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BIOACCUMULATION AND RISK ANALYSIS OF SELECTED HEAVY METALS IN *CLARIAS GARIAPINUS* AND *TILAPIA ZILI* FISH SPECIES OF ABANDONED MINING PONDS

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Abstract: *Heavy metals (Cd, Co, Cr, Cu, Ni and Pb) were determined in some selected fish species (Clarias gariepenus and Tilapia zili) from Bokkos abandoned mining sites. Sample matrices examined were flesh gills, kidney and liver of each fish species. Twenty (20) sample sites were selected for the sample matrices under investigation. After sample collection and treatment, heavy metals were determined using Atomic Absorption Spectrophotometer (AAS, Bulk Scientific Model 210 VGP). The concentration patterns for each of the elements in the fish species showed significant and relatively similar patterns in cat fish with Ni having the highest concentration, followed by Cr, Co, Pb Cd and Cu in that order with respective. Cumulative bioconcentration in Tilapia zili showed that Cd < Cu < Pb < Co < Cr < Ni respectively. Pearson correlation showed various interactions and relationships existing between and within sample matrices, indicating that these heavy metals have similar source, species or geochemical interaction. Only Co has a weakly positive correlation 0.58 with Pb while in Tilapia zilli, while Cu has correlation with Ni in Clarias gariepenus. Also the interactions and behaviors of the fish species suggests water and sediment for Cu, Ni and Co, Pb respectively. The relative contributions of Cr, Ni and Pb to the aggregated risk were 59.86%, 0.21%, 38.03% and 1.76% respectively. Consumption of these fish species from the study area therefore poses serious health concern upon consumption over time.*

Keywords: *Bioaccumulation, Clarias gariepenus, Heavy Metals, Risk Analysis, Tilapia zilli*

INTRODUCTION

Heavy metals are well-known environmental pollutants due to their toxicity, persistence in the environment, and bioaccumulative nature. Their natural sources include weathering of metal-bearing rocks and volcanic eruptions, while anthropogenic sources include mining and various industrial and agricultural activities (Hazrat et al., 2019). Mining and industrial processing for extraction of mineral resources and their subsequent applications for industrial, agricultural, and economic development has led to an increase in the mobilization of these elements in the environment and disturbance of their biogeochemical cycles. The concentration of bioaccumulated heavy metals in the fish body is a function of some environmental parameters, including pH, temperature, alkalinity of the environment, pollutant type, sampling site (Miri et al., 2017; Fakhri et al., 2018). The presence of heavy metals in marine environment is the results of two main sources of contamination: natural occurring deposit and anthropogenic activities such as domestic, industrial, and agricultural activities (Miri et al., 2017; Kargin et al., 2001).

Contamination of aquatic and terrestrial ecosystems with toxic heavy metals is an environmental problem of public health concern. Being persistent pollutants, heavy metals accumulate in the environment and consequently contaminate the food chains. Accumulation of potentially toxic heavy metals in biota causes a potential health threat to their consumers including humans.

Fish is an important part of the human diet because of its high nutritional quality (Sioen et al., 2007). Consequently, fish are often used as indicators of heavy metals contamination in the aquatic ecosystem because they occupy high trophic levels and are important food source (Agah et al., 2009). Fishes are known for their innate potential to bioaccumulate heavy metals in their muscles and various organs (Opasola et al., 2019) and so nonessential trace elements in the edible tissues of fish have been detected due to be bioaccumulation in organism and the highly persistent and non-biodegradable properties (Burger & Gochfeld, 2007; Zhang & Wang, 2012. However, fish are relatively situated at the top of the aquatic food chain; therefore, they normally can accumulate heavy metals from food, water

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and sediments (Yilmaz et al., 2008; Zhao et al 2012).The content of toxic heavy metals in fish can counteract their beneficial effects; several adverse effects of heavy metals to human health have been known for long time Castro-Gonzalez & Mendez-Amenta, 2008). This may include serious threats like renal failure, liver damage, cardiovascular diseases and even death (Al-Bisaidi et al., 2012; Rahman et al., 2012). Therefore, many international monitoring programs have been established in order to assess the quality of fish for human consumption and to monitor the health of the aquatic ecosystem (Meche et al., 2003). According to the literatures, metal bioaccumulation by fish and subsequent distribution in organs is greatly inter-specific. In addition, many factors can influence metal uptake like sex, age, size, reproductive cycle, swimming patterns, feeding behavior and living environment (i.e., geographical location) (Mustafa & Guluzar, 2003; Zhao et al 2012). Hence, fishes are considered as one of the best indicator of heavy metal contamination in coastal environment (Evans et al., 1993; Rashed, 2001).

Fish have the ability to accumulate heavy metals in their tissues by absorption along gill surface and kidney, liver and gut tract wall to higher concentration levels than in environmental samples (Miri et al., 2017). Accumulation of heavy metals by organisms may be passive or selective; and differences in accumulation of heavy metals by organisms could be as a result of differences in assimilation, egestion or both (Nangbes et al., 2020: Fakhri et al., 2018). Non-essential but toxic heavy metals such as Cadmium (Cd), Mercury (Hg) and Lead (Pb) have no known beneficial role in living organisms but exhibit extreme toxicity even at very low levels of metal exposure and have been regarded as major threats to all forms of life especially human health (Nangbes et al., 2020: Kargin et al., 2001; Nabayi et al., 2012). Toxic effects occur when excretory, metabolic, storage and detoxification mechanisms are no longer able to counter uptake (Sayyad et al., 2007) eventually resulting in biochemical, physiological and histopathological alterations (EC, 2014; FAO/WHO, 2011; Kargin and Cogum, 1999). These changes can also be altered biochemically by water physico-chemistry (Miri et al., 2017). Entry of heavy metals into the organs of a fish mainly takes place by adsorption and absorption; the rate of accumulation is a function of uptake and depuration rates (Miri et al., 2017). According to Kargin, (1999), non-essential metals, aside from being toxic and persistent, are bioaccumulated and internally regulated using different strategies such as active excretion and storage. Significant variations in the levels of non-essential heavy metals have been reported between organs and species of fish inhabiting the same freshwater body:

The concentrations of heavy metals in fish have been extensively studied over the past several decades. Research has shown that extent of accumulation of heavy metals in fish is dependent on the metal types, fish species, and the tissues respectively (Korkmaz et al., 2012; Petrovic et al., 2013). Water chemistry (Driscoll et al., 1994) directly affects the accumulation of heavy metal in fish. Sediment is also know to an important factor heavy metal accumulation in fish, as it is considered as the major source of contaminants for bottom dwelling and bottom feeding aquatic organisms (Farag et al., 1998), which in turn represents the concentrated source of metals in the diet of fish. Heavy metals accumulate in fresh water and elevate through food chain and fishes are badly affected because they are top consumer in aquatic systems. Humans are also affected by intake of fishes for mostly people of those areas where main food is fish (Afshan et al., 2014).

Mercury (Hg) is one of the most hazardous environmental pollutants due to its toxicity and its accumulation in aquatic organisms. The relative toxicity of mercury depends on its chemical form, methyl mercury being one of the most toxic substances existing in the environment (Nangbes *et al.,* 2020). The consumption of fish is the main route of exposure of humans to monomethylmercury, which represent the main form of mercury in fish due to biomagnification and bioconcentration in the marine food chain (Bakre-dunola, 2005). According to some other researchers (Akan *et al.,* 2012; Mehdi *et al.,* 2013; Mensoor and Said, 2018), the order of mercury concentrations in tissues of the fish species was as follows: liver > gill > muscle and in tissues of the kingfisher species was as follows: feather > liver > kidney > muscle. Several researchers have shown that although the bioaccumulation of heavy metals in the tissues of fish and other aquatic lives vary in the sense that are higher than the permissible limit, hence posing health risk upon consumption, other can be within or below the tolerable limits (Aytekin *et al.,* 2019; Shahsavani *et al.,* 2017; Yi *et al.*, 2017; Omoregie, *et al* 2016). However, upon continuous consumption and bioconcentration, they can equally be harmful to the human body system, hence the essence of this work.

MATERIALS AND METHODS

All glass wares used were washed with liquid detergent and rinsed thrice with distilled water followed by oven drying. Polyethylene sample bottles and Teflon beakers were washed with liquid detergent and rinsed with distilled water prior to sample collection (Ogunfowokan A. O. et al., 1998, 2008).

Bokkos L.G.A is a local government in Plateau state of Nigeria at latitude 9o1757.16 North and longitude 8o559.81 East. It has area 1,682km2 (649 sq miles) and population of (2006 census) 178,454. The chemo metric study covered five mining ponds. They are one of the notable areas because of their large industrialization that potentially contribute to soil pollution. The locations of the sample sites are shown below.

Table 1. Geographical location of sampling sites

Sample Site	Latitude	Longitude	Altitude (M)
Mai-Katako	09o33.913’	008o54.030’	1299
Kuba	09o31.748’	008o54.081’	1295
Bot	09o32.966’	008o53.173’	1287
Mabel	09o30.859’	008o58.997’	1297
Ganadanji	09o32.876’	008o52.116’	1289

After the fish were rinsed with distilled water, each fish was dissected using stainless-steel knife to extract the organs of interest (liver, gills, kidney and flesh). Polyethylene gloves were worn during dissection of fish tissues to reduce surface contamination of samples. After dissection, 20 g samples of each tissue were dried at 60 °C until they were reduced to constant weight. Dried tissues were ground, sieved and transferred to porcelain dishes.

One gram powdered tissue sample was digested in 65% HNO3 mL for 0.5 g of dried sample) and 30% H2O2. All the digested liquors were diluted to 25 mL in volumetric flasks with double-distilled water and stored in acid-washed polyethylene bottles. The sediment samples were digested using a concentrated acid mixture (HNO3/HClO4/HF=5/1/1, v/v/v). Blank digestions were also carried out in the same way. The concentrations of heavy metals in the digests were determined by flame atomic absorption spectrophotometry (AAS, Perkin Elmer, (Model 3100) under standard operational procedures. The filtrate obtained was analyzed for Cd, Cu, Cr, Ni, Co, and Pb using a buck scientific atomic absorption spectrophotometer mede1210VGP. Ar-Acetlylene (8:6) flame and hallow Cathode Lamps for the respective elements were used at their various wavelengths, Calibration standards were obtained by preparing 100N/gcm^3 stock solution of the nitricate salts of the metals and the stock solution diluted to obtain working standards. Duplicate analyses were carried out for each samples and the average was taken.

RESULTS AND DISCUSSION

The mean result of heavy metals determined in the fish sample organs are as presented in Table 2 below. Tables 3 and 4 are the health risk analysis parameters.

Table 2. Mean Concentration of Heavy Metals in Fish species (mg/kg)

Sample Matrix	Organ	Cd	Co	Cr	Cu	Ni	Pb
Clarias gariapinus	Gills	0.02±0.02	0.30±0.02	0.27±0.02	0.09±0.02	0.59±0.02	0.14±0.02
	Flesh	0.02±0.02	0.10±0.02	0.74±0.02	0.02±0.02	1.94±0.02	0.27±0.02
	Kidney	0.01±0.02	0.28±0.05	0.25±0.13	0.02±0.02	2.90±0.55	0.64±0.12
	Liver	0.27±0.02	0.19±0.02	0.50±0.02	0.03±0.02	4.10±0.02	0.20±0.02
Tilapia zili							
	Gills	0.02±0.02	0.30±0.02	0.45±0.02	0.02±0.03	0.92±0.02	0.15±0.02

	Flesh	0.02±0.02	0.19±0.02	0.18±0.02	0.02±0.03	0.63±0.02	0.01±0.01
	Kidney	0.02±0.02	0.23±0.02	0.52±0.02	0.03±0.02	0.81±1.02	0.01±0.01
	Liver	0.02±0.00	0.15±0.05	0.34±0.01	0.03±0.02	1.18±0.02	0.11±0.00
Water		0.02±0.00	1.13±0.02	0.38±0.02	0.02±0.02	0.71±0.02	0.11±0.02

Health risk analysis of the metals determine in each fish sample were done using three parameters, bioaccumulation factor, health risk index, target hazard quotient and hazard index. Results were as shown in tables 3 and 4 for *Clarias gariapinus* and *Tilapia zili* respectively while table 5 showed the hazard index for the organs in both fish species.

Means, standard deviations, minimum and maximum of the concentrations of the heavy metals for the various samples were calculated. Pearson's correlation was applied to examine specific relationships among the different metals. Pearson's correlation analysis was done to distinguish the possible common sources of heavy metals contamination and how some of the heavy metals influence their concentration Zhang *et al*., 2018; Li *et al*., 2013).

To assess the potential health risks associated with long term ingestion of fish contaminated with heavy metals, the average daily dose (ADD) of heavy metals, bioaccumulation factor (BAF), hazard index (HI), target hazard quotient (THQ), and health risk index (HRI) were calculated. Table 1 shows the parameters that characterized the ADD where RfD is the potential toxic element (PTE) oral reference dose for As = 0.0003, Cd = 0.001, Cr = 0.003, Ni = 0.02, Pb = 0.0035 (Li *et al*., 2015a, 2015b); Chen *et al*., 2015; Udofia *et al*., 2016; Omoregie *et al*., 2016; Sharma *et al*., 2016; Jörg *et al*., 2019; Opasola *et al*., 2019; Somda *et al*., 2019).

$$BAF = \frac{\mathbf{CnBiota}}{\mathbf{CnWater}} \qquad \ldots\ldots\ldots\ldots \qquad \mathbf{(1)}$$

$$DIM = \frac{\mathbf{Cmetal\ x\ Cfactor\ x\ Dfood\ intake}}{\mathbf{Baverage\ weight}} \qquad \ldots\ldots\ldots\ldots \qquad \mathbf{(2)}$$

where Cmetal = Heavy metal concentrations in plants (mg·kg−1), Cfactor = Conversion factor (CF) of 0.070 was used for the conversion of fresh vegetables to dry weight, Dfood intake = Daily intake of the food crops was 0.50 kg·person−1 ·d−1 and Baverage weight = Body weight for the adult population was 65.0 kg.

$$HRI = \frac{DIM}{\mathbf{RfD}} \qquad \ldots\ldots\ldots\ldots \qquad \mathbf{(3)}$$

$$HQ = \frac{(\mathrm{D}) \times (\mathrm{Cmetal})}{\mathrm{Rf\,D} \times \mathrm{BO}} \qquad \ldots\ldots\ldots\ldots\ldots \qquad \mathbf{(4)}$$

where, D = daily intake of food (kg/day), C_{metal} = concentration of metal (mg/kg), Rf D = reference oral dose of metal (mg/kg of body weight/day) and BO = Body weight (kg). Daily intake of vegetables was taken as 0.100 kg for adults, as this is the minimum vegetable requirement for a balanced diet, it is prescribed that for a balanced diet, one must have a minimum serving of 100 g for 3 times (National Institute of Nutrition 2011).

Also the organ-organ heavy metal interactions were determined by Pearson correlation using the SPSS Microsoft software version 23. These results were as shown in tables 6 and 7.

Hazard index is used to estimate the potential human health risk when more than one heavy metal is consumer. HI was calculated as the sum of HQs.

HI = (THQi + THQii + THQiii………THQn) ΣTHQ (5)

The hazard index (HI) was computed as the sum of the Target Hazard Quotients of the heavy metals under study (US EPA, 1989, Guerra *et al*., 2012: Udofia *et al*., 2016; Ametepey *et al*., 2018) as described in Equation (5).

Table 3. Mean results of health risk factors in organs of *Tilapia zili*

Risk Factor	Organs	Cd	Co	Cr	Cu	Ni	Pb
BAF	Gills	1.00	0.26	0.71	4.50	0.83	1.27
	Flesh	1.00	0.08	1.95	1.00	2.73	2.45
	Kidney	0.50	0.24	0.65	1.00	4.08	5.81
	Liver	13.50	0.16	1.31	1.50	5.77	1.81
HRI	Gills	0.04	0.36	0.004	0.005	0.071	0.084
	Flesh	0.05	1.20	0.001	0.012	0.235	0.16
	Kidney	0.02	3.40	0.004	0.001	0.351	0.38
	Liver	0.065	2.30	0.001	0.001	0.004	0.121
THQ	Gills	0.40	495.312	6.513	0.027	0.355	0.422
	Flesh	0.241	5.475	176.534	6.031	0.112	0.814
	Kidney	0.120	16.887	60.311	6.031	1.749	1.929
	Liver	3.220	11.459	120.624	9.046	0.002	0.603

Table 4. Mean Hazard Index (HI) of fish species

Sample matrix	*Clarias gariapinus*	*Tilapia zili*
Gills	503.03	133.93
Flesh	189.21	62.07
Kidney	87.03	136.58
Liver	114.95	101.4

Table 5. Mean results of health risk factors in organs of *Clarias gariepenus*

Risk Factor	Organs	Cd	Co	Cr	Cu	Ni	Pb
BAF	Gills	1.00	0.26	1.18	1.00	1.29	1.36
	Flesh	1.00	0.16	0.47	1.00	0.88	0.09
	Kidney	1.00	0.20	1.36	1.50	1.14	0.09
	Liver	1.00	0.13	0.89	1.50	1.66	1.00
HRI	Gills	0.004	1.400	13.10	5.450	0.071	0.084
	Flesh	0.049	1.200	35.80	1.210	0.230	0.163
	Kidney	0.024	3.395	12.12	0.0012	0.350	0.387
	Liver	0.650	2.300	24.20	0.0018	0.490	0.121
THQ	Gills	0.241	18.093	108.561	6.031	0.554	0.452
	Flesh	0.241	11.969	43.424	6.031	0.379	0.030
	Kidney	0.241	1.330	125.448	9.046	0.488	0.030
	Liver	0.241	9.046	82.023	9.046	0.711	0.331

Table 6. Correlation of heavy metal concentration between organs of *Clarias gariapinus*

		Cd	Co	Cr	Cu	Ni	Pb
Cd	Pearson Correlation	1	-.215	.193	-.180	.751	-.367
	Sig. (2-tailed)		.785	.807	.820	.249	.633
	N	4	4	4	4	4	4
Co	Pearson Correlation	-.215	1	-.992**	.593	-.271	.232
	Sig. (2-tailed)	.785		.008	.407	.729	.768
	N	4	4	4	4	4	4
Cr	Pearson Correlation	.193	-.992**	1	-.487	.172	-.338
	Sig. (2-tailed)	.807	.008		.513	.828	.662
	N	4	4	4	4	4	4
Cu	Pearson Correlation	-.180	.593	-.487	1	-.722	-.582

	Sig. (2-tailed)	.820	.407	.513		.278	.418
	N	4	4	4	4	4	4
Ni	Pearson Correlation	.751	-.271	.172	-.722	1	.304
	Sig. (2-tailed)	.249	.729	.828	.278		.696
	N	4	4	4	4	4	4
Pb	Pearson Correlation	-.367	.232	-.338	-.582	.304	1
	Sig. (2-tailed)	.633	.768	.662	.418	.696	
	N	4	4	4	4	4	4

**. Correlation is significant at the 0.01 level (2-tailed).

Table 7. Correlation of heavy metal concentration between organs of *Tilapia zili*

		Co	**Cr**	**Cu**	**Ni**	**Pb**
Co	Pearson Correlation	1	.100	-.465	-.393	.322
	Sig. (2-tailed)		.873	.429	.513	.598
	N	5	5	5	5	5
Cr	Pearson Correlation	.100	1	.398	.274	.238
	Sig. (2-tailed)	.873		.507	.656	.700
	N	5	5	5	5	5
Cu	Pearson Correlation	-.465	.398	1	.618	-.256
	Sig. (2-tailed)	.429	.507		.266	.678
	N	5	5	5	5	5
Ni	Pearson Correlation	-.393	.274	.618	1	.524
	Sig. (2-tailed)	.513	.656	.266		.365
	N	5	5	5	5	5
Pb	Pearson Correlation	.322	.238	-.256	.524	1
	Sig. (2-tailed)	.598	.700	.678	.365	
	N	5	5	5	5	5

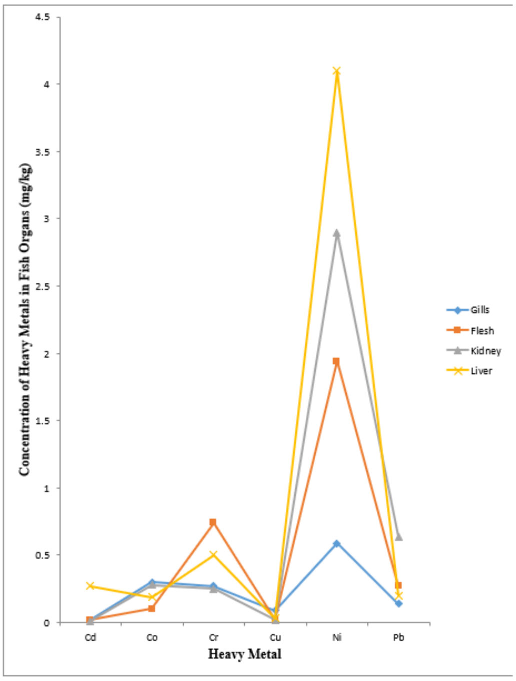

Figure 1. Concentration chart of heavy metals in Organs of *Clarias gariapinus*

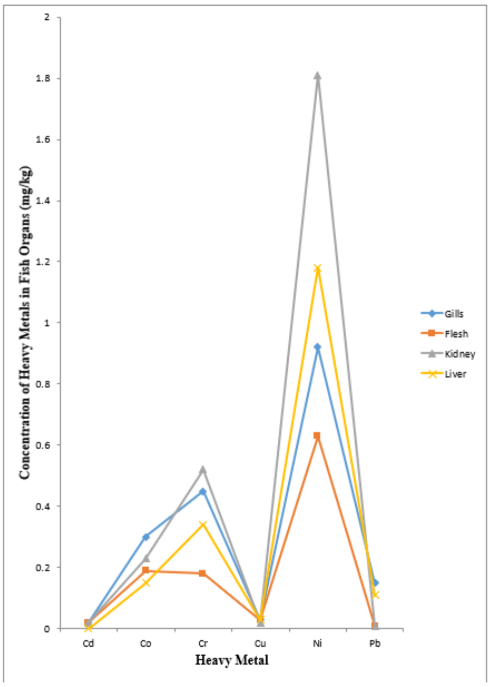

Figure 2. Concentration chart of heavy metals in *Tilapia zili*

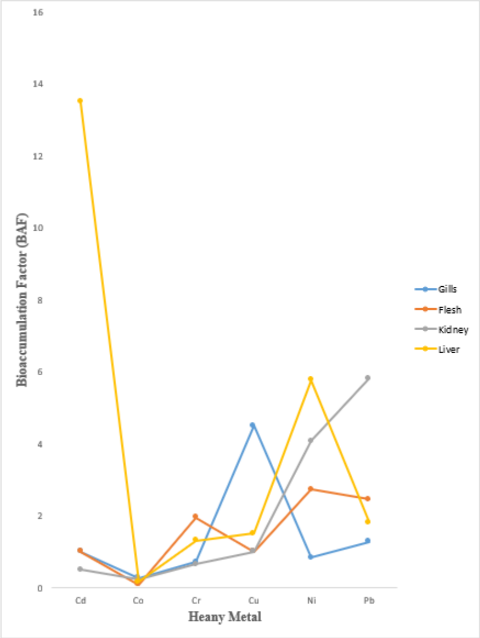

Figure 3. Bioaccumulation Factor in Organs of *Clarias gariapinus*

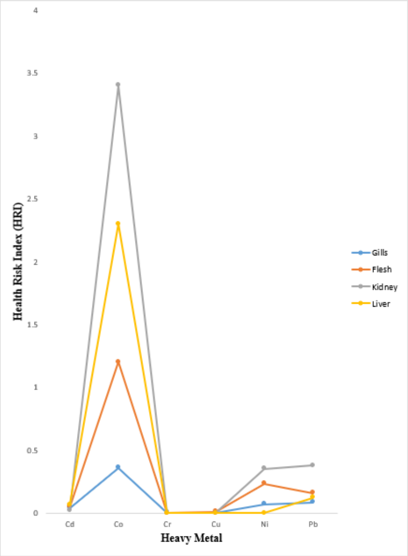

Figure 4. Health Risk Index in Organs of *Clarias gariapinus*

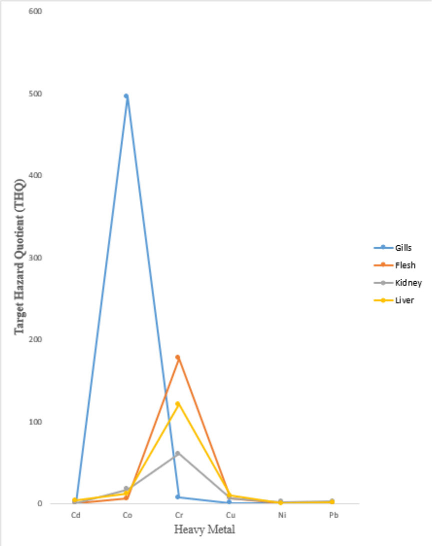

Figure 5. Target Hazard Quotient in Organs of *Clarias gariapinus*

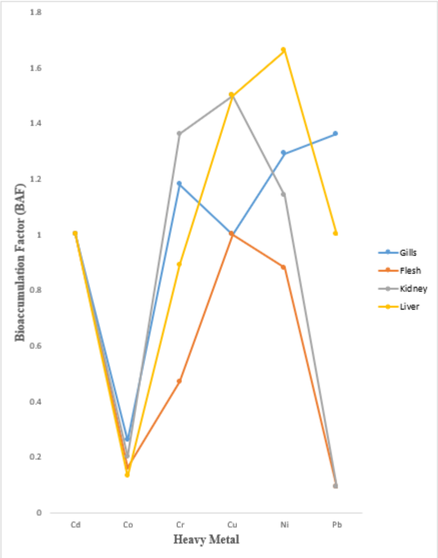

Figure 6. Bioaccumulation Factor in Organs of *Tilapia zili*

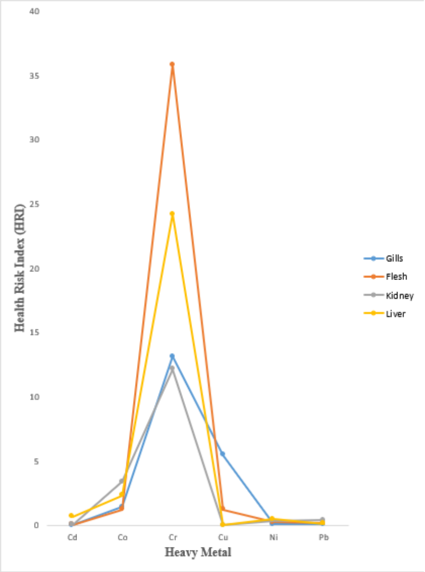

Figure 7. Health Risk Index in Organs of *Tilapia zili*

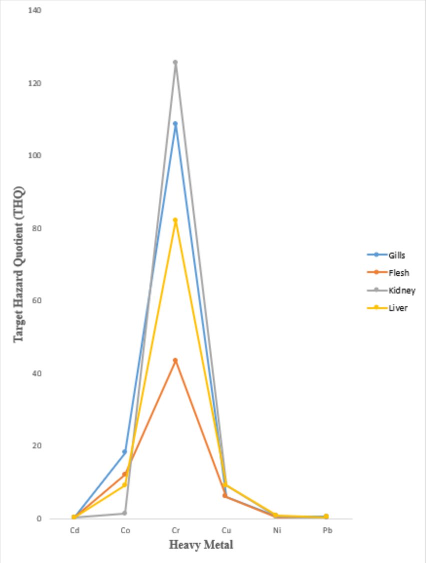

Figure 8. Chart for Target Hazard Quotient in Organs of *Tilapia zili*

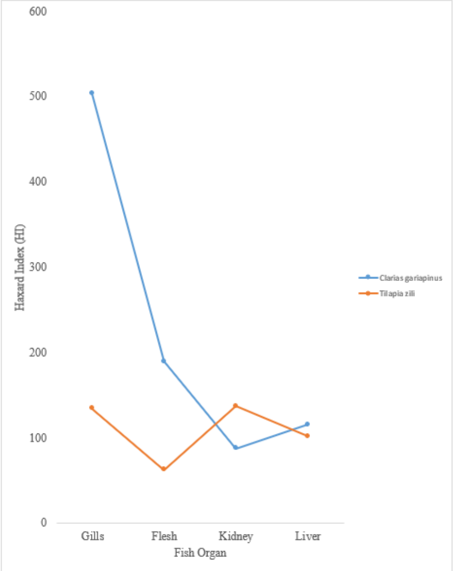

Figure 9. Chart for Hazard Index (HI) of fish species

The result of heavy metals concentration determined in the cat and tilapia fish samples (*Clarias gariapinus* and *Tilapia zili*) were as given in table 2. Tables 3 and 4 are the values for the hazard parameters examined, bioaccumulation factor (BAF), health risk index (HRI) and total hazard quotient (THQ). The concentration patterns for each of the elements in the fish species showed significant and relatively similar patterns in cat fish with Ni having the highest concentration, followed by Cr, Co, Pb Cd and Cu in that order with respective values 9.53, 1.76, 1.25, 0.87, 0.32 and 0.16 mg/ kg respectively. However, in tilapia fish species, the cumulative bioconcentration showed that Cd < Cu < Pb < Co < Cr < Ni, with values 0.08, 0.10. 0.28, 0.87, 1.49 and 3.54 mg/kg respectively (Li *et al*., 2015a, 2015b; Chen *et al*., 2015)

Cadmium (Cd) concentration in Cat and Tilapia fish sample matrices is also as given in table 2. The mean concentration for the cat fish and tilapia fish ranged from 0.50mg/kg - 0.34mg/kg and 0.02mg/kg - 0.34mg/kg respectively. The concentrations in gill, flesh and kidney showed relative similarity, with the kidney having the least. This may be due to the strategic metabolic role of liver in the system of the fish species, indicating minimal mobility and bioconcentration to this organs. The mean concentration of Chromium in cat (0.50mg/kg) is higher than that of Tilapia (0.34mg/l). The concentration is comparatively low in tilapia for all the elements under investigation and similar patterns in all the organs with similar concentration, which agrees with the woks of other researchers (Jörg *et al*., 2019; Opasola *et al.,* 2019; Udofia *et al*., 2016; Omoregie *et al*., 2016; Sharma *et al*., 2016)

The concentration range of chromium (Cr) is 0.34 - 0.50 mg/kg in Cat while it is 0.15 - 0.19 mg/kg in Tilapia. The mean concentration of Cr in Cat shows that it is higher than that of Tilapia, probably due to the difference in the habitat behavior of the fish species. The mean concentration of Cr is high which also seems to suggest anthropogenic impact which probably suggest its major source from sediments. The concentration pattern in the cat fish organs showed that kidney < gill < liver < flesh, while it is flesh < liver < gill < kidney, suggesting sediment source due to the habitat behavior of the fish type which is mostly fond of sediments, hence the highest bioaccumulation in flesh being the first contact organ (Aytekin *et al.,* 2019; Shahsavani *et al.,* 2017; Yi *et al*., 2017; Omoregie *et al*., 2016).

The mean concentration of cobalt (Co) in cat fish and tilapia fish ranged from 0.02 - 0.19 mg/kg and 0.05 - 0.15mg/kg respectively. The concentration pattern is similar for the organs as in Cd. As for *Tilapia zilli*, the pattern showed that liver < flesh < kidney < gill.

The mean concentration range of Nickel (Ni) in cat and tilapia fish species showed the range of 0.18mg/kg - 4.10mg/kg and 0.02 - 1.18 mg/kg respectively. The mean concentration of nickel in cat fish showed higher value than that of Tilapia in all respective organs. The pattern in cat fish indicated that gill < flesh < kidney < liver, while it is flesh < kidney < gills < live, with values 0.59, 1.94, 2.90, 4.10mg/kg and 0.63, 0.81, 0.92, 1.18 mg/kg respectively, thereby depicting the strategic metabolic role of liver as an organ of both fish samples and also a sediment and water sources of this element in sample matrices (Aytekin *et al.,* 2019; Opasola *et al.,* 2019; Shahsavani *et al.,* 2017; Yi *et al*., 2017).

Copper (Cu) concentration in Cat and Tilapia is also given in table 2. The mean concentration range from 0.02mg/kg - 0.03mg/kg in cat and 0.02mg/l to 0.09mg/kg in Tilapia. The mean concentration of Cu in organs of both fish species were similar with a concentration pattern where flesh and kidney is same least in cat fish while flesh = gill < kidney < liver in tilapia fish. Generally, the bioconcentration of this element in the organs of both fish species showed the least, indicating minimal bioabsorptivity and transportation (Udofia *et al*., 2016; Omoregie *et al*., 2016; Sharma *et al*., 2016).

Mean lead (Pb) concentration in Cat and Tilapia showed a range of 0.14mg/kg - 0.64mg/kg and 0.01mg/kg to 0.15mg/kg respectively with a bioconcentration pattern of gill < liver < flesh < kidney in cat fish (Nangbes et al., 2018) and flesh = kidney < liver < gill in tilapia, almost the reverse of the pattern in cat fish with values 0.14, 0.20, 0.27, 0.20, 0.64 mg/kg and 0.01, 0.01. 0.11, 0.15 mg/kg respectively (Aytekin *et al.,* 2019; Nangbes *et al* 2018; Shahsavani *et al.,* 2017; Yi *et al*., 2017).

Risk Analysis

Bioaccumulation Factor (BAF)

Generally, transfer factor expresses the bioavailability of the metals at a particular position on a species of fish and it is calculated by dividing the concentration of metals in the fish samples by concentration of water (Tsafe *et al*., 2012). The entire sample has significant difference in transfer factor of metal relative to the availability of same metal in the fish sample. Table 3 the bioaccumulation factor (BAF) in the cat fish is in decreasing order Cd > Ni > Pb > Cu > Cr > Co and for tilapia Cd > Cu > Ni > Cr > Pb > Co is in decreasing order (Hazrat *et al*., 2019; Opasola *et al.,* 2019; Fakhri *et al*., 2018). Therefore in cat fish: Cr, Cu, Cd, Ni and Pb value which is < one indicates that the fish are enriched in element from the water (Bioaccumulation). And Co is > one indicate that the fish exclude the element from water. However, it is more revealing that, when the value is higher than one , the total concentration of metals in the water do not necessary correspond to the bioavailability of heavy metals but depends on a number of physicochemical properties such as PH, organic matter content, cation exchange capacity, (Mwegoha and Kihampa (2010).

Health Risk Index (HRI)

Health risk assessment of consumers from the intake of metals contaminated fish is characterized by using HRI (Xue *et al*., 2012; Li *et al*., 2015A). When the HRI > 1 for any metal in food crop it means the consumer population faces a health risk, the following formula was used HRI is equal to DIM divided by R_FD. Where DIM is the daily intake of metal and R_FD is the reference dose, from the result, the estimated HRI for adult for the consumption of fish for all the heavy metals determined, the result revealed that HRI for heavy metals for Cd, Co, Cr, Cu, Ni and Pb in the studied fish are < 1 except Co which has a value of 2.3 indicating they safe for the consumption of the consumer, for *Clarias gariapinus*. However Co and Cr which are > 1 in *Tilapia zilli* shows that the consumption of fish face a health risk because Cr can promote the the formation of cancer cells (Somda *et al*., 2019; Zhang et al., 2009; li et al., 2013; WHO/FAO, 2011)

Target Hazard Quotient (THQ)

In the *Clarias gariapinus* fish sample, target hazard quotient follows the trend flesh > liver > kidney > gills for Cr, whereas foe Co, the trend is gills >> kidney > liver > flesh (Omoregie *et al*., 2016). For Cu, the trend for the hazard quotient is flesh = kidney = liver > gills, whereas for Cd, Ni, and Pb, the trend is same for all the fish organ sample matrices.

For *Tilapia zilli* the total hazard quotient follows the trnd kidney > gills > liver > flesh for Cr whereas it showed the sequence gill > flesh > liver > kidney for Co (Chen *et al*., 2015; Udofia *et al*., 2016). The values for the total hazard quotient for Cd, Ni, and Pb are same just as in *Clarias gariapinus.* This shows that the source of these heavy metals are same as inferred by the correlation results, suggesting that the metals could probably be from the water body in which the fish species were pick, considering their different habitat life (Nangbes, 2018; Zhang *et al*., 2019).

Hazard Index (HI)

This risk parameter was considered to evaluate the potential risk to human health through more than one heavy metal, the hazard index (HI) has been developed (US EPA, 1989 cited in Querra *et al*., 2012; Ametepey *et al*., 2018). It assumes that the magnitude of the adverse effect will be proportional to the sum of multiple metal exposures. It also assumes similar working mechanisms that linearly affect the target organs (Omoregie *et al*., 2016; Querra *et al*., 2012). There is serious concern for potential health effects when the Hazard Index is greater than 1. Even though there was no apparent risk when each metal was analyzed individually, the potential risk could be multiplied when all metals are considered together. The hazard index for a typical adult of body weight 70 kg considered in this study was found to be 2.84. The relative contributions of Cr, Ni and Pb to the aggregated risk were 59.86%, 0.21%, 38.03% and 1.76% respectively. Consumption of these fish species from the study area therefore poses serious course for concern.

Correlation of heavy metals

Correlation relationships among HMs were determined using Pearson correlation analysis to provide information on their sources and transport (Zhang *et al*., 2019; Nangbes *et al*., 2018; Li *et al*., 2013). The results of Pearson correlation analysis in soils at all sampling sites are displayed in Tables 6 and 7 for *Clarias gariapinus* and *Tilapia zili* respectively. In *Clarias gariapinus*, Co has a weakly positive correlation 0.58 with Pb while in *Tilapia zilli,* Cu has correlation with Ni. All other heavy metals examine have no correlation with other metals. These indicate great differential in the source and interactions of the heavy metals within the organs of the two fish species examined. Also the interactions and behaviors of the fish species suggests water and sediment for Cu, Ni and Co, Pb respectively (Aytekin *et al.,* 2019; Zhang *et al*., 2019; Shahsavani *et al.,* 2017; Yi *et al.*, 2017; WHO/FAO, 2011).

CONCLUSION

Heavy metal concentrations were determined in fish-pond sediments near a mining area. All two fish species showed high bioaccumulation factors for Cd in four selected tissues. Heavy metal concentrations of two fish species were found to be significantly different among different tissues. The present results indicate that fish cultured in the mine-affected fishpond can carry an appreciable body burden of Cr and Cu. The highest Pb concentrations were found in gills of all two fish species. Livers of all two fish species had high capacity to accumulate Cd, Cr and Cu. The total metal accumulation was the greatest in the liver and the lowest in the Kidney. The estimated daily intakes and target hazard quotients indicated a relative absence of health risk associated with consumption of flesh from these two selected fish. Owing to the fact that the fishpond sediment and the farmed fish were contaminated by mining activities, consumption of farmed fish species (especially internal organs) in the human diet should be regulated, particularly for *Tilapia zili*.

It is recommended that further research should look into following areas of the sample matrices: 1) Concentration of heavy metals in the pond sediments of the fish samples; 2) Speciation studies of the heavy metals be carried on all the environmental samples with a view to identifying the various species and toxic elements within the environment so as to ascertain the health risks posed by each element; 3) Phytoremedation should be applied in other to reduce the level of heavy metals; and 4) Health screening should be carried out periodically on the inhabitants and fish consumers to check for some symptom of heavy metals.

REFERENCES

Adedeji O.B. and Okocha R. C. (2011). Bioconcentration of heavy metals in prawns and water from Epe Lagoon and Asejire River in Southwest Nigeria. *Journal of Applied Sciences in Environmental Sanitation,* 6 (3): 377-384.

Adewoye, S.O. and O.O. Fawole, (2002). Bioconcentration of metals in the tissue of *Clarias gariepinus* fingerlings exposed to lethal concentration of cassava Waste water. *World J. Biotechnol*., 3: 465-468.

Akan, J. C., Mohmoud, S., Yikala, B. S. and Ogugbuaja, V. O. (2012). Bioaccumulation of Some Heavy Metals in Fish Samples from River Benue in Vinikilang, Adamawa State, Nigeria: *American Journal of Analytical Chemistry*, 3, 727-736

Alidadi1, H., Seyedeh B. T. S., Oftadeh, B. Z. G., Mohamad, T., Hosein, S. and Fakhari, M. (2019). Health risk assessments of arsenic and toxic heavy metal exposure in drinking water in northeast Iran; *Environmental Health and Preventive Medicine,* Alidadi 24: 59 https://doi.org/10.1186/s12199-019-0812-x

Ametepey, S. T., Cobbina, S. J., Akpabey, F. J., Duwiejuah, A. B. and Abuntori, Z. N. (2018). Health risk assessment and heavy metal contamination levels in vegetables from Tamale Metropolis, Ghana; International Journal of Food Contamination 5:5 https://doi.org/10.1186/s40550-018-0067-0

Dahunsi S.O., Oranusi S.U. and Ishola R.O. (2012). Bioaccumulation Pattern of Cadmium and Lead in the Head Capsule and Body Muscle of *Clarias gariepi*nus [Burchell, 1822] Exposed to Paint Emulsion Effluent Research; *Journal of Environmental and Earth Sciences* 4 (2): 166-170.

EC, (2014). Commission Regulation (EC) No 488/2014 of 12 May 2014: Amending Regulation (EC) No 1881/2006 as Regards Maximum Levels of Cadmium in Foodstuffs, *Official Journal of the European Union*, L, 138 75–79.

Edogbo, B., Okolochaa, E., Makai, B., Aluwong, T., Uchenduc, C. (2020). Risk analysis of heavy metal contamination in soil, vegetables and fish around Challawa area in Kano State, Nigeria; *Scientific African* 7 1 – 9 e00281.

Fakhri, Y. Saha, N. Miri, A. Baghaei, M. Roomiani, L. Ghaderpoori, M. Taghavi, M. Keramati, H. Bahmani, Z. Moradi, B. Bay, A. Pouya, R.S. (2018). Metal concentrations in fillet and gill of parrotfish (Scarus ghobban) from the Persian Gulf and implications for human health, *Food Chem. Toxicol*. 118 348–354.

FAO/WHO (2011). Joint FAO/WHO Food Standards Programme Codex Committee on Contaminants in Foods, Codex Alimentarius Commission, Hegue, Netherland,

Hazrat, A., Ezzat, K. and Ikram, I. (2019). Environmental Chemistry and Ecotoxicology of Hazardous Heavy Metals: Environmental Persistence, Toxicity, and Bioaccumulation; *Hindawi Journal of Chemistry*, Article ID 6730305, 14 pages https://doi.org/10.1155/2019/6730305.

Ishaq.Y. Habib, J. Na'aliya, Murtala Muhammad, Fahad I Danladi (2014). Analysis of Heavy Metals in Muscle Tissues of Tilapia Zilli of Gwale Pond, Kano State, Nigeria; *International Journal of Scientific and Research Publications*, Volume 4, Issue 9, 1 ISSN 2250-3153

Jörg, R., Vasileio, A., Sabry, M. S., Oliver, R., Manfred, A. (2019). Health risk assessment of potentially toxic elements in soils along the Central Elbe River, Germany; *Environment International;* 126 76 – 88

Kargin F. (1996). Seasonal changes ın levels of heavy metals ın tıssues of *Mullus barbatus* and *Sparus aurata* collected from Iskenderun Gulf (Turkey), *Water Air Soil Pollut*. 90 (1996) 557–562.

Kargin, F. Donmez, A. Çogun, H.Y. (2001). Distribution of heavy metals in different tissues of the shrimp *Penaeus semiculatus* and *Metapenaeus monocerus* from the Iskenderun gulf, Turkey: seasonal variations, *Bull. Environ. Contam. Toxicol*. 66 102–109.

Kargin, F., & Çogun H.Y. (1999). Metal interactions during accumulation and elimination of zinc and cadmium in tissues of the freshwater fish Tilapia nilotica, *Bull. Environ. Contam. Toxicol*. 63 511–519.

Karim, S., Aouniti, A., El hajjaji, F., Taleb, M., Belbachir, C., Hammouti, B., and Zarrouk, A. (2016). Bioaccumulation of heavy metals in commercially important marine fishes (Palaemon Serratus and Solea Vulgaris) caught in the Mediterranean coast from the North East of Morocco; Der Pharma Chemica, 8 (19): 515 – 523.

Li, F.; Huang, J.; Zeng, G.; Yuan, X.; Li, X.; Liang, J.; Wang, X.; Tang, X.; Bai, B. (2013). Spatial risk assessment and sources identification of heavy metals in surface sediments from the Dongting Lake, Middle China. *J. Geochem. Explor*. 132, 75–83.

Mehdi Hosseini & Seyed Mohammad Bagher Nabavi & Yaghob Parsa (2013). Bioaccumulation of Trace Mercury in Trophic Levels of Benthic, Benthopelagic, Pelagic Fish Species, and Sea Birds from Arvand River, Iran; *Biol Trace Elem Res*. 156:175–180.

Miri, M. Akbari, E. Amrane, A. Jafari, S.J. Eslami, H. Hoseinzadeh, E. Zarrabi, M. Salimi, J. Sayyad-Arbabi, M. (2017). TaghaviM, Health risk assessment of heavy metal intake due to fish consumption in the Sistan region, Iran, *Environ. Monit. Assess*. 189 579–583.

Mohammed, E., Mohammed, T. and Mohammed, A. (2017). Optimization of an acid digestion procedure for the determination of Hg, As, Sb, Pb and Cd in fish muscle tissue: *MethadsX* 4 513 – 523.

Nabavi, S.F. Nabavi, S.M. Latifi, A.M., Eslami, S., Ebrahimzadeh, M.A. (2012). Determination of trace elements level of pikeperch collected from the Caspian Sea, *Bull. Environ. Contam. Toxicol*. 88 401–405.

Nangbes, J. G., Dawam, N. N. & Lawam, T. D. (2020). Assessment of Heavy Metals in Water and Fish Samples of Abandoned Mining Ponds in Barkin Ladi, Plateau State, Nigeria; *Mediterranean Journal of Basic and Applied Sciences* (MJBAS) 4 (3) 18-32,

Nangbes, J. G., Sase, J. T., Lawam, T. D. (2018). Bioaccumulation and Risk Analysis of Heavy Metal Pollutants in *Tilapia zilli* and *Clarias gariepinus* Fish Species Found in Rivers Dilimi and Tudun Wada of Jos, Plateau State, Nigeria; *Mediterranean Journal of Basic and Applied Sciences* (MJBAS); Volume 2, Issue 3, Pages 127-135

Omoregie, I. P., Imoobe T. O. T., Idowu, I.J., Oluowo, E. F. (2016). Assessment of some heavy metals and total hydrocarbons in *Clarias gariepinus* fish of Osse River, Edo State, Nigeria; *IOSR Journal of Environmental Science, Toxicology and Food Technology* (IOSR-JESTFT) e-ISSN: 2319-2402,p- ISSN: 2319-2399. 10 (9) Ver. II 144-151

Omoregie, I. P., Imoobe, T. O. T., Izegaegbe, J. I. and Oluowo, E. F. (2016). Assessment of some heavy metals and total hydrocarbons in *Clarias gariepinus* fish of Osse River, Edo State, *Nigeria, IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)* e-ISSN: 2319-2402,p- ISSN: 2319-2399. 10, (9) Ver. II

Opasola, O. A.; Adeolu , A. T.; Iyanda, A. Y.; Adewoye, S. O. & Olawale S. A. (2019). Bioaccumulation of Heavy Metals by *Clarias gariepinus* (African Catfish) in Asa River, Ilorin, Kwara State, *Journal of Health & Pollution* 9 (21): 1 – 10.

Querra F, Trevizam A, R., Muraoka3 T., Marcante N. C. Canniatti-Brazaca, S. G (2012). Heavy metals in vegetables and potential risk for human health. Sci. Agric. 69 (1): 54-60.

Sayyad, N.R., Khan A.K., Ansari N.T., Seema H., & Shaikh M.A.J (2007). Heavy metal concentrations in different body part of crab, *Barytelphusa guerini* from Godavari River, *J. Ind. Pollut. Control* 23 (2) 363–368.

Sehar, A., Shafaqat, A., Uzma, S. A., Mujahid, F., Saima, A. B., Fakhir, H., and Rehan, A. (2014). Effect of Different Heavy Metal Pollution on Fish; *Res. J. Chem. Env. Sci*., 2 (1): 74-79.

Shahsavani, A., Fakhri, Y., Ferrante, M., Keramati, H., Zandsalimi, Y., Bay, A., Pouya, S. R. H., Moradi, B., Bahmani, Z., & Khaneghah, A. M. (2017). Risk assessment of heavy metals bioaccumulation: fished shrimps from the Persian Gulf; Toxin Rev. early online, 1 – 9. DOI: 10.1080/15569543.2017.1312451

Sharma, A., Katnoria, J. K. and Nagpal, A. K. (2016). Heavy metals in vegetables: screening health risks involved in cultivation along wastewater drain and irrigating with wastewater, *SpringerPlus* 5:488 DOI 10.1186/s40064-016-2129-1

Sivakumar. R. and Xiaoyu, L. (2018). Bioaccumulation of heavy metals in fish species from the Meiliang Bay, Taihu Lake, China; Toxicology Reports, 5 288 – 295.

Somda, M. K., Samake, S., Kabore, D., Nikiema, M., Mogmenga, I., Dabire, Y., Ouattara , A., Keita, I., Mihin, H. B., Akakpo, A. Y., Traore, A. S. (2019). Assessment of Heavy Metals and Microbial Pollution of Lettuce (Lactuca sativa) Cultivated in Two Sites (Paspanga and Tanghin) of Ouagadougou, Burkina Faso; Journal of Environmental Protection, 10, 454-471 http://www.scirp.org/journal/jep ISSN Online: 2152-2219 ISSN Print: 2152-2197

U.S. Environmental Protection Agency [US EPA]. 1989. Risk Assessment Guidance for Superfund: Human Health Evaluation Manual [Part A]: Interim Final. U.S. Environmental Protection Agency, Washington, DC, USA [EPA/540/1-89/002].

Udofia, U. U., Udiba, U. U., Bate, G. B., Udofia, L. E. (2016). Evaluation of the Toxicological Implication of Consuming Carrots (*Daucus carota L*) Cultivated Along River Galma Basin Around Dakace Industrial Layout, Zaria, Nigeria; International Journal of Ecological Science and Environmental Engineering, 3 (1): 10 – 19.

Yi, Y., Tang, C., Yi, T., Yang, Z., Zhang, S. (2017). Health risk assessment of heavy metals in fish and accumulation patterns in food web in the upper Yangtze River, China; *Ecotoxicology and Environmental Safety*, 145 295 – 302.

Zhang, Q., Han, G., Liu, M., Li, X., Wang, L. and Liang, B. (2019). Distribution and Contamination Assessment of Soil Heavy Metals in the Jiulongjiang River Catchment, Southeast China; Int. J. Environ. Res. Public Health 2019, 16, 4674; doi: 10.3390/ijerph16234674