Journal of Environment and Earth Science www.iiste.org
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol. 3, No.1, 2013

Heavy Metals Concentrations in some selected Fish Species in Tono Irrigation Reservoir in Navrongo, Ghana

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Abstract

An assessment of heavy metals (lead, cadmium, copper, manganese, zinc and iron) in water, sediments and in the organs of Tilapia (*Sarotherodon gallelacus*) and African Giraffe Bagrid (*Auchenoglanis occidestalis*) from the Tono irrigation dam has been carried out. Sediments contained the highest concentrations and appeared to be the major source of bioaccumulation of heavy metals in the fish species as deduced from estimated transfer factors. The mean concentrations of heavy metals Cd, Zn and Cu in muscle and gills both fish species fell within USEPA (2002) acceptable levels for human uses while those of Pb, Mn and Fe were above. The mean concentrations of heavy metals in raw water fell within the permissible limits of WPCL (2004) for aquaculture except Cd (0.03mg/l) and Fe (0.86mg/l). The relatively high mean concentrations of Pb (0.375mg/kg FW in the two fish species may originate from chemicals (fertilisers, weedicides and pesticides) being used for agricultural purposes in the study area. This is a potential health hazard and requires monitoring and awareness creation.

Keywords: fish species, Ghana, heavy metals, Navrongo, Tono dam,

1. Introduction

Trace metals are in extremely small quantities that reside in or present in animals and plant tissues through natural and also artificial (anthropogenic) through such natural processes as weathering and dissolution, and also through artificial means such as agricultural(from fertilisers, weedicides, pesticides etc.) and industrial activities(Gaseous, liquid solid wastes). Pollution of aquatic ecosystem has been on the ascendancy worldwide (Mance, 1987), and this has been attributed to rapid population growth given rise to increased urbanisation with its attendant increase in agricultural activities and industrialisation (Giguere et al., 2004). Naturally, heavy metals tend to accumulate in soils and sediments after weathering processes and can be deposited in water bodies during surface run-offs, and once they come into the aquatic environment, the heavy metals scatter among the various compounds (water, solids in suspension, sediments and biota). Artificially, a variety of pollutants can affect the quality of most natural and man-made water bodies, which receive agricultural, industrial and domestic waste effluents (Saad et al., 1981). Notably among these pollutants are heavy metals which have the potential to be highly toxic if consumed by man through any of the food chain. In agriculture, heavy metals are released during land preparation such as ploughing, ridging and hallowing among others. Also agrochemicals such as fertilizer (phosphate fertilizer, N-P-K fertilizer) and herbicides contain heavy metals that easily accumulate in the soils, carried by run-off or leach into water bodies around farm lands. The contamination of freshwater with heavy metals such as cadmium, lead, arsenic and copper etc. has become a matter of great concern in public health. From the public health point of view, attention has been drawn to the necessity of measuring the accumulation of heavy metals, particularly those metals which pose serious health hazards to humans (e.g. As, Pb, Hg). In required doses, some heavy metals are essential for maintaining body growth, health and reproduction in plants and animals while in excess, they could be poisonous and dangerous to human health through the ingestion of food and water due to the inherent toxicity of some heavy metals (Forstner, 1998). As heavy metals cannot be degraded, they are deposited, assimilated or incorporated in water, sediment and aquatic animals Abdel-Baki et al, 2011). Microorganisms, micro flora and algae are capable of incorporating and accumulating metal species into their living cells from various supply sources (Biney and Beeko, 1991). Consequently, fish become enriched with the accumulated heavy metals, and when consumed on continuous basis can expose human to serious health hazards (Forstner and Wittmann, 1983). As long as human induced generation of heavy is increasing due to the increasing use of these chemical products as farm practices, there is need to obtain knowledge of the changing concentrations and distribution of heavy metals and their compounds in various compartments of the environment is a priority for good environmental management programmes all over the world (Don-Pedro *et al.*, 2004). Fish can respond to environmental changes that can be used for pollution indicator study. Fish is a bio-indicator because it is easy to be obtained in large quantity, potential to accumulate metals, long lifespan, and optimum size for analysis and easy to be sampled. Heavy metal intakes by fish in polluted aquatic environment are different depending on ecological requirements, metabolisms and other factors such as salinity, water pollution level, food and sediments. Fish accumulates metals in its tissues through absorption and human can be exposed to metal via food web. This will cause acute and chronic effect to human (Nord et al., 2004). According Rashed (2001), the use of fish as a bio-indicator can determine the actual situation of pollution level before and during monitoring.

Inland fish production is one of the major sources of fish protein for inhabitants in northern Ghana. The main natural source of inland fish are from the Black and White Volta rivers while major dams such as Tono and Vea, and Botanga in the Upper east and Northern regions are important sources of inland fish production as a means of alternative livelihood programme for affected communities who lost their farmlands due to the construction of the dams in the upper east and northern regions of Ghana. There is massive irrigation farming going on within the catchments of the streams feeding these dams that utilise mainly chemical fertilisers, weedicides, herbicide and pesticides in the cultivation of vegetables, cereals and rice. The Tono Irrigation dam and irrigation scheme has about the largest reservoir of raw water among all man-made irrigation dams in Ghana, serving primarily as the source of raw water for irrigational all year round within the municipality. The facility was built in the late 70's and early 80's to promote the production of food crops by small scale farmers within organized and managed irrigation scheme. The scheme covers an area of 3860 ha with about 2490 ha developed for irrigation. The Dam has a total catchment area of about 650 km^2 with a maximum surface area of 1860 ha and a maximum storage of 93x103 m^3 (Fig. 3), serving about 4000 small-scale farmers with holdings between 0.2-2 ha per farmer (Wedjong, 2004). The major crops cultivated on the project are tomato, rice, soya bean among others. It also serves as the major source of fish production in Upper East region most especially the inhabitants of Kasena-Nankana Municipality and its environs.

An earlier studies on surface and groundwaters as well as sediments within the catchment of the Tono irrigation scheme and the bottom of the dam had revealed the occurrence of certain heavy metals (i.e. Fe, Mn and Cu) having concentrations higher than World Health Organisation guideline values and some pesticides including DDT, BHC and Heptachlor epoxide (Pelig Ba, 2011). Furthermore, since the past five years, there has been tremendous increase in farming activities (including cultivation of vegetables and rice) with about four thousand hectares of cultivated lands currently. The main farm practices employed by farmers are the use of weedicides, chemical fertilisers and various types of pesticides due to effectiveness and ease of usage. These chemicals have been found to contain some heavy metals (including As, Cd, Mn) as traces (Anim-Gyampo et al., unpublished), and therefore when applied to soils and crops has the tendency for them to be leached into the groundwater system and also carried by surface run-offs into streams which eventually may find their way into the dam reservoir. The presence of these heavy metals has the potential to contaminate aquatic animals including fishes, which when consumed can pose serious health risks to immediate consumers due to their toxicity. This study assesses the bioaccumulation levels of heavy metals in two commonly consumed fish species- Tilapia (*Sarotherodon gallelaeus*) and African Giraffe Bagrid (*Auchenoglanis occidentalis*) and also ascertain the heavy metals contamination in aquatic ecosystem of the Tono irrigation scheme in Upper East Region of Ghana since they occupy high trophic levels and are important food sources.

Figure 1: Samples of Sarotherodon Galilaeus (tilapia) from Tono Dam

Figure 2**:** Samples of Auchenoglanis Occidentallis (African Giraffe Bagrid) from Tono dam.

2. Materials and Methods

2.1 The Study Area

The Tono irrigation is located at latitude 10°60'N N and longitude 1° 07' W at an altitude of 160m. The catchment area of the dam together with the reservoir is estimated to be 650km with an approximate cultivated area of about 3860 hectares (Pelig Ba, 2011). The dam is located in Navrongo, the district capital of Kasena-Nankana Municipality in the Upper East Region of Ghana, which lies within latitudes 10º30' N and 11º10' N and longitudes 1º 01' W and 1º 30' W, the map of the study is shown in figure 3 below. The study area is influenced by the movement of the Inter-Tropical Convergence Zone (ITCZ) and it is among the areas with lowest rainfall values in Ghana with mean annual rainfall of about 100-115cm. The study area is characterised by generally high temperature and is among the driest places in the Ghana. The highest mean monthly and daily temperatures of 33 and 42ºC, respectively are recorded in March-April; whilst the lowest mean monthly value of 26.5ºC is registered during the peak Harmattan season in December and January each year. Relative humidifies of 70-90% are recorded during the rainy season and in the dry season; the lowest value of 20% is observed (Dickson and Benneh, 1980). The vegetation of the study area is characterized by the interior wooded Savannah type which is the largest vegetation zone in Ghana, which is characterised by major trees such as baobab, dawadawa, acacias and Shea trees that are adaptive to the long dry conditions with plant life varying with season. Plants are green in the wet season and changes through yellowish brown in the dry season ready for shedding.

The main rivers draining the area are Asibelika and Afumbeli, which are tributaries of the Sissili River, (K.N.D.A, 1998). The overburden is usually shallow and the texture of the soils is coarse-grained sandy-loam (Kesse, 1985). The major rock is the belt granitoids (described as Bongo granites), which is composed of Precambrian crystalline igneous rocks and covers about 95% of the district. The remaining 5% is composed of Precambrian Birimian Meta-Volcanic and Meta-Sedimentary rocks (Wright et al., 1985). The belt granitoids are basically biotite-rich granites, granodiorites, hornblende granites and hornblende-diorites. They consist of highly altered feldspars, typically unfoliated and are rich in hornblende and are found in association with the meta-volcanics. Basin granitoids composing of gneisses, migmatites that are rich in Potassium are also found in the study area in association with Meta-sedimentary rock formation (Kesse, 1985).The meta-volcanic sedimentary rocks occur in a general NE-SW direction that are dominantly volcaniclastic interbedded with subordinate argillites and occasional minor mafic flows, which were deposited fairly proximal to the volcanic ridges. They are characterised by relatively short widths varying between 20 to 70 km and in some places wider and long strikes that can be measured up to about 1000 km. Common lithologies include metamorphosed lavas, pyroclastics rocks, hypabyssal intrusive, phyllites and greywackes. Common fractures found within the meta-volcanics are joints, fault and shear zones (Griffis et al., 2002).

2.2 Sample Collection

Water samples were collected from identified sites in bay two with 500mL litre plastic bottles, the sampling protocols described by Welz and Sperling, (1999) were strictly followed during sample collection: the sampling bottles were conditioned by washing with metal-free non-ionic detergent solution, and finally rinsing several times with distilled water. This was carried out to ensure that the sample bottles were free from contamination, which could affect the concentrations of various ions in the water samples. Also, the sampling bottles were rinsed with the dam water first before the samples were finally collected. Two separate samples were collected into the 0.5litre bottles. One portion was acidified for heavy metal analysis. This was done to keep the metals in solution and other portion not acidified and kept for physic-chemical analysis. Soil sediments were collected from the respective water sampling points using core sampler as described in (Boyd and Tucker, 1992), then kept in cleaned plastic bags and chilled on ice box for transport to the laboratory for heavy metals determination. Two commonly consumed fish types, Tilapia (*Sarotherodon gallelacus*) and African Giraffe Bagrid (*Auchenoglanis occidestalis*) were caught using nets through the assistance of a fisherman from *Gia*, one of the communities surrounding the dam reservoir. The fishes were labelled on a polymer bucket containing the river water and then taken to the laboratory prior to further treatment. In the laboratory, the fishes were cut into three parts with stainless steel knife namely gills, muscles and the tissue.

2.3 Analysis of Water, Soil and Fish

2.3.1 Physical Parameters and Heavy Metals

Temperature and pH were determined in-situ, using a mercury-in-glass thermometer and Hanna portable pH meter respectively. A multipurpose electronic Jenway 4520 conductimeter was used to measure the conductivity, salinity, and TDS of all samples. A 2100P turbidimeter was also used in determining the turbidity of all samples. EDTA Titration was used to determine the water hardness. The analyses of heavy metals (Fe, Mn, Zn, Cu, Pb and Cd) were performed in accordance with APHA-AWWA-WEF, 2001, using Shimadzu Atomic Absorption Spectrophotometer (AAS)-AA 6300 model.

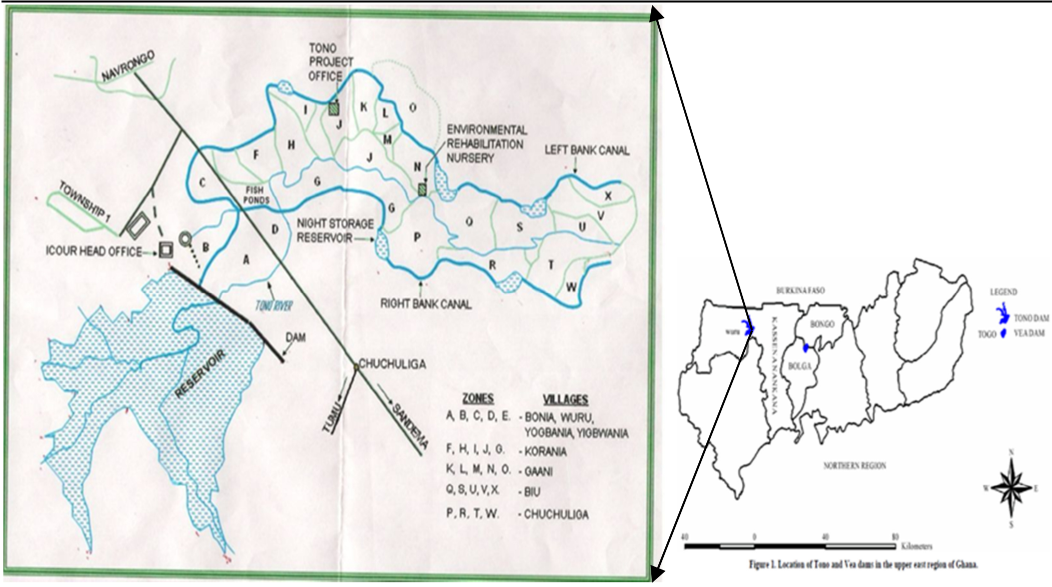

Figure 3: The map of the study area showing the Tono Irrigational Scheme

2.3.2 Digestion of Soil Samples for Analysis

The soils were air-dried for 24 hours, grounded, homogenized and sieved through a 0.4µm-mesh to remove debris and sediments were digested after sieving according to Kouadia and Trefry (1987) method. About 2.0g of sieved soil was weighed into an acidic washed centrifuge bottle, and about 35ml of the HNO_3 solution was added and the lid tightly closed and put in an end-over-end shaker and shakes vigorously for 16hrs. The sample was then centrifuged at high speed (3000 revolution for 10min). Remove the supernatant with a pipette and store the filtered solution in a scintillation bottle until analysis.

2.3.3 Digestion of fish samples

Fish organs (gills and muscles) were digested after dissecting according to AOAC (1990) methods. About 2.0g of partially thawed fish muscles and gills were weighed into Teflon tubes and 4ml of NH O_3(conc.) was slowly added to the Teflon tube. The tubes were then tightly closed and placed in a stainless steel bombs. The bombs were placed on a hot plate and heated at 110^0C for one hour and then to 150^0C for three hours. Allow the samples to cool at room temperature, and then carefully open the bombs and transfer samples into 50ml polypropylene graduated tubes in a fume chamber wearing nose ground. Rinse the tube deionized water three times adding the wash to the tube.

3. Results

The summary of results of physico-chemical analysis conducted on water samples, sediments samples and fish species (tilapia and “gear box”) from the Tono Irrigation Dam are presented tables 1, 2, 3 and 4 below. The mean Fe, Cd, Zn, Cu, Mn, and Pb concentration in the raw water sample and soil sediments are shown in figure 3 and 4 respectively.

Table 1: Summary of results of water quality analysis

Groups	Para	Unit	WHO	LS	MS	US	Max	Min	Mean	SD
Physical P.	pH		**6.5-8.5**	7.47	7.60	7.62	7.62	7.47	7.56	0.08
	TDS	mg/l	**1000**	50.9	54.2	50.7	54.2	50.7	51.93	1.97
	Cond	µs/cm	**250**	84.9	90.4	84.2	90.4	84.2	86.50	3.40
	Hard.	ppm	**500**	44.0	50.0	32.0	50.0	32.0	42.0	9.17
	Turb	NTU	**5.0**	30.0	30.0	30.0	30.0	30.0	30.0	0
	Alk	mg/l	**1000**	46.0	46.0	44.0	46.0	44.0	45.33	1.15
	Col	Hz	**15**	15.0	15.0	15.0	15.0	15.0	15.0	0
Heavy metals	Mn	mg/l	**0.5**	0.033	0.005	0.052	0.052	0.005	0.03	0.023
	Cd	mg/l	**0.003**	0.002	0.001	0.002	0.002	0.001	0.017	0.006
	Cu	mg/l	**2.0**	0.001	0.023	0.020	0.023	0.001	0.015	0.012
	Zn	mg/l	**5.0**	0.004	0.002	0.003	0.004	0.002	0.003	0.001
	Pb	mg/l	**0.01**	0.003	0.004	0.005	0.005	0.003	0.0004	0.001
	Fe	mg/l	**0.3**	**0.930**	**0.633**	**1.007**	**1.007**	**0.633**	**0.86**	**0.197**

Table 2**:** Mean heavy metal concentrations in Sediments (mg/kg dry weight)

Guidelines	Fe	Mn	Zn	Cu	Cd	Pb	References
LEL(lowest element level)	10.30	0.60	26.00	2.00	0.50	0.01	
TEL(threshold element level)	10.28	0.99	43.40	2.32	0.48	0.15	
PEC (probable effect conc.)	20.03	4.90	111.00	3.02	2.35	0.05	
SEC(severe effect level)	35.30	10.00	110.00	2.02	3.35	0.11	**NOAA,2009**
Sediment	**43.81**	**0.0002**	**0.35**	**0.25**	**4.45**	**0.36**	**This study**

Table 3: Mean heavy metal concentrations (mg/l) in reservoir (raw water)

Guidelines	**Fe**	**Mn**	**Zn**	**Cu**	**Cd**	**Pb**	**References**
WPCL	0.45	0.002	4.25	2.00	0.003	0.05	**WPCL,2004**
WHO	0.30	0.50	5.00	2.25	0.010	0.01	**WHO,2003**
USEPA	0.50	0.02	5.00	2.25	0.010	0.11	**USEPA1986**
Water	**0.86**	**0.003**	**0.017**	**0.003**	**0.03**	**0.004**	**This study**

Table 4: Mean heavy metals concentration (mg/kg FW) in fish tissues

Samples	**Heavy metals concentrations**						
	Fe	**Cd**	**Zn**	**Cu**	**Mn**	**Pb**	**References**
Tilapia Gills Muscle	 **7.39** **3.61**	 0.003 0.035	 0.003 0.004	 0.076 0.045	 **0.767** **0.693**	 **0.365** **0.375**	 This study
African Giraffe Bagrid Gills Muscles	**1.721** **2.293**	0.003 0.035	0.003 0.035	0.020 0.045	**0.749** **0.693**	**0.364** **0.375**	This study
USEPA	***0.50***	***0.010***	***5.00***	***2.25***	***0.020***	***0.110***	*USEPA,1986*
WHO	***0.30***	***0.010***	***5.00***	***2.25***	***0.500***	***0.010***	*WHO,2003*
WPCL	***0.45***	***0.003***	***4.25***	***2.00***	***0.002***	***0.0.05***	*WPCL,2004*

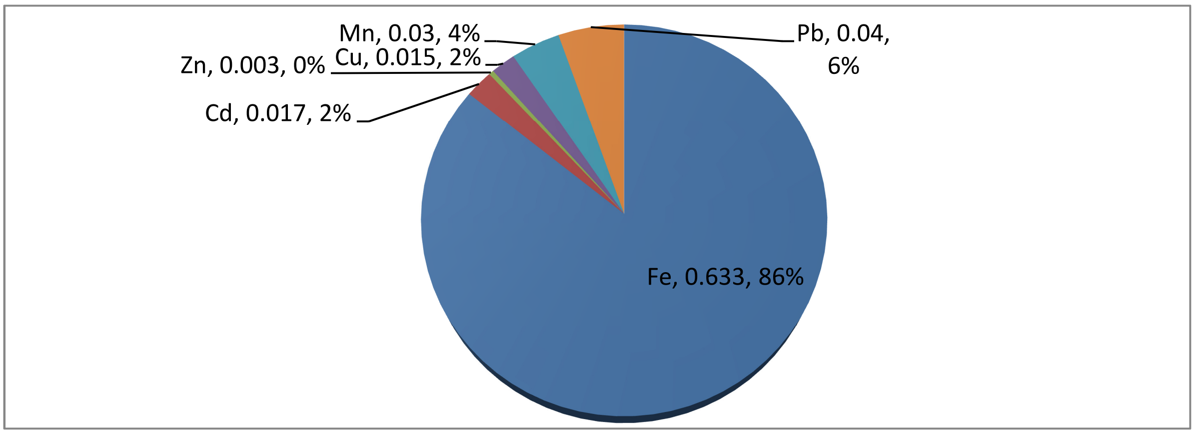

Figure 3: Mean Heavy Metal Concentrations in Raw Water Samples

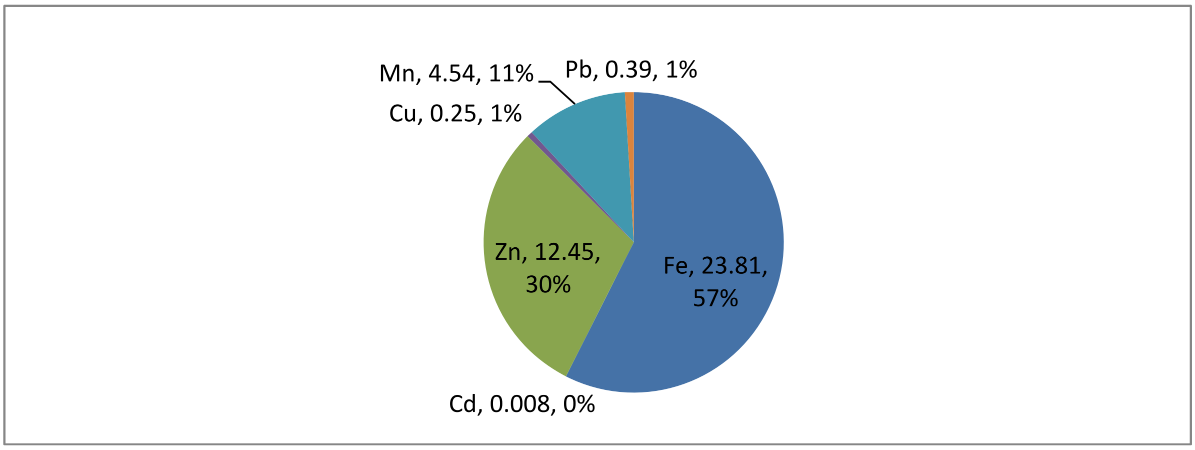

Figure 4: Mean Concentrations of Heavy Metals in Sediments

Transfer Factor (TF)

The transfer factor in fish tissues from the aquatic ecosystem, which include water and sediments, was calculated according to Kalfakakour and Akrida-Demertzi (2000) and Rashed (2001) as follows:

$$TF = \frac{\text{Metal concentration in tissue}}{\text{Metal concentation in sediment or water}}$$

Table 5 and 6 represent the transfer factors of heavy metals in tissues in the two fish species with respect to raw water and sediments.

Table 5: Transfer factor (TF) of heavy metals in different tissues of tilapia fish

PARAMETER	**Fe**	**Cd**	**Zn**	**Cu**	**Mn**	**Pb**
Water/Muscles	0.239	4.857	0.857	0.333	0.0433	0.011
Sed./Muscles	12.15	0.571	3557.14	5.556	655.123	0.960
RWQ Standard(mg/dw)	**0.30**	**0.003**	**5.0**	**2.00**	**0.500**	**0.005**
Water/Gills	0.116	5.667	1.00	0.197	0.0391	0.0011
Sed./Gills	5.922	0.667	4150.00	3.289	5.9192	0.9863

Table 6: Transfer factor (TF) of heavy metals in different tissues of (African Giraffe Bagrid)

PARAMETER	**Fe**	**Cd**	**Zn**	**Cu**	**Mn**	**Pb**
Water/Muscles	0.375	4.857	0.857	0.333	0.0532	0.0112
Sed/Muscles	19.106	0.571	3557.14	5.556	8.0496	1.0084
WHO(mg/l)	**0.30**	**0.003**	**5.0**	**2.000**	**0.500**	**0.005**
Water/Gills	0.4997	5.667	1.000	0.750	0.0400	0.0110
Sed/Gills	25.456	0.667	4150.00	12.50	6.061	0.989

4. Discussions

4.1 Heavy metals in water and sediments

Mean heavy metal concentrations in raw water samples from the Tono reservoir follow a decreasing order of Fe > Zn > Cd > Cu=Pb > Mn (tables 1 & 2). The presence of elevated concentrations of heavy metals in raw water in the Tono reservoir has confirmed the findings of an earlier studies on the raw water quality of the Tono irrigation reservoir by Anim-Gyampo (unpublished), which concluded that heavy metals concentrations are on the increase within the catchment of Tono Irrigation Scheme. The heavy metal concentrations obtained from the raw water were compared to various raw water quality guidelines (WPCL, 2004; WHO, 2003 and USEPA, 1986). The results obtained showed that with the exception of Pb, Zn and Cu, the mean concentrations of all metals in the raw water exceeded the above guidelines values. The mean concentrations of Fe and Cd (i.e. 0.86mg/L and 0.03mg/L) exceeded all the raw water guideline values, while Mn (0.003mg/L) exceeded the guideline value of WPCL (2004) (see Table 3). The concentration of metals obtained from the sediment samples were compared with sediments quality guidelines (Table 2), which showed that the mean concentrations of Fe, Cd and Pb (i.e. 43.81mg/Kg FW, 4.43mg/Kg dw and 0.36mg/Kg FW) had exceeded the Probable Effect Concentration (PEC) and the Severe Effect Concentrations (SEC) levels (20.03, 35.30 for Fe; 2.35, 3.35 for Cd and 0.05, 0.11 for Pb respectively). The decreasing order of heavy metal concentrations in sediments is Fe > Cd > Pb > Zn > Cu >Mn (table 3). Generally, the mean concentrations of heavy metals in the sediments were found to be higher than that of raw water (Table 2 & 3), which is in agreement with Depinto and Martin (1980) that bottom sediment contains higher concentrations of metals than that of overlying water and that sediments act as important reservoirs or sinks of metals and other pollutants in the aquatic environment (Fernandes et al., 2007). Fe was found to be of highest concentration in both raw water and sediments with mean concentrations of 0.86mg/L and 43.81mg/Kg dry weight respectively, followed by Cd with 0.04mg/L and 4.45mg/kg dry weight respectively while Mn is the least concentrated heavy metal in both raw water and sediments with values of 0.003mg/L and 0.0002mg/Kg dry weight respectively.

4.2 Heavy metals concentration in fish Species

From the study, it has observed that the mean heavy metal concentrations in tissues of the two fish species are higher than metal concentrations in raw water (see table 3 & 4). This agrees with the concept that concentrations of heavy metals in fish tissues are always higher than that of water (Chale, 2002). Furthermore, the mean concentration of heavy metals in the muscles and gills of Tilapia were found to be higher than in the African Bagrid (figure 2 &3). However, the results after analysis showed that the decreasing order of mean concentrations of heavy metals in the muscles and gills in both the African Bagrid and Tilapia are the same i.e. Fe > Mn > Pb > Cu > Cd > Zn (see Tables 4 & 5). It is further observed that Fe, Mn and Pb were maximally bioaccumulated in the gills and muscles of the fish species while Cu, Cd and Zn are the least accumulated. Muscles are the main edible parts of fish and therefore if any contamination from toxic substances occurs in it can adversely affect human health (Agah et al., 2009). In this study, it was observed that with the exception of Zn and Cu which are within acceptable limits, Fe, Cd, Mn and Pb had all exceeded the international guideline limits of WHO, 2003; WPCL, 2004 and USEPA, 1986 implying significant level of heavy metal contamination of the edible parts of the two consumed fish species in the study area. The presence of relatively high concentrations of Lead (Pb) and Cadmium (Cd) in the muscles of the fish species in the study area might be due to chemicals from agricultural activities and/or also from old buried pipes underneath the dam. With the exception of Mn, the mean concentrations of all the heavy metals in the muscles of the African Bagrid were higher than were observed in the gills (Table 4), while the concentrations of Fe, Mn and Cu were higher in the gills of the tilapia than in the muscles. The observed higher concentrations of Fe and Mn in the gills of both fish species than in the muscles is in partial agreement with conclusion of Hayton and Baron, (1990) that target organs such as gills and intestines are metabolically active parts that can accumulate heavy metals in higher levels and are considered to be the dominant site for contaminant uptake because of their anatomical and/or physiological properties that maximise absorption efficiency from water. However, the observed higher mean concentrations of Pb and Cd in the muscles as compared to the gills in both fish species in this study is at variance to the conclusions of Hayton and Baron (1990). Thus, the concept that the gills of fishes normally contain higher contaminants may not apply to all situations, but rather, levels of heavy metals in aquatic ecosystem could greatly be dependent on several environmental and natural factors. According to Rashed (2001), Pb and Cd concentrations can increase in fish tissues collected in freshwater ecosystem impacted by agriculture activities. Heavy metals such as Pb, Cu, Zn and Cd are common trace metals found in chemical fertilisers, which are currently being utilised massively in all-year-round irrigational farming within the catchment of the Tono Irrigational dam. Thus, there is the possibility of these heavy metals emanating from the chemical fertilisers, weedicides and all forms of pesticides being utilised in the cultivation of large farms within the irrigation scheme at Navrongo and which might be carried-out by surface run-off into the reservoir as contaminant. From table 5 & 6 above, it can be deduced from the estimated values of the transfer factors that the major source of heavy metal contamination of fish species in the Tono irrigation reservoir is from sediments at the bottom of the reservoir..

5. Conclusion

The occurrence of heavy metals concentrations in the raw water, sediments and tissues of these two commonly consumed fish species in Navrongo and its environs from the Tono Irrigation reservoir had established in this study. The water from Tono Irrigation Scheme is suitable for fish farming and for other agriculture activities and the consumption of these fishes is safe to some extent. The mean concentrations of heavy metals; Fe, Mn, and Pb (in mg/kg FW) in muscles and gills of tilapia and African Bagrid were 3.61,7.39; 0.693,0.767 0.375,0.365and 2.293,1.721; 0.693,0.749; 0.375,0.364 respectively, which were above the tolerable values as defined by USEPA, 1986, WHO, 2003 and WPCL, 2004 for trace metals in fishes (see Table 4). The high level of Fe and Zn shows that they were good bio-indicators to monitor pollution in the Tono dam for the two fish species. Sediments at the bottom of the reservoir are the main source of heavy metal contamination in fish species as depicted by transfer factor values. Heavy metal concentrations in fish samples were found to be generally higher than raw water while the sediments contain the highest concentrations. Contrary to general knowledge, the muscles of the two fish species contained higher heavy metal concentrations than the gills. The high metal levels in the muscles suggest that, the fishes are capable of concentrating heavy metals in their bodies from aquatic environments.

6. Recommendation

This study recommends the need for constant monitoring of trace metals concentrations in Tono irrigation dam since the dam serves as a source of fish and production of water for all-year-round irrigational farming and in some areas as a source of drinking water for the local inhabitants in the study area and beyond. Although no immediate health risk had been estimated from consumption of fish species from the dam, risk prevention and assessment should be done on the consumption of fish aimed at reducing the volume of heavy metals discharged from agriculture areas as well as other anthropogenic activities into the catchment. However,

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