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Mineral Uptake of Heavy Metals by Some Marine Organisms along the Limbe Coastline in Cameroon and Health Risk Assessment

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Abstract

This study aimed at investigating the content of heavy metals in some marine organisms of the Cameroon Atlantic coast and assessing the health risk due to their consumption by the population. Nine fish and one shrimp species were collected for this study. These fish species were *Ethmolosa fimbriata*, *Drepane africana*, *Dentex moroccanus*, *Arius latiscotatus*, *Scarus hoefleri*, *Cynoglossus browni*, *Sardinella madorensis*, *Pseudotolithus elongatus*, *Pseudotolithus typus*. The shrimp species was *Macrobranchium macrobranchium*. The elements investigated in this study were: Fe, Co, Cu, Cd and Pb. For seven fish species it was found that the concentration of heavy metals followed the order Fe > Co > Cd > Cu > Pb. For most fish species the Target Hazard Quotient (THQ) value calculated showed the following trend Cd > Co > Pb > Fe ≥ Cu. Cadmium was found to be the main contributor to health risk that may result from the consumption of the fish species under study. The THQ for this element was in the range 0.7 - 1.2 while the Target Cancer Risk (TR) due to ingestion of this metal was in the range (3×10^{-4} - 6×10^{-4}). These values are slightly above the threshold limits established for both carcinogenic and non carcinogenic risks by the United States, Environmental Protection Agency. The estimated weekly intake of cadmium due to consumption of some fishes under study was greater or equal to the Provisional Tolerable Weekly Intake (PTWI) determined by Food and Agriculture Organization/World Health Organization.

Keywords

Marine Fish, Heavy Metal, Health Risk, Target Hazard Quotient

1. Introduction

Pollution of the aquatic environment with heavy metals has become a worldwide problem during recent years, because they are indestructible and most of them have toxic effects on organisms (Macfarlane & Burchett, 2000) and consequently on human health. Among environmental pollutants, metals are of particular concern, due to their potential toxic effect and ability to bioaccumulate in aquatic ecosystems (Censi et al., 2006). Although some trace metals may be very essential for the survival of living organisms (Forstner & Wittman, 1981), beyond certain threshold levels they can be very toxic to humans and other organisms that depend on them and can result in various illnesses and eventually death (Debelius et al., 2009; Khan & Weis, 1993). Besides natural sources, anthropogenic activities release significant quantities of heavy metals into the aquatic environment including industrial waste (arising from manufacturing, mining, agricultural and metal finishing plants) and domestic wastewater discharge. Heavy metal concentrations in aquatic ecosystems are usually monitored by measuring their concentrations in water, sediments and biota (Camusso et al., 1995), which generally exist in low levels in water and attain considerable concentration in sediments and biota (Namminga & Wilhm, 1976).

The contamination of aquatic environment with cadmium is recognized to be due to the discharge from "textile factories, distilleries pulp and paper mills, fertilized plants, chemical and allied industry, food, beverages and tobacco industries, soap, detergents and confectionery industries" (NEST, 1991; Mateo-Sagasta et al., 2017).

Cadmium (Cd) is a non-essential toxic heavy metal, an environmental toxicant, and toxic at a low concentration and to date it has no known valuable function in the human body. It is a cumulative toxicant with a biologic half life of up to 30 years in humans (Abou et al., 2005; Andujar et al., 2010). The most important route of Cd exposure is by inhalation of fumes and dust containing Cd and ingestion through contaminated hands and food, or from active/passive cigarette smoke. Once Cd is absorbed, more than 70% is found in the blood where it is bound to red blood cells; accumulation occurs mostly in the kidney and the liver, where cadmium is bound to metallothionein (Belliardo, 2018; Boukhallout & Touati, 2016). The critical target organ after long term exposure to cadmium after ingestion is the kidney, particularly to the proximal tubular cells with the first detectable symptom of kidney toxicity being an increased excretion of specific proteins (Järup et al., 1998). Various health effects of cadmium can include also, bone demineralization including increased hazard of fractures and osteoporosis and greater exposure to airborne (Abou et al., 2005; Järup et al., 1998). Cd may deteriorate lung function and elevate the risk of lung cancer by inhalation. Cd has been implicated in promoting apoptosis, oxidative stress, DNA methylation and DNA damage (Karcioglu & Arslan, 2019). Hostile reproductive health impairments are also described following Cd intoxication and it includes erectile dysfunction, low sperm motility and viability in men and a non-significant elevation in early follicular phase levels, increased length of mensuration cycle among others (Abou et al., 2005; Andujar et al., 2010; Byber et al., 2016; Mezynska & Brzóska, 2018). In most countries pregnant women are encouraged to eat various types of fish due to the fact that fish provides a variety of fatty acid that is good for the development of the fetus. But when the food is contaminated by Cd, several health problems can occur, like spontaneous abortion and newborns health issue (Andujar et al., 2010).

Cameroon is a country that opens to the Atlantic ocean and contains major rivers that flow into the sea. These rivers pass through urban and large agricultural areas. Thus, they carry into the sea pesticides that are used in agriculture, domestic waste and other pollutants that must be identified. The presence of the national oil refinery company on the coastline, offshore oil exploitation installations and numerous boats that dock at the beach would be another major source of pollutants in this marine environment. Marine pollution is a reality in Cameroon and the fishing industry is developed in marine waters. Cameroon has a coastline of about 402 km (Sayer at al., 1992), starting from Nigeria in the north to the limit with Equatorial Guinea in the south. As part of past research results on coastal and marine pollution in Cameroon, Angwe (1987) reported the concentration of heavy metals in shrimps and fish consumed by the population. He investigated the concentration of five metals (Hg, Cd, Pb, Cu, Zn) in four fish species (*Pseudotolithus typus*, *P. Elongatus*, *P. Senegalensis* and *Ethmalosa fimbriata*). The results showed that the concentration of Zn was practically the same (0.2 mg/g fresh weight) in the fish species under study. The elements Hg, Cd and Pb are not determined, while the concentration (in mg/g fresh weight) of Cu in different fish species was as follows *Pseudotolithus typus* (2.20), *P. Elongatus* (0.39), *P. Senegalensis* (0.47) and *Ethmalosa fimbriata* (0.42).

This paper aims at investigating the content of some heavy metals in fish species along Limbe coastal area and assessing the health risk due to consumption of the concerned fish species. The work presented in this paper includes the sampling area, sampling technique and sample preparation, sample analysis, health risk assessment, results and discussion.

2. Material and Methods

2.1. Sampling Area

Sampling was carried out at the Limbe coastline situated in the Gulf of Guinea. The Limbe coastline stretches for 60 km and forms part of the 402 km stretch of the Cameroon coastline. The area has a tropical climate with two major seasons: the wet (April to October) and dry (November to March) seasons. Rainfall is bimodal, peaking in July and August. Minimal rainfall is in January and February. Mean relative humidity in the area is about 80%.

This coastline of concern has 9 coastal fishing villages: Limbe Dockyard, Bota land, Wovia, Ngeme, Batoke, Bobende, Idenau, Sanje and Enyenge meaning fishing is one of the major activities here. Other human activities are also carried out here including offshore drilling, transportation of petroleum products, mining, agro industrial activities and so on. Discharge of waste and effluent from most of these activities releases a wide range of pollutants into the sea including heavy and trace metals, organics, nutrients, hydrocarbons, radionuclide, just to name a few.

The fish species collected for this study, that is, *Ethmolosa fimbriata*, *Drepane Africana*, *Dentex moroccanus*, *Arius latiscotatus*, *Scarus hoefleri*, *Cynoglossus browni*, *Sardinella madorensis*, *Pseudotolithus elongates*, *Pseudotolithus typus*, *Ethmolosa fimbriata* and *Sardinella madorensis* are part of the main exploited fish species in Cameroon coastal area (Sheves et al., 1992). *Arius latiscotatus* is found along the coasts of western Africa, from Senegal to Angola (Taylor & Van Dyke, 1981).

2.2. Sampling Techniques and Sample Preparation

Sampling sites were established using a Global Positioning System (GPS). Consideration for the choice of the sampling sites was based on human activities and the importance of the ecological settings of the area. Fish samples were collected in August from two locations which are landing sites for fishermen. From the first site i.e. Wovia village (N 040 00.780, E 0090 09.119), one fish was captured while at the second sampling site i.e. Limbe Dockyard (N 040 00.45, E 0090 12.696) 8 fish samples and shrimps were collected. In addition, the selection of sampling sites was done according to the following criteria: 1) The largest/busiest fish landing site Limbe Dockyard and the other smaller/less busy fish landing site Wovia were considered. 2) Wovia is equally closer to a shipyard company as well as the nation's lone oil refinery while the Limbe Dockyard is further away. The sampling sites are presented in **Figure 1** below. **Table 1** shows characteristics of marine organisms sampled during the survey.

These samples were transported in an ice-containing cooler to the laboratory of Institute of Agricultural Research for Development (IRAD) at Ekona for preparation. At the laboratory the fish was allowed to thaw at room temperature. They were dissected with a stainless still knife to remove the head and the gut. The flesh was chopped into small pieces and oven dried at 80˚C to constant weight. Each species was pounded in a mortar and parceled into plastic papers for analysis.

2.3. Sample Analysis

The analysis was carried out using an Atomic Absorption Spectrometer. The procedure involved digesting the sample to obtain a clear solution, preparing a standard solution and calibrating the instrument, passing the prepared solution through the AAS to get the concentration of a particular metal in mg/L and finally calculating the concentration in mg/kg. The elements analyzed included copper, cobalt, lead, cadmium and iron.

2.4. Heath Risk Assessment

Risk to human health by the consumption of marine coastal fish species by the

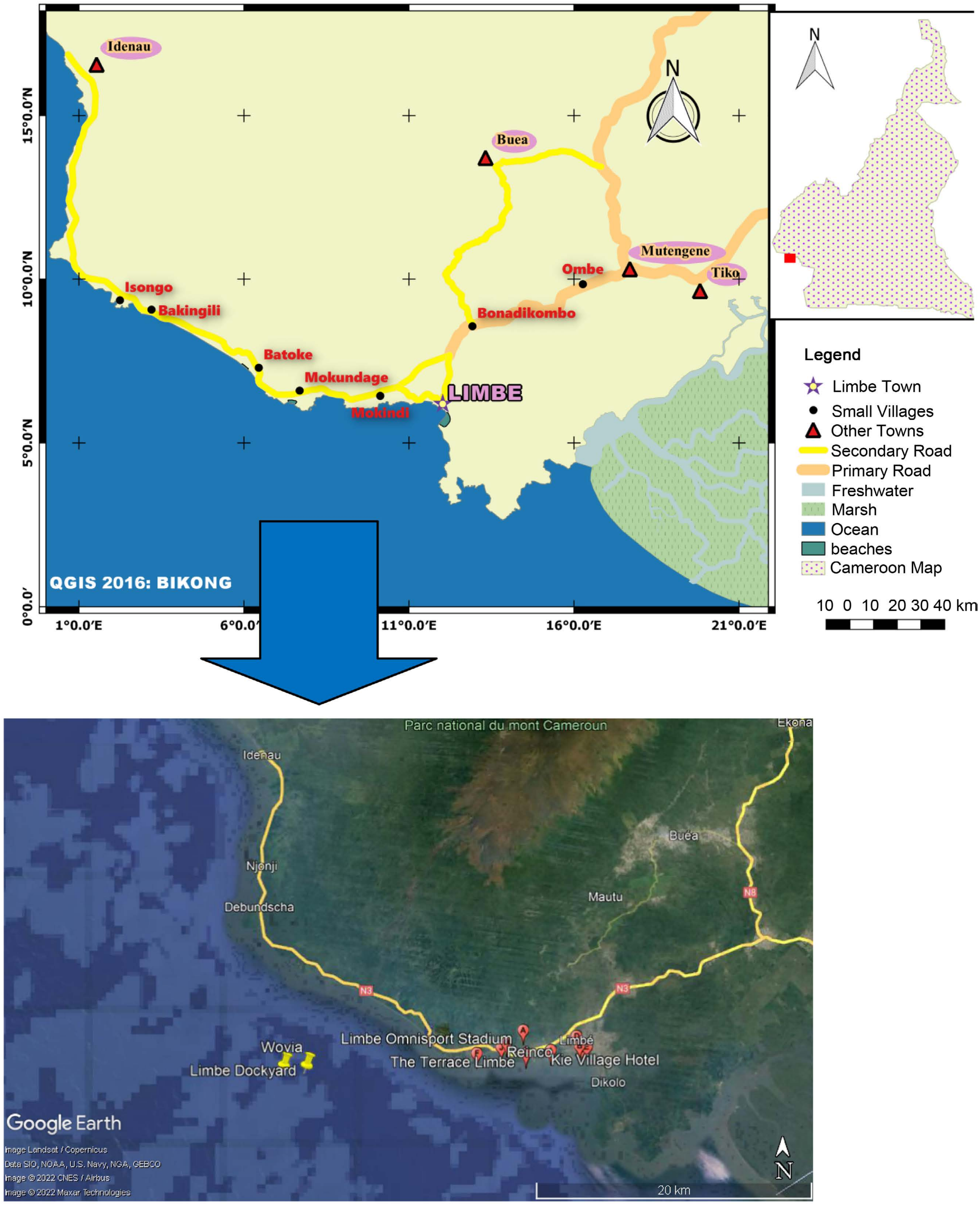

Figure 1. Localization of sampling sites along Limbe Coast line.

population was characterized using the Target Hazard Quotient (THQ) and Target Risk Cancer (TR). THQ parameter is used for estimating risks based on

Table 1. Characteristics of marine organism species sampled during the study.

Common/Local name	Scientific name	Family	Exploitation	Status	Site
Bonga	*Ethmallosa fimbriata*	Clupeidae	commercial	premature/mature	Down beach
Strong Kanda	*Sardinella maderensis*	Clupeidae	commercial	mature	Down beach
	Drepane Africana	demersal fish	subsistence	mature	Down beach
Mud fish	*Arius latiscotatus*	Ariidae	commercial	mature	Down beach
Sole	*Cynoglossus browni*	Cynoglossidae	commercial	mature	Down beach
Mussobo/bar	*Pseudotolithus elongatus*	Scianidae	commercial	mature	Wovia
Mussobo/bar	*Pseudotolithus typus*	Scianidae	commercial	mature	Down beach
Parrot fish	*Scarus hoefleri*	Scaridae	commercial	mature	Down beach
Seabreams	*Dentex moroccanus*	Spariidae	commercial	mature	Down beach
Njanga	*Macrobranchium macrobranchium*	Palaemonidae	subsistence	mature	Down beach

non-carcinogenic effects (Chien et al., 2002) while TR is used for carcinogenic effects.

Methods to estimate THQ and TR are provided by US EPA (US EPA, 2007). THQ is expressed as the ratio of determined dose of a pollutant to a reference dose. If THQ is less than 1, the exposed population is unlikely to experience obvious adverse effects. When THQ is greater than 1 there is a potential risk related to concerned heavy metal in the exposed population. In that case, there is a chance of non-carcinogenic effects with an increasing probability as the value upsurges (Gebeyehu & Bayissa, 2020).

There are certain assumptions which should be taken while evaluating the THQ for human health risk which are as follows: 1) ingested dose of pollutant is equal to the absorbed dose, 2) cooking has no effect on pollutants (Gebeyehu & Bayissa, 2020; Naji et al., 2016).

THQ is calculated as follows:

$$\text{THQ} = \frac{EF_r \times ED \times FI \times C_m}{RfD \times B_W \times AT} \times 10^{-3} \quad (1)$$

where, EF_r (365 days/year) is exposure frequency; ED is exposure duration, which is equivalent to the average lifetime (US EPA, 1989) and is considered as 59 years from Rapport de Suivi de 100 indicateurs clés de santé au Cameroun (Rapport de Suivi, 2019) FI (g/(person·day)) is fish ingestion; Cm (mg/kg on wet weight basis) is heavy metal concentration in fish; RfD (mg/(kg·day)) is the oral reference dose; B_w is the average body weight, which is considered to be 70 kg for an adult; AT is averaging time for non-carcinogens (365 days/year × number of exposure years, assuming 59 years in this study). RfD values for Fe, Co, Cu, Cd and Pb are 0.7, 0.043, 0.04, 0.001, 0.004 mg/(kg·day) respectively (US EPA, 1989, 2005, 2007). The FI value considered in this study (41.1 g/day) is the average consumption of fish for African type diets, excepted North African type diets (Safety Reports, 1999).

Concentration values of heavy metals in fish given on dry weight basis were normalized in concentration on wet weight basis using a wet weight/dry weight ratio of 4 (Sarayut et al., 2010), assuming a water content of 75%.

The model for estimating TR was shown as follows:

$$TR = \frac{C_m \times FI \times CPS_O \times EF_r \times ED}{B_w \times AT_c} \quad (2)$$

where C_m, FI, EF_r, ED, B_w and AT are already explained above. CPS_o is carcinogenic potency slope for ingestion of carcinogenic element in mg/kg (bw-day-1) and AT_c is averaging time exposure to carcinogens (365 days/year × 59 years), due to average life expectancy for Cameroonians (already described earlier). CPS_o values found for Cd and Pb are respectively 0.38 and 0.0085 (US EPA, 2012).

TR is an upper limit of the probability that the individuals may have cancer sometime in his/her lifetime following exposure to a toxicant (NYSDOH, 2007). TR values are categorized as follows (Kawser et al., 2016):

- $TR < 10^{-6}$ = negligible for carcinogenic risk;
- $10^{-6} \le TR \le 10^{-4}$ = acceptable range;
- $TR > 10^{-4}$ = unacceptable.

The Estimated Daily Intake (EDI) for a metal is determined through the following equation:

$$EDI = \frac{C_{\text{metal}} \times DI_{\text{fish}}}{B_{\text{average weight}}} \quad (3)$$

where C_{metal} is concentration of heavy metal in fish, DI (g·day^{-1}) is fish ingestion rate or daily intake of fish, and $B_{\text{average weight}}$ is the average body weight (which is considered to be 70 kg for an adult).

3. Results and Discussion

Heavy metal concentrations varied widely among different organisms indicating a species bioaccumulation process. Unfortunately, anthropogenic environmental impacts (industry, agriculture, mining) significantly increase the naturally occurring amounts of heavy metals in the environment, including the marine ecosystem. In this study, the five elements Fe, Co, Cd, Cu and Pb were present in detectable quantities in all fish species under study. The concentration (in µg/g, dw) ranges of these elements in fish samples were as follows: 14.5 - 309.7 for Fe; 48.4 - 85.7 for Co; 5.7 - 10.1 for Cd; 2.4 - 6.9 for Cu and 2.7 - 4.2 for Pb. Cadmium, copper and lead tend to be the least concentrated elements in the fish in this study as compared to other elements measured. For comparison purposes these concentration values on dry weight basis were converted to concentrations on wet weight basis using a wet weight/dry weight ratio of 4 (Sarayut et al., 2010). The concentration (in µg/g, wet weight) range in wet weight basis were then: 3.6 - 77.4 for Fe; 12.1 - 21.4 for Co; 1.4 - 2.5 for Cd; 0.6 - 1.7 for Cu and 0.7 - 1.1 for Pb. A previous study along the coast of Cameroon, reported a concentration of Cu in four fish species in a range 0.4 - 2.2 µg/g, wet weight (Angwe, 1987). So, the concentration values of Cu in fish samples obtained in this study are in accordance with previous studies. **Table 2** presents the results obtained in this study compared to data reported in literature concerning heavy metal content in some fish species. Concentration of Fe, Co, Cu, Cd and Pb values obtained in this study for two fish species (*Ethmolosa fimbriata and Drepane Africana)* were greater than those reported in other studies for the same fish species (Kawser et al., 2016; Bandowe et al., 2014).

A review of literature was also made to see the agreement of actual results with other data on concentration of heavy metals in fish species in different coastal locations in Africa. Before this comparison, concentration values are converted into the same basis (dry weight or wet weight) for harmonization, using the conversion factor wet weight/dry weight ratio of 4. Corresponding data are presented in **Table 3**. The elements Fe, Co, Cu, Cd and Pb were present in fish from the coastal areas of Cameroon and Ghana. These heavy metals were more concentrated in fish from Cameroon coastline. Copper and cadmium were present in fish from the four selected coastal areas. Lead was not found in fish

Table 2. Trace element concentrations (in µg/g, wet weight) in fish samples.

Species	Site	Fe	Co	Cu	Cd	Pb	Reference
Ethmolosa fimbriata	Down beach	77.4	17.2	1.4	2.2	0.9	This study
	Ambas Bay	-	-	0.4	-	-	[19]
Drepane africana	Down beach	25.8	14.5	1.7	1.9	0.9	this study
	Tema port	18.5	nd	0.3	nd	0.08	[35]*
	Takoradi fishing harbor	9.8	nd	0.3	0.03	nd	
	Elmina landing beach	8.3	nd	0.2	0.03	nd	
Dentex moroccanus	Down beach	3.6	19.6	0.8	2.3	1.0	This study
Arius latiscotatus	Down beach	37.7	12.1	0.7	1.4	0.7	
Scarus hoefleri	Down beach	40.4	16.5	0.9	1.9	0.8	
Cynoglossus browni	Down beach	29.0	21.4	1.3	2.5	1.1	
Sardinella madorensis	Down beach	29.6	16.4	1.3	1.7	0.8	
Pseudotolithus elongatus	Wovia	44.6	16.4	0.6	2.0	0.9	
Pseudotolithus typus	Down beach	74.9	21.1	1.1	2.1	0.9	

nd = non detected. *Concentration values reported by Bandowe *et al.* are converted to concentration on wet weight basis using a conversion factor wet weight/dry weight ratio of 4.

Table 3. Comparison of trace metal concentrations (in µg/g, wet weight) in fish collected in Cameroon coastline with those collected in other coastal locations in Africa.

Coastal area	Fe	Co	Cu	Cd	Pb	Reference
Coast of Cameroon	3.6 - 77.5	12 - 21.5	0.6 - 1.7	1.4 - 2.5	0.7 - 1.1	This study
Coast of Ghana	6.3 - 38	nd	nd - 1	nd - 0.1	nd - 0.3	(Bandowe et al., 2014)
Coast of Togo	0.7 - 7	–	0.03 - 3.5	nd - 0.1	nd - 15	(Gnandi et al., 2011)
Coast of Mauritania	-	-	0.2 - 1.7	0.001 - 0.068	-	(Sidoumou et al., 2005)
Western and Central Africa coastal waters	-	-	0.46 - 11.3	0.10 - 0.26	0.36 - 2.28	(Biney et al., 1994)

nd = non detected.

samples from Mauritania coast. Concentration values for Cu in fish from Cameroon, Ghana, Togo and Mauritania coastal areas were in agreement with results reported by Biney et al. (1994) for the concentration range of this element in fish collected in Western and Central Africa coastal waters (0.46 - 11.3 µg/g, wet weight). For cadmium, only the concentration values obtained from Cameroon (1.4 - 2.5 µg/g, wet weight) were greater than those reported by Biney et al (0.10 - 0.26 µg/g, wet weight). Concerning lead, only the concentration values reported for Togo (nd - 15 µg/g, wet weight) by Gnandi et al. (2011) were greater than those reported by Biney et al. (1994) (0.36 - 2.28 µg/g, wet weight).

The Estimated Daily Intake (EDI) of each heavy metal was determined using Equation (3), assuming an average body weight of 70 kg for an adult. The obtained value was then converted to Estimated Weekly Intake (EWI) for the same element. The Comparison of estimated weekly intakes of metal of fish species examined in this study with recommended values defined by FAO/WHO is presented in **Table 4**. Except for one fish species (*Arius latiscotatus*), it can be noticed that for cadmium the estimated weekly intake is greater or equal to the Provisional Tolerable Weekly Intake (PTWI) determined by FAO/WHO. For the other elements (Fe, Cu, Pb) we have the relation EWI < PTWI. The ratio PTWI/EWI for Fe, Cu and Pb were in the ranges 17.3 - 381; 500 - 1250; 6 - 8.9 respectively.

Calculated Target Hazard Quotient values for individual heavy metals caused by consumption of different fish species are given in **Table 5**. For the fish species considered in this study the ranges of THQ values for Fe, Co, Cu, Cd and Pb are respectively 0.003 - 0.06; 0.1 - 0.2; 0.007 - 0.02; 0.7 - 1.2; 0.08 - 0.1. The results showed that THQ values in all fish species were in the following order: Pb < Co < Cd. As shown in **Figure 2**, THQ values for Cd in certain fish species slightly exceeded the threshold limit of 1. The resulting conclusion is that there are possible adverse effects related to Cd intake due to the consumption of some fish species collected in Limbe coastal area.

Table 4. Comparison of estimated weekly intakes of metal in fish species examined in this study with recommended values by FAO/WHO (2004).

Fish species	Metal	EDI	EWI	PTWI
Ethmolosa fimbriata	Fe	45.5	318.5	5600
	Co	10.1	70.7	-
	Cd	1.3	9.1	7
	Cu	0.8	5.6	3500
	Pb	0.5	3.5	25
Drepane africana	Fe	15.1	105.7	5600
	Co	8.5	59.5	-
	Cd	1.1	7.7	7
	Cu	1.0	7.0	3500
	Pb	0.5	3.5	25
Dentex moroccanus	Fe	2.1	14.7	5600
	Co	11.5	80.5	-
	Cd	1.4	9.8	7
	Cu	0.5	3.5	3500
	Pb	0.6	4.2	25
Arius latiscotatus	Fe	22.1	154.7	5600
	Co	7.1	49.7	-
	Cd	0.8	5.6	7
	Cu	0.4	2.8	3500
	Pb	0.4	2.8	25
Scarus hoefleri	Fe	23.7	165.9	5600
	Co	9.7	67.9	-
	Cd	1.1	7.7	7
	Cu	0.5	3.5	3500
	Pb	0.4	2.8	25
Cynoglossus browni	Fe	17.0	119.0	5600
	Co	12.6	88.2	-
	Cd	1.5	10.5	7
	Cu	0.8	5.6	3500
	Pb	0.6	4.2	25
Sardinella madorensis	Fe	17.4	121.8	5600
	Co	9.6	67.2	-
	Cd	1.0	7.0	7
	Cu	0.7	4.9	3500
	Pb	0.4	2.8	25

Continued

Pseudotolithus elongatus	Fe	26.2	183.4	5600
	Co	9.6	67.2	-
	Cd	1.2	8.4	7
	Cu	0.4	2.8	3500
	Pb	0.5	3.5	25
Pseudotolithus typus	Fe	44.0	308.0	5600
	Co	12.4	86.8	-
	Cd	1.2	8.4	7
	Cu	0.6	4.2	3500
	Pb	0.5	3.5	25

Table 5. THQ for individual heavy metals caused by consumption of different fish species.

Fish species	THQ (Fe)	THQ (Co)	THQ (Cu)	THQ (Cd)	THQ (Pb)
Ethmolosa fimbriata	0.06	0.2	0.02	1.1	0.1
Drepane africana	0.02	0.2	0.02	0.9	0.1
Dentex moroccanus	0.003	0.2	0.01	1.1	0.1
Arius latiscotatus	0.03	0.1	0.008	0.7	0.08
Scarus hoefleri	0.03	0.2	0.01	0.9	0.09
Cynoglossus browni	0.02	0.2	0.02	1.2	0.1
Sardinella madorensis	0.02	0.2	0.02	0.8	0.09
Pseudotolithus elongatus	0.04	0.2	0.007	1.0	0.1
Pseudotolithus typus	0.06	0.2	0.01	1.1	0.1

Table 6. TR for individual heavy metals (Cd and Pb) caused by consumption of different fish species.

Fish species	TR (Cd)	TR (Pb)
Ethmolosa fimbriata	5×10^{-4}	4×10^{-6}
Drepane africana	4×10^{-4}	4×10^{-6}
Dentex moroccanus	5×10^{-4}	5×10^{-6}
Arius latiscotatus	3×10^{-4}	3×10^{-6}
Scarus hoefleri	4×10^{-4}	4×10^{-6}
Cynoglossus browni	6×10^{-4}	5×10^{-6}
Sardinella madorensis	4×10^{-4}	4×10^{-6}
Pseudotolithus elongatus	4×10^{-4}	4×10^{-6}
Pseudotolithus typus	5×10^{-4}	4×10^{-6}
Risks related to carcinogenic effects	Unacceptable	Acceptable

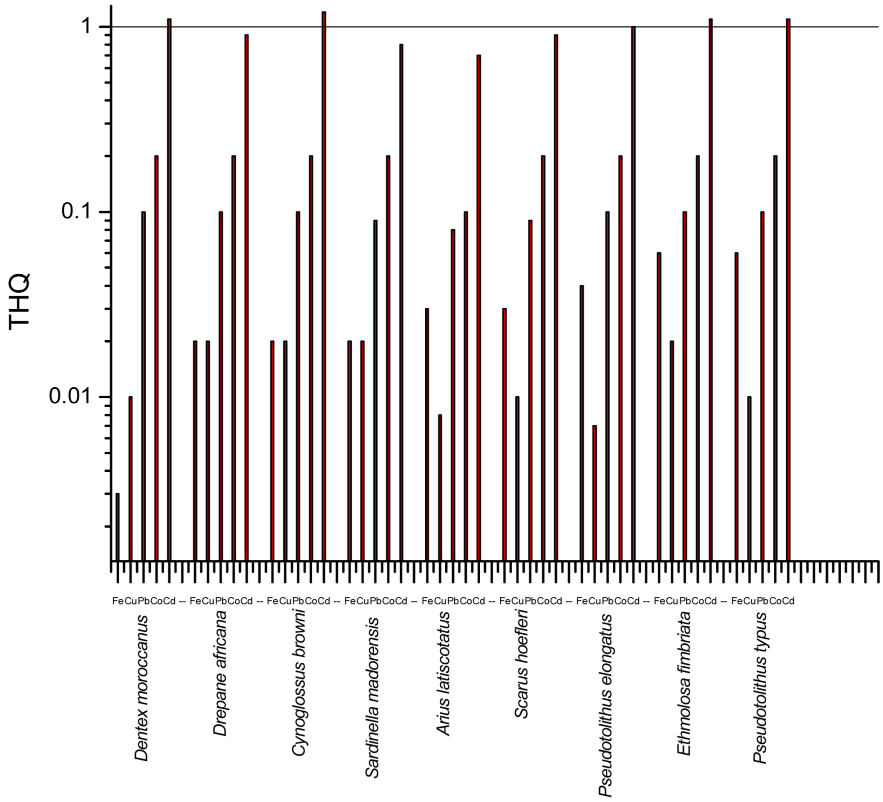

Figure 2. THQ values for different fish species.

Since CFSo values were known for Cd and Pb, so TR values were calculated for intake of these metals to assess the carcinogenic risk. Results of Target Cancer Risk (TR) values for Cd and Pb are given in Table 6 below. For all fish species TR (Pb) < TR (Cd) and TR values for Cd are in unacceptable range described in Health risk assessment section above.

The results of this study showed that cadmium contamination in some fish species may lead to some harmful effects due to the consumption of those fish. The concentration of Cd in fish species under study is in the range 1.4 - 2.5 µg/g ww.

4. Conclusion

In summary five heavy metals (Fe, Co, Cu Cd, Pb) were investigated and found to be present in nine fish species collected along the Limbe coastal area. The concentration values obtained were compared with each other to see the element with the highest concentration and to see the trend for different fish species. The study showed that for the majority of fish species considered, the concentration of heavy metals followed the order Fe > Co > Cd > Cu > Pb. To assess the health risk that may result from the consumption of the fish species target hazard quotients and estimated intakes were calculated for each metal, assuming that fish are consumed by adults with an average weight of 70 kg. The comparison of estimated weekly intake values with the provisional tolerable weekly intake defined by the FAO/WHO showed that a particular attention should be taken for cadmium. In some fish species the EWI for cadmium was up to 1.5 times greater than the PTWI defined by FAO/WHO. The target hazard quotient for Pb and Cd due to consumption of the fish species under study was in the order Pb < Cd. Calculated THQ for Cd in all fish species was in the range 0.7 - 1.2 and TR was in the range 3×10^{-4} - 6×10^{-4} which means that the population faces both non-cancerogenic and cancerogenic risks. This work aimed at investigating the impact of heavy metal pollution on the population through assessment of health risk due to consumption of fishermen products along Limbe coastal area. To assume representativity of study area, specific criteria were used for the selection of sampling sites. Such a study should be extended to cover the entire Cameroon coastline.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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