PRINT ISSN 1119-8362
Electronic ISSN 1119-8362

Full-text Available Online at
https://www.ajol.info/index.php/jasem
http://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 26 (5) 885-892 May 2022

Potential Health Risk Assessment of Bioaccumulation of Heavy Metals in Freshwater Organisms from Ojo River, Lagos, Nigeria

[1]SANYAOLU, VT; *[1]OMOTAYO, AI; [2]ADETORO, FA

[1]Department of Biological Science (Environmental Biology Unit), Lagos State University of Science and Technology, Ikorodu, Lagos, Nigeria
*[*2]Department of Zoology, University of Lagos, Akoka, Yaba, Lagos, Nigeria*

*Corresponding Author Email: *ormorteey32@yahoo.com; Tel: +234-806-250-9578*
Other Authors Email: vaksanyaolu@yahoo.com; adetorofouad@gmail.com

ABSTRACT: This study investigated potential health risk associated with heavy metal bioaccumulation in freshwater organisms in Ojo River, Lagos, Nigeria. Liver, gills and muscle from fish samples and muscle and exoskeleton from crab samples were analysed for concentration of Cd, Cr, Zn, Pb, Ni and Cu using Atomic Absorption Spectrophotometer after digestion of samples. Generally, heavy metal concentration in water samples from different locations in Ojo river did not exceed WHO limits. Concentration of Pb, Cu, Zn and Cr in tissues of *M. niger* and *L. campechanus* shows high bioaccumulation of heavy metals. Heavy metals bioaccumulated more in liver > muscle > gills in both fish samples. Ni and Cd were not detected in the two fish species. Similarly, Pb, Cu and Ni were found in muscles and exoskeleton of *C. pagurus* and *S. serrate* at quantities higher than WHO limits. Zinc was detected only in muscle and not exoskeleton of both crab samples, while Cr was found only in exoskeleton of *C. pagurus* and Ni was not detected in all crab species. Estimated daily intake (EDIs) for Pb, Cu, Zn and Cr in *M. niger* and *L. campechanus* and for Pb, Cu and Ni in *C. pagurus* and *S. serrate* were higher than the oral reference doses. Target Hazard Quotient (THQ) for heavy metals were also extremely high. Significantly high bioaccumulation of heavy metals in freshwater organisms from Ojo River calls for serious actions because it is a major source of freshwater foods for residents of Lagos.

DOI: **https://dx.doi.org/10.4314/jasem.v26i5.16**

Impact factor: **http://sjifactor.com/passport.php?id=21082**

Google Analytics: https://www.ajol.info/stats/bdf07303d34706088ffffbc8a92c9c1491b12470

Dates: Received: 20 February 2022; Revised: 13 April 2022; Accepted: 21 May 2022

Keywords: Potential health risk; Heavy metals; Bioaccumulation; Freshwater organisms; Ojo River; Nigeria

Contamination of heavy metal (HM) in aquatic environments has continued to attract global attention. This is due to their level of abundance, wide range of sources, bioaccumulation (Liu *et al.,* 2014), persistence and environmental toxicity (Ali *et al.*, 2016). Both natural and anthropogenic activities are responsible for abundance of heavy metals in the environment (Karadede and Unlu, 2007), however, anthropogenic activities are the major sources of heavy metals in the aquatic environment (Bosnak, 2007). Direct human activities such as dredging (Ohimain *et al.*, 2008), oil exploration in offshores (Seiyaboh, 2017) and poor waste management (Angaye *et al.*, 2015) are some of the methods through which heavy metals enter the aquatic environment. Effluent discharges into water bodies from industries also contain ranges of toxic heavy metals that increase heavy metal pollution in the aquatic ecosystems (Dakkak, 2013). In the aquatic ecosystems, particularly in near shore areas, these metals enter into the food chain and become bioaccumulated in aquatic organisms (Adeyeye, 2002; Charis and Abbasi, 2005). Residues of heavy metals in polluted habitats may accumulate in microorganisms, fishes, crustaceans and other aquatic animals and through these means, heavy metals enter into human food chain and cause health challenges (Gupta *et al*. 2009). Typically, fishes have the tendency to bioaccumulate heavy metals in different parts of their body (Aghoghovwia *et al.*, 2016). Likewise, studies have also shown heavy metal content in decapod crustaceans such as crabs (Yusuf, 2006; Liu *et al*., 2015). To some extent, crabs can

**Corresponding Author Email: ormorteey32@yahoo.com*

fulfill the main requirements of bio-indicators such as being relatively sedentary, easy to identify, abundant, long lived, available for sampling all year round and getting wide distribution (Rainbow, 1995). These make crab samples suitable biological indicators for monitoring heavy metal pollution in aquatic systems (Beltrame *et al.*, 2011; Pinheiro *et al.*, 2012). Monitoring the concentration of heavy metals in water, sediment and aquatic fauna is important because it provides vital information regarding sources, distribution and degree of pollution (Adefemi *et al*, 2004; Oyakhilome *et al*, 2012). Heavy metals are essential for normal functioning of biological systems, however, the differences between beneficial and toxic concentrations of all heavy metals are small. There is increasing concerns about health effects emanating from continuous consumption of food contaminated with heavy metals (Chukwujindu *et. al.*, 2008), because metallic toxicants attack proteins (notably enzymes) in humans (Ademoroti, 1996) and their toxic effects are cumulative and cause slow poisoning of the human system over time (Nriagu, 1988; Ukpebor *et al*, 2005). Heavy metals have been implicated in the upsurge of liver and kidney diseases, and is believed to be responsible for a high proportion of mortality caused by kidney and liver morbidity (Friberg *et al.*, 1986; Ndiokwere, 2004). High concentration of heavy metals above permissible level in drinking water and aquatic foods could cause pathological health effects over a long period of time. Accumulation of heavy metals in tissues of freshwater organisms calls for serious concerns due to the potential health risk associated with consumption of these organisms. More importantly, monitoring of heavy metal concentration in tissues of these organisms become necessary in communities where freshwater organisms are major sources of food so as to guide against negative health consequences of heavy metal consumption beyond recommended limits. Thus, this study examined the level of bioaccumulation of heavy metals (Cu, Pb, Ni, Zn, Cd and Cr) in edible and non-edible parts of some freshwater fishes and crabs collected from middle of Ojo river, Lagos, Nigeria. Also, we examined potential health risk involved in daily consumption of these freshwater organisms by assessing the potential noncarcinogenic health hazards (Target Hazard Quotient) for each of the heavy metals (Liu *et al*. 2019).

MATERIALS AND METHODS

Description of study site: Ojo River is situated in Ojo Local Government Area (LGA) of Lagos state. It is situated on the eastern section of the Trans–West African Coastal Highway, about 37km west of Lagos at Latitude: 6° 27' 59.99" N and Longitude: 3° 10' 60.00" E. It is part of the Lagos Metropolitan Area. Ojo River (also known as Ebute-Ogbo River) and other water bodies are the ultimate repository of man's wastes in Ojo Local Government area of Lagos State.

Collection of samples and preparation: Three (3) samples each of two common freshwater fish species (*Macolor niger* and *Lutjanus campechanus*) were collected at the middle of Ojo river from three different spots at a distance from each other and two crab species (*Scylla serrate* and *Cancer pagurus*) were also collected at three (3) distant spots at the bank of the river. Samples were transferred to the laboratory in an ice chest. Liver, gills and muscle from the fishes and muscles and exoskeleton of crabs were extracted with a clean stainless knife. The choice of these body parts is dictated by their roles in biological processes and their edibility by residents of Lagos. Extracted body parts were stored in a deep freezer at -20ºC for further analysis. Samples of water from the river were collected from the shore (within 2 meters offshore) in four (4) main activity areas (denoted L1, L2, L3, and L4) and a fifth location at 100 meters away from the shore (L5). These were also tested for Cd, Cr and Pb to compare with the concentrations in fish and crab samples.

Analysis of heavy metal concentration: Heavy metal analysis was done according to the procedures of Liu et al. (2019). Water samples collected from the different locations where digested and 0.2g of powdered forms of fish and crab samples were measured and digested and heavy metals concentration was analysed with Atomic Absorption Spectrophotometer (AAS) (iCE 3300, Thermo Scientific UK model). Concentrations of Lead (Pb), Cadmium (Cd), and Chromium (Cr) were analysed from the river water samples while concentrations of Lead (Pb), Copper (Cu), Nickel (Ni), Cadmium (Cd), Zinc (Zn) and Chromium (Cr) were analysed from tissues of fishes and crabs. Focus on Lead (Pb), Cadmium (Cd), and Chromium (Cr) only in water samples is dictated by their carcinogenic potentials unlike the three other heavy metals. Concentration of samples is expressed in mg/kg and presented in mean $\pm$ standard error of mean (SEM).

Health risk assessment: Assessment of health risk was done by calculating Estimated Daily Intake and Target Hazard Quotient of the heavy metals in edible body parts of the fishes and crabs. Estimated daily intake (EDI) of heavy metals through fish and crab consumptions were calculated using the formula:

$$\boldsymbol{EDI = \frac{IR\ x\ C}{ABW}}$$

Where EDI = Estimated daily intake; IR = ingestion rate is 105 g/person/ day for fish and 8.3 g/person/ day for crab; C = heavy metal concentration in muscle; and ABW = average body weight is 55.9 kg (Liu et al. 2020). Also, Target Hazard Quotient (THQ) was calculated by comparing EDI with the oral reference dose according to USEPA (2014).

RESULTS AND DISCUSSION

Heavy metal concentration in water samples from Ojo River: Table 1 shows results for heavy metals in water samples from different sections of Ojo River. Results for three metals tested shows presence of Pb, Cd and Cr in water samples at all locations sampled. Lead and Cadmium concentrations ranged between 0.001 – 0.002 mg/kg while Chromium ranged between 0.003 - 0.061 mg/kg. There was no significant difference in concentration of the three metals in all the locations and the concentrations where far below the WHO limits.

Table 1: Mean concentration of heavy metal in water samples from different sections of Ojo River

Study Location	Heavy metals (mg/kg)		
	Lead	Cadmium	Chromium
1	0.002±0.01[a]	0.01±0.07[a]	0.032±0.01[a]
2	0.001±0.01[a]	0.01±0.09[a]	0.050±0.01[a]
3	0.002±0.01[a]	0.01±0.09[a]	0.003±0.00[a]
4	0.001±0.00[a]	0.01±0.012[a]	0.040±0.12[a]
5	0.001±0.00[a]	0.01±0.031[a]	0.061±0.02[a]
WHO	0.10	0.01	0.10

Mean values having dissimilar superscripts along the same column are significantly different (P ≤ .05. DMRT)
1 = Ebute shoreline, 2= Sales section, 3= Jetty area, 4= Beach section 5= 100 m from shoreline at location 1

Heavy metal concentration in Macolor niger and Lutjanus campechanus: Results of heavy metal concentration in fish samples are presented in Table 2. Traces of two (2) heavy metals; Nickel and Cadmium were not found in the liver, gills and muscle of *M. niger* and *L. campechanus.* Chromium was found only in the muscles of *M. niger* and in gills and muscles of *L. campechanus.* Copper and Zinc were found in all the body parts of both fish samples in varying concentrations, with the concentration of Cu ranging from 0.91-1.10 in *M. niger* and 0.25 -1.98 in *L. campechanus.* The highest Zn concentration was found in the liver of *M. niger* with the lowest concentration found in the gills of same species. For all the four heavy metals (Pb, Cu, Zn and Cr) found in the fish samples, only Cu was found in quantities lower than the specified WHO limits.

Table 2. Mean concentration of heavy metals in liver, gills and muscles of *M. niger* and *L. campechanus*

Species		Heavy metals (mg/kg)					
		Pb	Cu	Ni	Cd	Zn	Cr
Macolor niger	Liver	0.83±0.82[a]	1.10±1.09[a]	0.00±0.00	0.00±0.00	18.25±3.98[b]	0.00±0.00[a]
	Gills	0.00±0.00[a]	0.91±0.90[a]	0.00±0.00	0.00±0.00	3.28±3.27[a]	0.00±0.00[a]
	Muscle	0.39±0.39[a]	1.03±1.02[a]	0.00±0.00	0.00±0.00	3.50±1.39[a]	4.59±4.59[b]
Lutjanu	Liver	1.19±1.19[a]	1.98±0.76[a]	0.00±0.00	0.00±0.00	6.58±3.40[a]	0.00±0.00[a]
scampechanus	Gills	1.29±1.29[a]	0.38±0.16[a]	0.00±0.00	0.00±0.00	4.41±4.40[a]	10.22±10.21[c]
	Muscle	0.67±0.67[a]	0.25±0.24[a]	0.00±0.00	0.00±0.00	6.98±1.91[a]	0.34±0.33[a]
WHO		0.50	3.50	0.04	0.007	7.00	0.15

Mean values having dissimilar superscripts along the same column are significantly different (P ≤ .05. DMRT)

*Heavy metal concentration in Cancer pagurus and Scylla serrate***:** Mean concentrations of heavy metal in muscle and exoskeleton of *C. pagurus* and *S. serrate* are shown in the Table 3. Concentration of heavy metals was generally higher in *C. pagurus* and *S. serrate.* Concentration of Pb (0.00 $\pm$ 0.00) and Cu (1.95 ± 0.20 mg/kg) were found at their lowest in muscle of *S. serrate*. Cd was not detected in both muscle and exoskeleton of the two crab samples while Cr was detected only in exoskeleton of *C. pagurus.* Likewise, Zn was detected only on muscles and not exoskeleton of the two crab species. Highest concentration of Pb (9.02 ± 0.85), Ni (11.90 ± 0.28) and Cr (2.13 ± 0.16) were detected in exoskeleton of *C. pagurus*, while those of Cu (31.38 ± 0.44) and Zn (37.04 ± 0.14) were detected in muscle of same species. All the heavy metals detected in both *C. pagurus* and *S. serrate* were found at concentrations higher than the specified WHO limits.

Health risk assessment of heavy metal bioaccumulation in Ojo River: Result for health risk assessment for consumption of the fishes and crabs in presented in table 4 and 5. The estimated daily intake of heavy metals from consumption of fillets of the fishes showed that residents feeding on both fish samples take in daily concentration of Pb, Cu, Zn and Cr higher than the oral reference doses.

Table 3. Concentration of heavy metal in muscle and exoskeleton of *C. pagurus* and *S. serrate*

Species		Heavy metals (mg/kg)					
		Pb	Cu	Ni	Cd	Zn	Cr
Cancer pagurus	Muscle	2.74 ± 0.49^b	31.38 ± 0.44^d	2.07 ± 0.19^a	0.00 ± 0.00^a	37.04 ± 0.14^c	0.00 ± 0.00^a
	Exoskeleton	9.02 ± 0.85^c	5.64 ± 0.15^c	11.90 ± 0.28^d	0.00 ± 0.00^a	0.00 ± 0.00^a	2.13 ± 0.16^b
Scylla serrate	Muscle	0.00 ± 0.00^a	1.95 ± 0.20^a	2.90 ± 0.15^b	0.00 ± 0.00^a	12.77 ± 0.17^b	0.00 ± 0.00^a
	Exoskeleton	8.46 ± 0.41^c	4.36 ± 0.07^b	10.54 ± 0.23^c	0.00 ± 0.00^a	$0'00 \pm 0.00^a$	0.00 ± 0.00^a
WHO		0.50	3.50	0.04	0.007	7.00	0.15

Mean values having dissimilar superscripts along the same column are significantly different ($P \leq .05$. DMRT)

Similarly, the EDIs for crabs were very high for most heavy metals with the exception of Cd and Cr (Table 4). Target hazard quotient on human health for consumption of both fishes was extremely high for Pb, Cu, Zn and Cr. Remarkably, THQ for the edible muscles of *M. niger* for Cr was 2874. Additionally, THQ for Pb, Zn and Cr were higher for the fish samples while THQ for Cu and Ni were higher in crab samples than fish samples (Table 5).

Table 4: Estimated daily intake of heavy metals from muscle of fish and crabs from Ojo River

Estimated Daily Intake (EDI) (mg/kg)						
Fish sample	Pb	Cu	Ni	Cd	Zn	Cr
Macolor niger	0.733	1.935	0.000	0.000	6.574	8.622
Lutjanu scampechanus	1.259	0.470	0.000	0.000	13.111	0.639
Crab sample	Pb	Cu	Ni	Cd	Zn	Cr
Cancer pagurus	0.407	4.659	0.307	0.000	5.500	0.000
Scylla serrate	0.000	0.290	0.431	0.000	1.896	0.000
Oral reference dose (RfDo, mg/kg bw/day)	**0.0035**	**0.04**	**0.02**	**0.001**	**0.3**	**0.003**

Oral reference doses except for Pb (Hang et al. 2009) were obtained from the Regional Screening Level (RSL) Summary Table (US EPA 2014).

Table 5: Target hazard quotient of heavy metals from muscle of fish and crabs from Ojo River

Target Hazard Quotient (THQ) (mg/kg)						
Fish sample	**Pb**	**Cu**	**Ni**	**Cd**	**Zn**	**Cr**
Macolor niger	209.43	48.38	0.00	0.00	21.91	2874.00
Lutjanu scampechanus	359.72	11.75	0.00	0.00	43.70	213.00
Crab sample	**Pb**	**Cu**	**Ni**	**Cd**	**Zn**	**Cr**
Cancer pagurus	116.29	116.48	15.35	0.00	18.33	0.00
Scylla serrate	0.00	7.25	21.55	0.00	6.32	0.00

Target hazard quotient > 1 poses threat for consumers of the species.

Bioaccumulation of heavy metals in freshwater foods have long been an issue of concern especially in areas where residents depend largely on sea/freshwater foods for their daily nutrients. Humans rely largely on these freshwater foods because they are good sources of protein. Thus, it is necessary to assess health risk related to consumption of freshwater foods considering the fact that freshwater organisms bioaccumulate heavy metals known to cause adverse health impacts in human system. In assessing the potential health risk from consumption of freshwater foods from Ojo River, this study assessed the concentration of heavy metals in Ojo River and bioaccumulation of heavy metals in two (2) species of fishes and crabs each from the river. More importantly, the level of bioaccumulation in edible parts of the organism was assessed and daily intake and target hazard was estimated. Results showed that Pb, Cd and Cr exist in water samples from Ojo river at different concentrations. While Pb and Cr were detected at concentrations below the WHO limits, Cd concentration in the different locations was at same level (0.01 mg/kg) with the limits set by WHO. The concentrations at which the heavy metals were detected in the river suggests that the water is safe for consumption, however, biomagnification of the heavy metals along the food chain need to be assessed to fully ascertain the safety of consumption of freshwater foods collected from the river. Therefore, concentration of heavy metals in body tissues of two (2) common edible freshwater fish species (*M. niger* and *L. scampechanus*) and two (2) edible crab species (*C. pagarus* and *S. serrate*) were assessed and it was revealed that, concentration of heavy metals in the body parts of the fishes and crabs were higher than the concentration of heavy metals in water samples from Ojo river. This agrees with earlier postulations that heavy metal concentrations in aquatic organisms are higher than concentrations in their surrounding medium (Kalfakakon and Akrida-Demertzi 2000; Gary, 2002), thereby suggesting bioaccumulation of heavy metals in tissues of the freshwater organisms (Jakimska *et al.*, 2011). Bioaccumulation is the process through which substances accumulate in the tissues and body part of organisms along the food chain. Typically, fishes have the tendency to bioaccumulate heavy metals in different part of their body (Zhao *et al*., 2012; Aghoghovwia *et al.,* 2016), this support the result from this study as heavy metals were detected in all the body parts analysed at higher concentration that what is obtained in water samples from Ojo River. Also, finding from this study revealed that concentration of heavy metals in both fish samples showed higher bioaccumulation in the liver tissues than the gills and muscle except for concentration of Cr in *L. scampechanus*. This report contradicts earlier finding by Liu *et al*., (2015), where concentration of heavy metals in gills were seen to be higher than other parts of the body. Higher concentrations in liver may have occurred due to the fact that the liver is the main organ involved in detoxification of toxins in the body of animals. Similarly, lower concentration of heavy metals in muscles of fishes than in liver agrees with earlier propositions that the bioaccumulation power of fish muscles is lower than other body parts of fishes (Tapia *et al*., 2012). Worthy of mentioning is the fact that Nickel and Cadmium were not found in all body parts of the two fish species. Nickel and cadmium are two heavy metals that are usually connected with metallurgical processes, alloy production, nickel-cadmium batteries and electroplating (Genchi *et al*., 2020). The two heavy metals have been reported to be carcinogenic albeit nickel at its right dose is an essential nutrient required for some biochemical and physiological functioning of living systems (Genchi *et al*., 2020). Fish are a major source of animal protein (Izah and Angaye 2015), likewise, crab meat is nutritionally valuable as a rich source of high-quality protein, minerals and vitamins (Adeyeye, 2002; Skonberg and Perkins, 2002) with low levels of fat and carbohydrates (Udo and Arazu, 2012). This accounts for why these two aquatic organisms are major sources of food around the world. The bioaccumulation of heavy metals in crab body parts was also analysed. Heavy metal concentrations were generally higher in exoskeleton of crabs than in the muscles except for Zn that was not found at all in exoskeleton of the two crab species and found in relatively high concentration in the muscles. Likewise, as recorded for the concentration in the fish samples, cadmium was not found at all in all body parts of the two species of crab. It is pertinent to note that the concentration of these heavy metals in the two species of crab were far higher than the concentration in the body parts of fishes. Higher bioaccumulation potential in crabs as against fishes have been recorded in numerous other studies and this have been attributed to the benthic nature of crab (Das *et al*., 2007; Bonsignor *et al*., 2018). As a benthic aquatic organism, crabs are more exposed to heavy metals in sediments at the benthic zone or floors of rivers and seas. This allows them to pick up more quantities of heavy metals that have accumulated at the bottom (Bonsignor *et al*., 2018) of the water body and this informs why they are more suitable as heavy metals monitoring organism unlike fishes that spend a good deal of the life time at the middle and upper part of the water body. Also, there was very high bioaccumulation of Nickel in tissues of the two crab species unlike the fishes that no trace of Nickel was found in their liver, gills and muscles. The sharp difference in the bioaccumulation of Nickel in crab and fishes may be due to difference in the space the organisms spend most of their time in the water body as well as the solubility of the nickel compounds that find their way into the water body. More likely, the nickel compounds are non-soluble and aggregate at the benthic zone of Ojo river where crabs are more likely to feed unlike the two fish species. This finding corroborates previous researches that have suggested that crabs are better bioaccumulators of heavy metals, therefore they are good candidates for biomonitoring of the concentration and impact of heavy metals in water bodies (Kamaruzzaman *et al*., 2012). Bioaccumulation of heavy metals by aquatic lifeforms located at the end of the food chain usually enhance passage of these heavy metals to humans through consumption of the aquatic organism and these have been known to lead to chronic or acute diseases (Subrahmanyam and Al-Mohanna, 2001). These heavy metals biomagnify in human systems and the metallic toxicants attack proteins notably enzymes (Ademoroti, 1996) and their toxic effects are cumulative and cause slow poisoning of the system over a period of time (Ukpebor *et al.,* 2005). In many cases, biomagnification of heavy metals in human system has been implicated in the upsurge of liver and kidney diseases, and it is believed to be responsible for a high proportion of mortality caused by kidney and liver morbidity (Friberg, *et al.,* 1986; Ndiokwere, 2004). In line with this, we estimated the daily intake and target hazards of these heavy metals for residents of Lagos, Nigeria that depend on aquatic lifeforms in Ojo River as source of foods. The estimated daily intakes for Pb, Cu and Zn were extremely high when compared with the oral reference dose (USEPA, 2014). This poses huge risk for residents that depend on freshwater foods from Ojo River for nutrient. The possibility of gradual accumulation of these three metals in the body of residents is high and these could lead to several alteration in the physiology of the human system, thereby leading to malfunctioning of several organs. More importantly, accumulation of Pb in human system has been attributed to failure of key organs (especially liver and kidney) in the human body (Al-Busaidi *et al*., 2011). It has also been implicated in the development of cancer in other vital parts of the body (Barrento *et al*., 2009). Likewise, accumulation of Cu and Zn in the body have been attributed to malfunctioning of several other organs in the body (Rahman *et al*., 2012). Of particular concern is the EDI of Cr through consumption of these aquatic organisms. The high EDI calls for serious concerns as Cr may accumulate to a harmful level at which it can cause damage to the human body within short period of time. Excess Cr in human system have been documented to lead to lung cancer, skin ulterations (Arain *et al*., 2009) and dysfunction in human hormonal system (Shobana *et al*., 2020). In the same vein, THQ for all the metals except Cd that is found in both fishes and crabs also support the concerns raised on the EDI for consumers of freshwater foods from Ojo River. The risk involved in consuming these foods is extremely high due to extreme level of heavy metals in the edible muscles of the fishes and crabs. The level of bioaccumulation of heavy metals in freshwater organisms in Ojo River is alarming. The level of at which the heavy metals exist in tissues of seafoods calls for serious research into routes through which these heavy metals enter Ojo river. It is of serious concern because of the extremely high EDI and THQ that suggest serious health risk for Lagos residents that feed on seafoods from the river. Further research focused on unveiling and mitigating entry of heavy metals in the river should be look into. Lastly, appropriate regulations to guide against further deterioration of the impacts of the heavy metals in Ojo River and regulate consumption of seafoods from the river need to be put in place.

Conclusion: There is high heavy metals concentration in Ojo River and bioaccumulation is very high in aquatic organism such as fishes and crab. Aquatic organisms such as fishes and crabs accumulate the heavy metals in their tissues beyond the suggested limits. The EDI and THQ suggest that residents feeding on freshwater foods from Ojo river are at extremely high health risk and this could affect the overall health of the population in few years to come. This calls for serious reconsideration concerning consumption of edible aquatic produce from Ojo River.

Acknowledgement: The authors appreciate the efforts of staff of Environmental Biology Department Laboratory, Lagos State Polytechnics, Ikorodu, Lagos, Nigeria.

REFERENCES

Adefemi, OS; Olaofe, O; Asaolu, SS (2004). Concentration of Heavy metals in water, sediment and fish parts (Illisha africana) from Ureje dam, Ado-Ekiti, Ekiti State, *Nig. J. Biol. Phy. Sci.* 3: 111 –114.

Ademoroti, CMA (1996). Environmental Chemistry and Toxicology. Foludex Press Ltd. Ibadan, 215.pp

Adeyeye, EL (2002). Determination of the chemical composition of the nutritionally valuable part of male and female common West African fresh water crab *Sudananautes africanus. Int. J. Food. Sc. Nutria.* 53(3): 189-196.

Aghoghovwia, OA; Ohimain, EI; Izah, SC (2016). Bioaccumulation of Heavy metals in different tissues of some commercially important fish species from Warri River, Niger Delta, Nigeria. *Biotech Res.* 2(1): 25-32.

Al-Busaidi, M; Yesudhason, P; Al-Mughairi, S; Al-Rahbi, WAK; Al Harthy, KS; Al-Mazrooei, NA; Al-Habsi, SH (2011). Toxic metals in commercial marine fish in Oman with reference to national and international standard. *Chemosphere*. 85: 67-73.

Ali, MM; Ali, ML; Islam, MS; *Rahman*, MZ (2016). Preliminary assessment of heavy metals in water and sediment of Karnaphuli River, Bangladesh. *Environ. Nanotech. Monit. Manag.* 5: 27-35.

Angaye, TCN; Zige, DV; Izah, SC (2015). Microbial load and heavy metals properties of leachates from solid wastes dumpsites in the Niger Delta, Nigeria. *J. Environ. Treat. Tech*. 3(3): 175 – 180.

Arain, MA; Haque, Z; Badar, N; Mughal, N (2009). Drinking water contamination by chromium and lead in industrial lands of Karachi. *J. Pak. Med. Assoc*. 59(5): 270-274.

Barrento, S; Marques, A; Teixeira, B; Carvalho, ML; Vaz-Pires, P; Nunes, ML (2009). Accumulation of elements (S, As, Br, Sr, Cd, Hg, Pb) in two populations of Cancer pagurus: ecological implications to human consumption. *Food Chem. Toxicol.* 47(1): 150-156.

Beltrame, MO; De Marco, SG; Marcovecchio, JE (2011). The burrowing crab Neohelice granulate as potential bioindicator of heavy metals in estuarine systems of the Atlantic coast of Argentina. *Environ. Monit. Assess*. 172: 379-389.

Bonsignore, M; Manta, DS; Mirto, S; Quinci, EM; Ape, F; Montalto, V; Gristina, M; Traina, A; Sprovieri, M (2018). Bioaccumulation of heavy metals in fish, crustaceans, molluscs and echinoderms from the Tuscany coast. *Ecotoxicol. Environ. Saf.* 162: 554-562.

Bosnak, CP (2007). *ICP-Mass Spectrometry* (PerkinElmer, Shelton,CT, USA) 1-9pp.

Charis, KB; Abbasi, SA (2005). Characteristics of Heavy Metals. *Int. J. Environ. Studies*. 62: 137-145.

Chukwujindu, MA; Nwoso, SO; Ossai, EK; Nwaje, GE (2008). Aquatic animals' way of life. *Am. J. Food. Tech.* 3(3): 220-223.

Dakka, A (2013). Egypt's Water Crisis – Recipe for Disaster. Middle East. 2pp.

Das, A; Mandal, B; Sarkar, J; Chaudhuri, S (2007). Bioaccumulation of heavy metals in some commercial fishes and crabs of the Gulf of Cambay, India. *Curr. Sci*. 92:1489-1491.

Friberg, L; Nordberg, GF; Vouk, VB eds. (1986). Handbook of the toxicology of metals. Vol. II. Amsterdam, Elsevier, 130–184 pp.

Gary, JS (2002). Biomagnifications of methyl mercury in marine systems the perspective of and ecologist. *Mar. Pollut. Bull.* 45:46- 52.

Genchi, G; Carocci, A; Lauria, G; Sinicropi, MS; Catalano, A (2020). Nickel: Human Health and Environmental Toxicology. *Int. J. Environ. Res. Public Health*. 17(3):679.

Gupta, A; Rai, DK; Pandey, RS; Sharma, B (2009). Analysis of some heavy metals in the riverine sediments and fish from river Ganges at Allahabad. *Environ. Monitor. Assess*. 157:449 – 458.

Hang, XS; Wang, HY; Zhou, JM; Ma, CL; Du, CW; Chen, XQ (2009). Risk assessment of potentially toxic element pollution in soils and rice (*Oryza sativa*) in a typical area of the Yangtze River Delta. *Environ. Pol.* 157(8): 2542–2549.

Izah, SC; Angaye, TCN (2015). Ecological perception of fish farmers in Yenagoa Metropolis, Nigeria. *Bull. Adv. Sci. Res.* 1(1): 26 – 28.

Jakimska, A; Konieczka, P; Skora, K; Namieśnik, J (2011). Bioaccumulation of metals in tissues of marine animals, part I: the role and impact of heavy metals on organisms. *Pol. J. Environ. Stud.* 20(5): 1117-1125.

Kalfakakon, V; Akrida-Demertzi, K (2000). Transfer factors of heavy metals in aquatic organisms of different trophic level. Accessed July 18, 2021, retrieved from http.//business.nol.gr/boil/allfile/ HTML / Kalfakhtm

Kamaruzzaman, BY; John, BA; Maryam, BZ; Jalal, KCA; Shahbuddin, S (2012). Bioaccumulation of heavy metals (Cd, Pb, Cu and Zn) in scylla serrata (forsskal 1775) collected from Sungai Penor, Pahang, Malaysia. *Pertanika J. Trop. Agric. Sci.* 35(1): 183-190.

Karadede-akin, H; Unlu, E (2007). Causes of heavy metals in the environment. *Environ. Monit. Assess.* 131: 323-337.

Liu, J; Wu, H; Feng, J; Li, Z; Lin, G (2014). Heavy metal contamination and ecological risk assessments in sediments and zoobenthos of selected mangrove ecosystems, South China. *Catena*. 119(4): 136-142.

Liu, JL; Xu, XR; Ding, ZH; Peng, JX; Jin, MH; Wang, YS; Hong, YG; Yue, WZ (2015). Heavy metals in wild marine fish from South China Sea: levels, tissue and species-specific accumulation and potential risk to humans. *Ecotoxicol*. 24: 1583–1592.

Liu, Q; Liao, Y; Xu, X; Shi, X; Zeng, J; Chen, Q; Shou, L (2020). Heavy metal concentrations in tissues of marine fish and crab collected from the middle coast of Zhejiang Province, China. *Environ. Monitor. Assess.* 192(5): 285. doi.org/10.1007/s10661-020-8234-1

Liu, Q; Xu, X; Zeng, J; Shi, X; Liao, Y; Du, P; Tang, Y; Huang, W; Chen, Q; Shou, L (2019). Heavy metal concentrations in commercial marine organisms from Xiangshan Bay, China, and the potential health risks. *Mar. Poll. Bull.* 141: 215–226.

Ndiokwere, CL (2004). Chemistry and Environment. University of Benin, Inaugural Lecture Series, 73 pp.

Nriagu, JO (1988). A silent epidemic of environmental metal poisoning? *Environ. Poll.* 50(1-2): 139-161.

Ohimain, EI; Jonathan, G; Abah, SO (2008). Variations in heavy metal concentrations following the dredging of an oil well access canal in the Niger Delta. *Adv. Biol. Res.* 2 (5-6): 97-103.

Oyakhilome, GI; Aiyesanmi, AF; Adefemi, SO; Asaolu, SS (2013). Interrelationship of heavy metals concentration in water, sediment and fish samples from Owena multi-purpose dam, Ondo State, Southern Nigeria. *J. Emerg. Trends Eng. Appl. Sci.* 4(2): 207-215.

Pinheiro, MAA; Silva, PPG; Duarte, LFA; Almeida, AAA; Zanotto, FP (2012). Accumulation of six metals in the mangrove crab *Ucides cordatus* (Crustacea: Ucididae) and its food source, the red mangrove *Rhizophora mangle* (Angiosperma: Rhizophoraceae) *Ecotoxicol. Environ. Saf*. 81: 114-121.

Rahman, MS; Molla, AH; Saha, N; Rahman, A (2012). Study on heavy metals levels and its risk assessment in some edible fishes from Bangshi River, Savar, Dhaka, Bangladesh. *Food Chem*. 134: 1847-1854.

Rainbow, PS (1995). Biomonitoring of heavy metal availability in the marine environment. *Mar. Pollut. Bull*. 31: 183-192.

Seiyaboh, EI; Izah, SC; Oweibi, S (2017). Assessment of water quality from Sagbama Creek, Niger Delta, Nigeria. *Biotech. Res.* 3(1): 20-24.

Shobana, N; Kumar, MK; Navin, AK; Akbarsha, MA; Aruldhas, MM (2020). Prenatal exposure to excess chromium attenuates transcription factors regulating expression of androgen and follicle stimulating hormone receptors in Sertoli cells of prepuberal rats. *Chemico-Biol. Interact.* 328: 109188.

Skonberg, DI; Perkins, BL (2002). Nutrient composition of green crab (*Carcinus maenus)* leg meat and claw meat. *Food Chem.* 77: 401-404.

Al-Mohanna, SY; Subrahmanyam, MN (2001). Flux of heavy metals accumulation in various organs of the intertidal marine blue crab, *Portunus pelagicus* (L) from the Kuwait coast after the Gulf War. *Environ. Int*. 27(4): 321-326

Tapia, J; Vargas-Chacoff, L; Bertrán, C; Peña-Cortés, F; Hauenstein, E; Schlatter, R; Jimenez, C; Tapia, C (2012). Heavy metals in the liver and muscle of *Micropogonias manni* fish from Budi Lake, Araucania Region, Chile: potential risk for humans. *Environ. Monitor. Assess.* 184(5): 3141-3151.

Udo, JP; Arazu, VN (2012). The proximate and mineral composition of two edible crabs *Callinectes amnicola* and *Ucatangeri* (crustacean: decapoda) of the Cross River Nigeria Park. *J. Nutrition.* 11(1): 78-82.

Ukpebor, JE; Ndiokwere, CL; Ukpebor, EE (2005). The uses of heavy metals load as an indicator of the suitability of Ikpoba River for domestic and consumption purposes. *Chem. Tech. J.* 1: 108--115.

US EPA (2014). Region 9, Regional Screening Level (RSL) Summary Table (TR=1E-6, HQ=1.0) Available online at https://semspub.epa.gov/work/HQ/401635.pdf accessed 30th December, 2021.

Yusuf, KA; Osibanjo, O (2006). Trace metals in water and sediments from Ologe lagoon, southwestern Nigeria. *Pak. J. Sci. Ind. Res*. 49: 88-89.

Zhao, S; Feng, C; Quan, W; Chen, X; Niu, J; Shen, Z (2012). Role of living environments in the accumulation characteristics of heavy metals in fishes and crabs in the Yangtze River Estuary, China. *Mar. Pollute. Bull*. 64: 1163-1171.

.