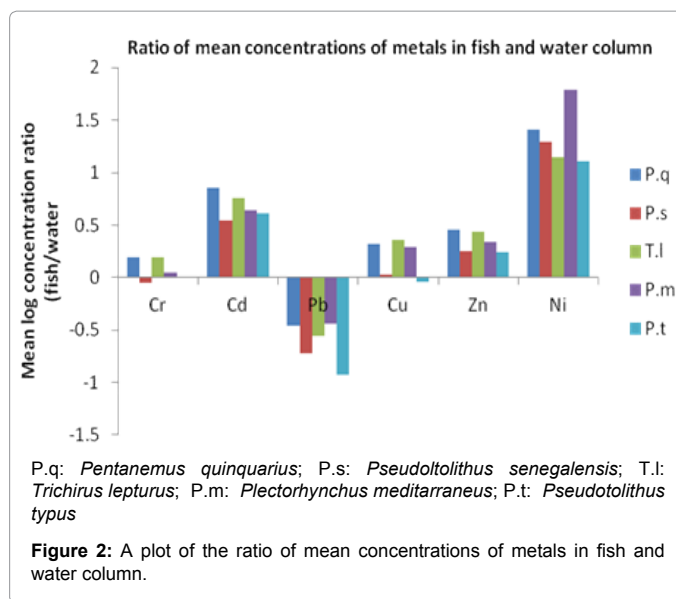
	Cr	Cd	Pb	Cu	Zn	Ni
P.q	1.57	7.01	0.34	2.09	2.89	26
P.s	0.89	3.48	0.19	1.09	1.79	19
T.I	1.58	5.7	0.28	2.31	2.73	14
P.m	1.12	4.36	0.37	1.93	2.2	62
P.t	1.01	4.09	0.12	0.9	1.74	13

Table 5: Concentration factor from water to fish.

	Cr	Cd	Pb	Cu	Zn	Ni
P.q	0.13	1.42	0.28	0.39	0.3	2
P.s	0.07	0.71	0.16	0.2	0.19	1.46
T.I	0.13	1.16	0.22	0.42	0.29	1.08
P.m	0.09	0.89	0.29	0.36	0.23	4.77
P.t	0.08	0.83	0.09	0.17	0.18	1

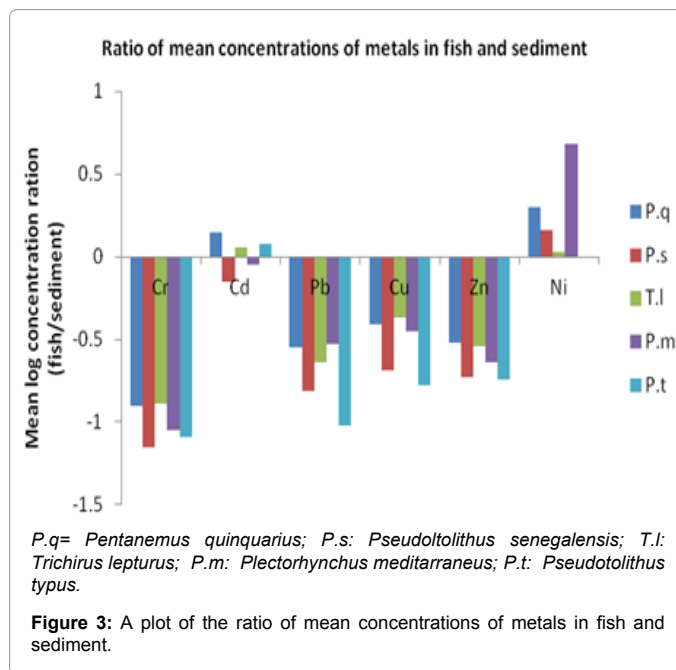
Pq: *Pentaneus quinquarius*; P.s: *Pseudotolithus senegalensis*; T.I: *Trichirus lepturus*; P.m: *Plectorhynchus mediterraneus*; P.t: *Pseudotolithus typus*

Table 6: Concentration factor from sediment to fish.



P.q: *Pentaneus quinquarius*; P.s: *Pseudotolithus senegalensis*; T.I: *Trichirus lepturus*; P.m: *Plectorhynchus mediterraneus*; P.t: *Pseudotolithus typus*

Figure 2: A plot of the ratio of mean concentrations of metals in fish and water column.



P.q= *Pentaneus quinquarius*; P.s: *Pseudotolithus senegalensis*; T.I: *Trichirus lepturus*; P.m: *Plectorhynchus mediterraneus*; P.t: *Pseudotolithus typus*.

Figure 3: A plot of the ratio of mean concentrations of metals in fish and sediment.

workers in Nigeria [18,30-32]. Figures 2 and 3 Show the comparisons of the ratio of investigated heavy metals levels in fish/water and fish sediment respectively.

Conclusion

The health safety of Ondo state coastal water for some fish species has been assessed, though there have not been reported cases of metal toxicity arising from direct use of water or consumption of fish from the area. The present results showed that metal concentration were lowest in muscle and highest in gill due to physiological roles in fish metabolism where the target tissues of heavy metals are the metabolically active ones. Therefore heavy metals in these active tissues are higher compared to muscle where metabolic activity is relatively lower. The result of these research has provided baseline information of heavy metals in water, sediment and tissues of some fish species from

the coastal waters of Ondo state, Nigeria with which future assessment program can be compared.

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