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DETERMINATION OF HEAVY METALS IN WATER SEDIMENTS AND *TILAPIA ZILLI* FROM KOLO-CREEK, OGBIA LOCAL GOVERNMENT AREA, BAYELSA STATE, NIGERIA

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ABSTRACT
The study investigated the heavy metal concentration in Tilapia zilli and water sediments along Kolo Creek in Ogbia Local Government Area, Bayelsa State. Tilapia fish and sediment samples were collected from 5 stations, and analyzed for heavy metals following standard procedures. Four metals (Copper, Lead. Cadmium and Nickel) were recovered with increasing order of mean concentration as follows; Cu > Pb > Cd > Ni. Copper was significantly more abundant in the sediments, gills and muscle tissues than other element with mean concentration of 10. 73-16.61mg /kg, 3.32 -5.20mg/kg and 2.48-4.89mg/kg respectively. Except for Ni, other metals were more abundant in the gills than in the muscle tissues. Positive correlation matrix of the elements highlights a common origin. The concentration of these metals exceeded the maximum internationally allowable tolerance limits in drinking water, suggesting that Kolo Creek water is polluted and calls for prompt interventions.

Key Words: *Heavy metals, Sediments, Tilapia, Kolo-Creek, Bayelsa State.*

INTRODUCTION
The contamination of water with a wide range of pollutants has become a matter of great concern over the last decades (Al-weher, 2008). Heavy metals are non-biodegradable natural resources while some are stable environmental trace components of both fresh and marine waters, but their levels have increased due to domestic, industrial, mining and agricultural activities (Kalay and Canli 2000, Yousafzai and shakoori 2008). If the concentration levels of these elements increased beyond the level required, they can act in either actually or chronically toxic manner (Gulfaraz et *al*, 2001).

Sediments have been reported to form the major repository of heavy metals in aquatic systems (Olowu *et a*l, 2010). However, aquatic organisms such as fish and shell fish accumulate the heavy metals that are many times higher than the concentrations in the parent water or sediments through the process of biosorption and magnification (Olaifa *et al*, 2004). Heavy metals have the tendency to accumulate on various organs which, in turn can enter into the human metabolism through consumption, causing serious health hazards (Peul *et al*, 1987., USEPA., 1991., Anadon *et al*, 1984; Birge *et al*, 2000).

Copper, Cobalt, Zinc, Iron and Manganese are essential for enzymatic activity and many biological processes. Other metals such as Cadmium Mercury and Lead have no known essential role in living organisms, thus are toxic even at low concentrations (Bryan, 1976). Gbem *et al* (2001) have reported that accumulation of Chromium, Copper and Zinc increases in the order of these tissues; liver >gill> gut > muscle tissues. Onwumere and Oladimeji (1990) also reported that there was 1000 fold accumulation of heavy metals in *Oreochromis niloticus* exposed to treated petroleum refinery effluent. Earlier reports showed that industrial and domestic effluent constituted the largest sources of heavy metal, which contribute to the steadily increasing metallic contaminant in aquatic environments in most parts of the world (Olowu *et al*, 2010 Wangboje and Oronsaye, 2001).

Kolo-Creek in Ogbia Local Government Area of Bayelsa State is one of the ancient settlements where oil exploration started in Nigeria. This activity has continued to the hinther land in the area. As a consequence, the water resources situation is now precarious and of great concern to both host communities and Government. However, there is paucity of information on the heavy metal level in fish and water sediments in Kolo Creek. This study is therefore undertaken to determine the heavy metal level in the fish gills, muscle tissues and sediments at different stations in the Kolo-creeks. This result shall provide base line data on the assessment of aquatic health in the area.

MATERIALS AND METHODS

Study Area:

Kolo creek, $4^{0}.53^{1}$N - $6^{0}.22^{1}$E is located within the lower delta plain. It is situated northwest of Yenagoa, the Capital City of Bayelsa-State. The Creek is non-tidal fresh water that empties into the River Nun (Alagoa, 1999). The major activity of Economic value in the area is exploration and exploitation of Crude Petroleum Oil. Oil fields are located in each settlement along the creek, where effluents are discharged into the water body. The creek is the source of drinking water and livelihood of the people. The major occupation is fishing and farming.

Sample collection:

Sampling was carried out in accordance with standard method (ALPHA, 1998). Five stations corresponding to human settlements were delineated for samples collection. Fish and sediments were collected twice from each of the delineated stations during the period September, 2009-February, 2010. *Tilapia zilli* (10-20cm) in Length were purchased fresh from indigenous fishermen from each station. Each fish was properly rinsed in distilled water to remove debris, plankton and other external adherents. It was then drained under folds of filter paper, weighed, wrapped in aluminum foil and then frozen at -10 ^{o}C prior to laboratory analysis.

In the same station, bottom sediments were collected into pre-cleansed polyether bag using a stainless van-dergrab; air dried at room temperature for few days, sieved with 200mm mesh screen and wrapped with aluminum foil. This was made ready for laboratory analysis.

Treatment and Analysis:

The fish samples were defrosted for two hours cleansed and eviscerated. The gills and muscle tissues were separated into different Petri dishes following standard procedure in Rauf *et al*, (2009). Each of the fish parts were dried at 110^{o}C for 2 hours in Gallenkamp hot box oven and then homogenized in an electric moulinex blender for chemical analysis. 2.0g of the gill and muscle tissues were weighed and heated to ash at 550 ^{0}C for 90mins in a volumetric flask and filtered. Two milliliters of IM HHO_3 was added to the residue and the solution was heated again until sample was completely digested and became colorless. The solution was allowed to cool. Ten milliliters of 1M HNO_3 was added to the solution and finally made up to the 500ml in distilled water. The digested sample volume was filtered through 0.45mm millipore membrane filter (Type HV). The concentration of the filtrate was analyzed for Pb, Cu, Cd and Ni using (Shimadzu AA-680 Japan Atomic Absorption flame

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emissions spectrometer fitted with GFA-4B Graphite furnace).

RESULTS

Heavy Metal Concentration in Sediments across Study Stations

The spatial abundance of heavy metals in the sediments of Kolo Creek rivers was in the order, Cu > Pb > Ni > Cd. The mean and standard deviation of the heavy metals in the sediments varied across sampling stations (Table 1). The mean concentration of Copper ranged from 10.73 – 16.61mg /kg. The highest Cu concentration (16.61-10.43mg) was in station 2 and least in station 4, (0.22-10.73mg).

The mean concentration of Pb ranged from 4.97 - 8.44 mg/kg. This was highest in station 2 (8.44 ± 2.58mg) and least in station 4 (4.97 ± 3.91mg). The highest concentration of Ni (6.54 ± 1.81mg) was recorded in station 1 and least in station 3 (4.58 ± 1.08mg). The mean concentration of Cd was relatively low and ranged from 0.01 – 0.11 mg/kg. The highest was recorded in station 1 (0.11± 0.16mg), followed by station 2 (0.10 ± 0.12) and least in station 4 (0.01 ± 0.03mg)

Heavy Metal Concentration in Gills and Muscle Tissues of *Tilapia zilli*

The concentrations of metal in the various fish parts caught from five stations across Kolo Creek is shown in Table 2. In both gills and muscle tissues, Cu was found to be significantly more abundant than other metals. Cu concentration ranged from (3.32-5.20mg/kg) in gills and (2.13-4.89 mg/kg) in muscle tissues. Pb was the second highest in concentration ranging from (0.14-3.01mg/kg) in gills and (0.05-0.97mg/kg) in muscle tissues. Ni was least in concentration; (0.38-0.72mg/kg) in gills and 0.06-0.65mg/kg in muscle tissues. However, the concentrations of Cu, Pb and Cd in the increasing order of gill > muscle tissues followed the same pattern. The differences was not significant ($p > 0.05$). The concentration of Ni was slightly higher in the muscle tissues than in the gills.

The correlation matrix constructed (Table 3) for element in the sediments showed a positive correlation between Pb and Cu (0.230), Pb and Cd (0.560), Pb and Ni (0.034), Cu and Ni (0.431); a negative correlation existed between Cu and Cd, Cd and Ni. In the gill, positive correlation existed between Pb and Cd (0.115), Cu and Ni (0.607). A positive correlation existed between all elements in the muscle tissues.

Ta**ble 1:** Concentration of Heavy Metals (Mg) In Sediments of Kolo Creek Water, September, 2009 – February. 2010

	Heavy metal concentration (mg1kg) in sediments							
	Cu		Pb		Cd		Ni	
Station	$\bar{X}$	S.D	$\bar{X}$	S.D	$\bar{X}$	S.D	$\bar{X}$	S.D
1.	11.00	1.92	6.98	1.51	0.11	0.16	6.54	1.81
2.	16.61	10.43	8.44	2.58	0.10	0.12	5.92	2.32
3.	11.55	2.85	6.64	1.97	0.04	0.05	4.58	1.08
4.	10.73	0.22	4.97	3.91	0.01	0.03	6.36	1.46
5.	12.26	8.78	7.74	1.94	0.07	0.05	4.84	1.42

$\bar{X}$ = Mean, S.D = standard deviation.

TABLE 2: Concentration of Heavy Metals in Gills and Muscle Tissues of *Tilapia zilli*, September 2009 – February 2010

	Heavy metal concentration (mg) in gills and muscle tissue							
	Cu		Pb		Cd		Ni	
Station	gill	muscle	gill	muscle	gill	muscle	gill	muscle
1.	5.20	4.89	1.78	0.97	0.18	0.15	0.72	1.06
2.	3.83	3.57	2.70	0.22	0.23	0.14	0.50	0.81
3.	5.12	2.48	3.01	1.07	0.14	0.14	0.55	0.70
4.	3.32	2.73	0.14	0.05	0.16	0.03	0.38	0.71
5.	3.36	2.73	2.01	0.74	0.26	0.12	0.62	0.65

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Table 3: calculation matrix of water – elemental relationship in sediments, gills and muscle tissues of *Tilapia zilli*, from Kolo creek

	Sediments				gills				muscle tissue			
	Pb	Cn	Cd	Ni	Pb	Cu	Cd	Ni	Pb	Cu	Cd	Ni
pb	1				1				1			
cu	0.229503	1			-0.00662	1			0.072234	1		
Cd	0.15699	0.20582	1		0.114827	-0.24241	1		0.16738	0.4656020	1	
Ni	0.03398	0.43104	-0.0063	1	-0.3619	0.607209	-0.2249	1	0.192905	.474145	0640966	1

DISCUSSION

The concentration of heavy metals; (Copper, Lead, Cadmium and Nickel) in the water sediments and fish organs from Kolo creek indicates a high level of metal pollution. This may be attributed to the high human activities, such as discharge of untreated sewage and uses of industrial materials that contain metals or the ability of the sediment to act as sink (Olowu, *et al* 2010). The presence of these elements in both the sediments, gills and muscle tissues of fish in the study stations agrees with reports elsewhere (Wangboje and Oronsaye, 2001; Al-weher 2008; Biney and Becko 1991; Yilmaz, 2003). Except for Cadmium (Cd), the concentrations of other metals were higher in the sediments than in the gills and muscle tissues.

The high mean Cu – sediment level in all the study stations exceeded the 1.5uglg Cu/l allowable level in drinking water in Nigeria (FEPA 1991). The Cu concentration in the gills and muscle tissues is comparable with the report of Al –weher (2008). This is an indication that most Copper minerals are relatively insoluble. Naturally, Copper is often not a threat to humans except when present in at abnormally high values, where it causes anaemia, disorder of bones and connective tissues and liver damage. The toxicity depends upon the hardness and P^H of the water. It is more toxic in soft water with low alkalinity (Taha 2004).

The level of lead (Pb) had been higher in the sediment than other organs and tissues of fish (Addo *et al*, 2011). The high level of Pb recorded in this study exceeds the allowable limits of 2.0mg/Pb/g. The higher level of Pb in the gills than in the muscle tissues indicated that the gill is the primary site for Pb uptake in fish. This observation is consistent with Yousalfzai and Shakoori (2008). There had been a strong relationship between gill metal burden and toxicity (Playle *et al* 1993; DiToro *et al*, 2001). The bioaccumulation of Pb by fish may create detrimental effects on fisheries resources and could constitute a considerably health hazard, to man. Lead reduces reproductive capacity (Wangboje, and Oronsaye, 2001) while the consumption of the fish lead – polluted fishes by man interferes with heamoglobin synthesis. In severe cases; Pb poisoning may lead to encephalopathy anaemia, renal problems and death (Lawson, 1989).

The concentration of Ni in the water sediments observed in this present studies is comparable with the values obtained by Addo *et al* (2011). Concentration of nickel in Kolo Creek water exceeds the maximum allowable value of 0.015 – 0.020mg/l in unpolluted waters (WHO 1998., USEPA, 1986). However, a higher concentration of Ni in the gills than in the muscle tissues agrees with the report of Yousafzai and Shakoori (2008). Although Ni is considered an essential element to plants and some animals; (Ni is present in the enzyme urease), its importance to man is yet to be demonstrated (Teo and Chen, 2001). According to McKenzie and Symthe (1998), more attention has been focused on the toxicity of Ni in low concentration, such as the facts that Ni can cause allerigic reactions and that certain Ni compound may be carcinogenic. Nevertheless, nickel- related health effects such as renal, cardio vascular, reproductive and immunological effects have been reported in man (Salnikow and Denkhaus 2002).

The Cd concentration in the sediments exceeds the tolerance level of 0.01-0.05 mg/l as contained in USEPA (1983). The low gill –Cd concentration than in muscle tissues contrasts with the result of Al-weher (2008), who reported that the gills seems to be the organ which accumulates the highest value of Cd; the muscle showed the lowest level of Cd in *Oreochromis aureus*. The possible explanation and mechanism to this present result is not yet known. However, according to Arellano *et al* (1999), the differences in the pattern of heavy metals distribution might be a result of the differences in feeding habits, habitats, ecological needs and metabolism of the fish.

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A positive correlation matrix constructed for elements in the sediments, gills and muscle tissues is an indication that these elements were likely contracted from the same sources. Negatively correlated matrix might have different geochemical factors influencing their concentrations. The bio-accumulation of metals in fish and water sediments can be considered as an index of metal pollution in aquatic bodies. The presence of the toxic elements. Cu, Pb, Cd and Ni in Kolo creek water traceable to the multinational companies, (Olowu *et at*, 2010). The concentration exceeds the maximum allowable level contained in WHO and USEPA regulations. This could be very detrimental to the health of human beings and aquatic life. It is recommended however that the multinationals in these areas, should take notice of their acts and ensure improved waste management and monitoring polices. Safe drinking water should also be made available to the affected areas.

REFEENCES

Addo, M.A; Okley, G.M; Affum, H.A; Acquah, S., Gbadago, J.K, Senu, J.K and Botwe, B.O. (2011): Water quality and level of some heavy metals in water and sediments of Kpeshie Lagoon, La Accra, Ghana. *Res. J. Environ. Earth Sci*. 3 (5): 487-497.

ALPHA, 1998): Standard methods for the examination of water and waste water. 20th Ed. *American public Health Association*, New York, USA, pp 130.

Al-weher, S.M (2008): Level of heavy metal; Cd, Cu and Zn in three fish species collected from the northern Jordan Valley *Jordan. j. biol. Sci*. 1(1):41-46.

Alagoa, E.J (1999): Land and people of Bayelsa State, central Niger Delta, onyema publications, Port- Harcourt, pp 167.

Anadon, A., Maria, J.M and Ortz, J., (1984): Accumulation of Zn, Pb, Fe, Cu and Cr by rainbow trout .*J Bombay nat. Hist. Soc*. 79: 225 – 230

Arellano, J.M, Ortiz, J.B Capeta dasilva, D. Gonzalez de Canales, M.L; Surasquete , C and Blasco, J. (1999): Levels of copper, Zinc, manages and iron in two fish species from salt marshes of Cadiz Bay (South west Ibrians Peniosula) . *Bal. Inst. Esp. ocenogr*. 31 (1): 485-488.

Biney, C.A and Becko, C.A (1991) : Trace metal concentration in fish and sediments from WIWI a small urban river in kumasi, Ghana. *Trop. Ecol* 32 (2): 197- 206

Birge, W.J, Price, J.R; Shaw, J.A Wigginton, A.J, and Hogstrand, C, (2000): Metal body burden and biological sensors as ecological indications. *Environ Toxicol*: *Chem*.19: 1199 – 1212.

Bryan, G.W (1976): some effects of heavy metal tolerance in aquatic organisms. In Lockwood AP.M (ed) effects of pollutants on aquatic organisms, Cambridge University Press, Cambridge, England pp.7.

DiToro, D.M, Allen, H.E, Bergman, H.L Meyer J.S, Paquin P.R and santore, R.C (2001): Biotic Ligand model of the acute toxicity of metal, *Environ. Toxicol. Chem*. 20: 2383.

Federal Environment Protection Agency (FEPA); (1991): Guidance and standards for environmental pollution in Nigeria. FEPA Lagos, Nigeria, PP1-10.

Gbem, T.T Balogun, J.K; Lawal, F.A; and Annune, P.A; (2001): Trace metal accumulation in *Clarias gariepinus* (Tuegels) exposed to sub-lethal levels of tannery effluent. *Sci Total environ*. 271: 1-9.

Gulfaraz, M. Almad, T and Afzai H; (2001): Concentration levels of heavy and trace metals in fish and relevant water from Rawal and mangla. *J. Biol. Sc*. 1: 414 – 420.

Kalay, M and Canli, M (2000): Elimination of essential (Cu, Zn) and non essential (Cd Pb) metals from tissues of a fresh water *Tilapia zilli* following an uptake protocol. *Tukr J. Zool*. 24: 429 – 436.

Lawson, E.M (1989): Petroleum industry safety hazards/ precautions. *Napetcor* 10 (3): 7 -11

McKenzie, H.A and Symthe, L.E. (1998): Quantitative trace of analysis of Biological materials, Elsevier, Amsterdam, 511-525.

Olaifa, P.E., Olaifa, A.K., Adelaja, A.A; and Owolabi, A.G. (2004): Heavy metal contamination of *Clarias gariapinus* from a lake and fish farm in Ibadan, Nigeria. *Afri J. Bio Med. Res* 7:145 – 158.

Olowu, R.A., Ayejuyo, O.O., Adewuyi, G.O., Adejoro, I.A., Denloye, A.A.B., Babatunde, A.O and Ogundajo, A.L. (2010): Determination of heavy metals in fish tissues, water and sediment from Epe and Badagry Lagoons, Lagos, Nigeria. *Electronic Journal of chemistry* 7 (1): 215 – 221.

Onwumere, B.G and Oladimeji, A.A (1990): Accumulation of metals and histo-pathology in *Oreochromis niloticus* exposed to treated NNPC Kaduna (Nigeria) petroleum refinery effluent. Ecotoxicol Environ. Safe. 19: 123 – 134.

Playle, R.C, Diton, D.G and Burnison, K (1993): Copper and stability constants and modeling of metal accumulation, *Can. J. Fish aquatic Sci*. 50: 2678-2687.

Puel, D, Zsuerger, N and Breittrot Mayer J.P, (1987): Statistical assessment of a sampling pattern for evaluation of changes in mercury and zinc concentration in *Patella coerulen.* Bill environs. Contam. Toxicol, 38:700-706.

Rauf, A., Javed, M., and Ubaidullah, M (2009): heavy metal levels in three major carps (*Catla catla*, *Labeo rohita* and *Cirrhina mrigala*} Pakistan. *Pakistan vet .J*. 29 (1): 24-26.

Salnikow, K and Denkhaus, E. (2002): Nickel essentiality, Toxicity and carcinogenicity. *Crit. Rev. oncol Hae*matol. 42 (i); 35 – 56.

Taha, A.A; (2004): Pollution sources and related environmental impacts in the new communities, Southeast Nile Delta, Egypt. *Emirat J.Eng. Res*. 19 (i) 14.

Teo, K.C and Chen (2001): Determination of Cobalt and Nickel in water using atomic absorption spectrometry after

Scientia Africana, Vol. 11 (No.1), June 2012. pp 44-52
© Faculty of Science, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*

cloud point extraction. *Anal. Chem. Acta*. 434 (3): 325-330.

United States Environmental Protection Agency (USEPA), (1986): Quality criteria for water. Office of water regulation and standards, Washington DC, USEPA 40015 – 86-001, 256.

United State Environmental Protection Agency (USEPA), (1983): Methods of chemical analysis of water and waste water, EPA/600/4-79/020, 374.3.1-375.43.

USEPA (1991): Methods for the determination of metals in environmental samples. EPA /000/491 -010. U.S. Environmental Protection Agency. Cincinati. OH.

Wangboje, O.M. and Oronsaye, J.A.O. (2001): Bio accumulation of Iron, Lead, Mercury, Copper, Zinc and Chromium by fish species from Ogba River, Benin city, Nigeria, *Afri .j. Appl zool. Environ. Biol*. 3: 45-49.

World health organization (WHO) (1998): Guide lines for Drinking water WHO criteria and other supporting information, WHO, Geneva 130.

Yilmaz, A.B. (2003): levels of heavy metals (Fe, cu, Ni, Cr, Pb and Zn) in tissues of. *Mugil cephalus* and *Trachurus mediteraneus*_from Iskenderum bay. *Turkey Environ. Res*. 92: 277-281

Yousalfzai, A.M and Shakoori, A.R. (2008): Heavy metal accumulation in the gills of an endangered South Asian fresh water fish as an indicator of aquatic pollution. *Pakistan .J. Zool*. 40 (6). 423 – 430.