Bioaccumulation Of Trace Metals In Water, Sediment And Crab (Callinectes) From Sombreiro River, Niger Delta, Nigeria.

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Abstract: Thetrace metal burden in surface water, sub-tidal sediment and edible crab – Callinectes in the lower (brackish/ sea water) reaches of the Sombreiro River was studied over a three month period. Sediments had a higher concentration of metals than water, with the concentration ranging from 0.022±0.006 – 340.66±106.21mg/kg and 0.002±0.001 – 0.99±0.104 mg/l respectively. It was revealed that Callinectes from the study area bioaccumulates all the heavy metals investigated from water and Cr, Cu, Ni and Zn from sediment. The concentration of all the heavy metals under investigation- Cr, Cu, Ni, Cd, Pb and Zn were below their stated limits in water and sediment, however, the metal body load of Cu, Cr, Ni, Pb and Zn in the tissue of Callinectes were above their stated limits, as such its consumption poses a health risk to consumers.

Key words: Bioaccumulation Factor, Callinectes, Niger Delta, Sediment, Sombreiro River, Tracemetal, Crab

1 INTRODUCTION

Naturalresources occur and are embedded in the environment, and that any factor(s) that result in stress to the environment therefore have direct impact on the biodiversity resources that they contain. Environmental threats to exploitable natural resources could arise from human activities or as a result of natural events[1]. Continuous anthropogenic input of pollutants into the aquatic environment constitutes a potential threat to natural ecosystems because of direct effect on the water quality as well as aquatic organisms. Since majority of pollutants entering into the marine environment are chemical in nature, theinvestigation of the release of chemicals into the workplace or into the environment is a topic of current interest,[2].Some pollutants such as heavy metals are bio-accumulated and some are biomagnified in food chains and thereby become risks to top predators, including humans. Because the residence times of metals on the biosphere are long even the transport of small amounts through biota is of eco-toxicological importance.Marine organisms such as fish-[3], [4]; periwinkle–[5], [6] andoyster – [7] have beenimplicated as accumulators of tracemetals.Metal body loads of aquatic biota are therefore often measured and used to evaluate ecological risks and potential sub-lethal effects [8].

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Coastal sediments are important hosts for pollutant trace metals andbecause of the devastating effect of certain toxic metals on human health, metal pollution is potentially one of the most serious forms of aquatic pollution. Benthic organisms (such as crabs) are likely to be most directly affected by sediment metal concentrations because the benthos is the ultimate repository of the particulate materials that wash into the aquatic systems [9]. As is the case in other coastal areas, the major and cheapest source of animal protein available and accessible to the local people (living along the coast line of Sombreiro River) is fish and other sea foods such as shrimps, crabs, oyster, periwinkle etc. gotten from the river, which therefore makes the maintenance of the health of the river and its resources inevitable. Callinectes (edible crab or true crab) referred to as ikoli by the native Kalabari people is a highly sought-after sea food of choice that is very nutritious and is used as a source of protein inseveral delicacies. It is an alternative to fish in the diets of some of the locals and serves as a means of livelihood to those involved in its harvesting and marketing. However, there is no information on the trace metal content and or the bio-accumulation potential of edible crabs from the Niger Delta, particularly the Sombreiro River, thus this investigation.Paez – Osunaet al[10] had earlier noted that since metal pollution is increasing in tropical areas, it is important to conduct such studies to record the range of concentration within commercial species, so that assessments about potentially hazardous levels, from the human – nutritional standpoint, can be made.

2 Materials and Method

i.) Study Area

The study area- Sombreiro River (Fig. 1a &b) is located in Rivers State in the Niger Delta region of Nigeria, and liesbetween latitude 04^0 43`18`` to $04^0$ 37` 37.3`` N and longitude 006^0 46` 25`` to $006^0$ 48` 56.5`` E. It is a tidal dominated river, with fresh water input.

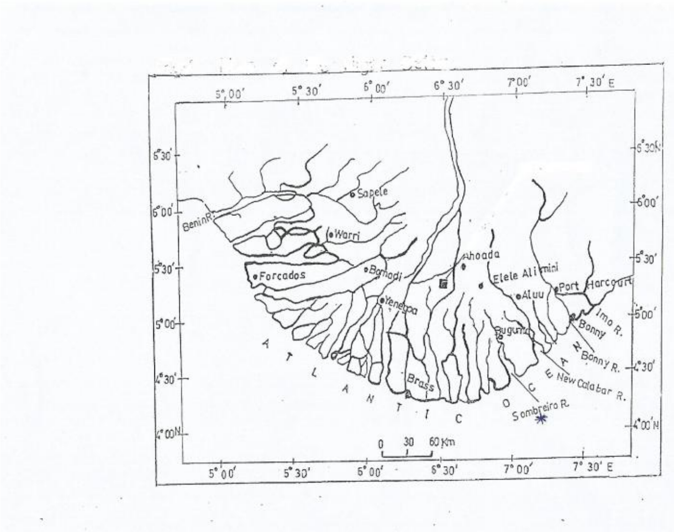

Fig. 1(a): *Map of the Niger Delta Area.*

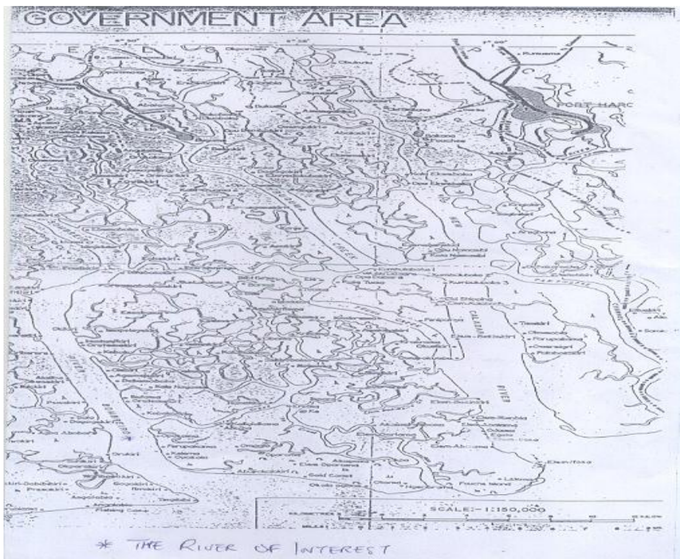

Figure 1(b)*: Map of the study area – Sombreiro River*

ii) Sample collection and Laboratory Analysis

Water samples were collected in 2 – litre plastic containers from the sub- surface (5- 10cm depth) in each station. Two replicate samples were collected per station and transported to the laboratory in an ice- chest container for analysis. Two replicate seabed sediment samples for trace metalanalysis were also collected in each of the sampling stations using Peterson Grab and transported to the laboratory in black polyethylene bags. 10 samples of the blue crab – Callinectes caught in fishing nets were gotten from local fishermen along the coasts of Sombreiro River. Samples were stored in an ice chest before transporting to the laboratory for identification and heavy metal analysis. Identification to the genus level was achieved with the aid of identification keys by [11]. Laboratory analysis of heavy metals in water was carried out using atomicabsorption spectrophotometer. Sample preparation was by acid digestion followedby filtration through a 0.45 micro membrane filter. Aliquots of the filtrate were thenused for the various metals.In the laboratory, Callinectes tissue samples were oven- dried at 80^{o}C for about 24hours after which 2g of the dried sample was digested in 10ml of concentratednitric acid at 60^{0}C for 30 minutes. I ml of hydrogen peroxide was added to furtheroxidize any recalcitrant lipid material in the sample as in [12]. The digested tissues were thendiluted to 100 ml with deionized water, andfiltered. The filtrate was then analyzedfor the different metals using Flame AtomicAbsorption Spectrophotometer.

3 Results and Discussion

Mean trace metal concentration in water, sediment and crab tissue ranged from0.002±0.001– 0.099±0.104mg/l, 0.022±0.006 - 340.66±mg/kg and 0.003 –123.42±7.35 mg/kgrespectively, (Table 1). The highest concentration of copper,chromium, nickel and zinc were gotten in the tissue of crab, while that ofcadmium, iron and lead were observed in sediment. Nevertheless, iron was themost abundant of all the metals investigated in both media and crab tissue asshown in Table 1. Generally, trace metal concentration pattern varied in water,sediment and crab tissue. The decreasing order of metal concentration in waterwas Fe > Ni > Cu > Cr > Zn >Pb> Cd, that of sediment was Fe > Zn > Cr > Ni >Cu >Pb> Cd and the order in crab tissue was Fe > Zn > Cu > Cr > Ni >Pb> Cd.

Table 1: Mean Heavy Metal Concentration in surface water, sediment and tissues of Callinectes in the study area.

	Fe	Cr	Cu	Ni	Cd	Pb	Zn
Water (mg/l)	0.099± 0.104	0.055 ± 0.067	0.056± 0.075	0.091 ± 0.132	0.002± 0.001	0.003± 0.011	0.04± 0.024
Permissible limit 1.[13] 2.[14]	1.0 0.05- 1	0.5	1.0 0.05-15	0.1	0.01 0.05	0.05 20.0	1.0 0.05
Sediment (mg/kg)	340.66 ± 106.21	4.27± 1.675	0.628± 0.495	1.693 ± 0.957	0.022± 0.006	0.474± 0.401	5.37± 1.918
Permissible limit [14] (mg/kg)	100	200	100.0	500	0.3	20.0	300
Callinectes (mg/kg)	123.42 ± 7.35	41.74 ± 2.17	45.31± 2.92	39.43 ± 1.77	0.003± 0.001	0.24± 0.04	52.47 ± 3.18
Permissible limit 1. [15] 2. [16] 3. [14]	146 400	0.3	30.0 3.28 30	5	0.5 0.18 0.5	0.5 0.12 3	40 300

The concentration recorded for trace metals in water were lower than thosereported by [7], but higher than that gottenby [3]. The concentrations of heavymetals inthe waters of Sombreiro River as revealed by this investigation are allbelow the permissible limits of [14] as well as that of [13]. For sediment, the observedconcentrations were higher than the reported concentrations of [5] except for iron and lead. Sedimentconcentration of trace metals in this investigation weregenerally higher than that in waterbecause as noted by [17] sediment serves as a natural sink for aquatic pollutants(such asheavy metals), andholds more than 99% of the total amount of metalpresent in the aquatic system [18]. The metal body load of Callinectes as revealed in this study is higher than thevalues reported by [19] in Tilapia gallier, [20] in the different organs ofClariasgariepinusand [21] in threecommercial fish species. It is however lower than theobserved range of 0.44 -136.9 mg/kg recorded by [22] in the liver of Oreochromisniloticus.Among marine invertebrates, [7] recordedhigher concentration of tracemetals in Tympanotonusfuscatus and Crassostreagasar for all the metals underinvestigation except Nickel. Similarly, the tracemetal burden (Zn 90 - 500µg/g, Pb0.3 - 26µg/g, Cd 1.6 - 4µg/g and Cu 30 – 140µg/g) in Littorinasaxatilis[6], fromsites around the Isle of Manwere alsohigher than that gotten in this study. The bioaccumulation factor (BAF) given by the ratio of the metal concentrations inCrab to that in sediment and or water indicates the occurrence of bioaccumulation.

Table 2: Bioaccumulation factor (BAF) of trace metals in Callinectes from water and sediment along the lower reaches of Sombreiro River

Medium	Fe	Cr	Cu	Ni	Cd	Pb	Zn
Water	1246.66	758.91	809.11	433.30	1.5	80	1311.75
Sediment	0.36	9.78	72.15	23.33	0.14	0.51	9.77

According to [23] a BAF greater than 1.00shows bioaccumulation. It then followsthat Callinectes accumulates trace metalsfrom water more than from sediment(Table 2). BAF in crab from water rangedfrom 1.50 –1311.75, indicating that allthe metals were bioaccumulated (that is, itsconcentration is higher in the tissuethan in the surrounding water), howeverthat for sediment reveals that iron,cadmium and lead are not bioaccumulated. Thisreport agrees with the conclusionof [5] thatperiwinkles show bioaccumulation. The bioaccumulation of iron andchromium incrab is in agreement with the report of [24] but is in contrast with thatof [5]. The order ofbioaccumulation in crab (from sediment) in this study is Cu >Ni > Cr > Zn >Pb>Fe > Cd, while that from water is Zn > Fe > Cu > Cr > Ni >Pb>Cd. Both trendsdoes not agree with the order of Mn> Cu >Pb> Ni > Fe > Crreported by [5] from the lower Sombreiro River.The concentration of chromium,nickel, copper and zinc in the tissues ofCallinectesare higher than the[14] and or[15] recommended limits while that of lead and copper are higher than the statedlimitsof[16].Similarly, the observedconcentrations of trace metals in thisinvestigation when compared tothe recommended daily intake of Fe(48.0mg/day),Zn (60.0mg/day), Cu (3.0) andPb (0.214mg/day) for an adult by [25] indicates thatconsumption ofCallinectes from SombreiroRiver might pose a health risk toconsumers.

REFERENCES

[1] Niger Delta Development Commission [NDDC], Niger Delta Regional Development Master Plan, Port Harcourt, Nigeria, pp. 258, 2006.

[2] R.J. Flanagan, A. Taylor, I.D. Watson and R. Whelpton,Fundamentals of Analytical Toxicology. John Wiley and Sons Ltd. The Atrium, Southern Gate, Chichester, West Sussex PO198SQ, England,pp.505, 2007.

[3] F. Upadhi, O.A.F. Wokoma and J.A. Edoghotu, 'Levels of Bioaccumulation of some Heavy Metals in Fish (Tilapia zilli) and their concentration in water and sediment of Owubu Creek, Niger Delta, Nigeria,'Resources and Environmentvol. 3, no. 3,pp. 59 – 64,2013.

[4] Lars Jarup, 'Hazards of heavy metal contamination'British Med. Bull. vol. 68,167 – 182, 2003.

[5] T.J.K. Ideriah, O.A. Briggs and H.O. Stanley, 'Bioaccumulation of heavy metals in periwinkle from Lower Sombreiro River, Nigeria,'JNESvol. 5, no. 3, pp. 207 – 216, 2010.

[6] E.R. Daka,'Heavy metal concentrations in Littorinasaxatilis andEnteromorphaintestinalis from Manx Estuaries,'Baseline 1 Marine PollutionBulletin, vol. 50, pp. 1433 – 1456, 2005.

[7] I.C. Howard, U.U. Gabriel and B.C. Onyekwere, 'Bio concentrationpatterns of some trace metals in Tympanotonusfuscatus (Var. Radula) andCrassostreagasar from the tidal flats of the Sombreiro River, Niger Delta,'JNESvol. 7, no. 3,pp.114 –123, 2012.

[8] M. Kalay, O. Ay and M. Canli, 'Heavy metal concentration in fish tissue from the Northeast Mediterranean Sea,'Bull. Environ. Contam.Toxicol. Vol. 63, pp.673 – 681, 1999.

[9] E.A. Laws, Aquatic Pollution: An Introductory Text. John Wiley & Sons Inc. New York, pp. 639, 2000.

[10] F. Paez- Osuna, R. Perez- Gonzalez, G. Izaguerro – Fierro, H.M. Zazueta – Padilla and L.M. Flores- Campana, 'Trace metal concentrations and their distribution in the Lobster Panilurusinflatus (Bouvier, 1895) from the Mexican Pacific Coast,'Environmental Pollution, Vol. 90, No. 2, pp.163- 170, 1995.

[11] FAO, Field guide to the Commercial Marine Resources of the Gulf of Guinea. FAO Species Identification Sheets for Fishery Purposes. FAO Regional Office for Africa. Pp 266, 1990.

[12] M.H. Abdullah, J. Sidiand A.Z. Aris, 'Heavy metals (Cd, Cu, Cr, Pband Zn) in MeretrixmeretrixRoding, Water and Sediment from Estuaries in Sabah, North Borneo,'International Journal of Environmental and Science Education, vol. 2, no. 3, pp. 69 – 74, 2007.

[13] United States Environmental Protection Agency (USEPA), Quality criteria for water. EPA 440/5-86-001. May 1986. Office of water regulations and standards.Washington DC., USA, 1986.

[14] RSMENR, Interim Guidelines and Standards on Environmental Pollution Control and Management in Rivers State. Ministry of Environment and Natural Resources, Port Harcourt. pp. 39 – 45, 2002.

[15] FAO/WHO, 'Evaluation of certain food additives and the contaminants mercury, lead and cadmium,'WHO Tech. Report.Series No. 505, 1989.

[16] E.J. Wyse, S.J. Azemard and S.J. Mora, 'Report on the world-wide inter-comparison exercise for the determination of trace elements and methl-mercury in fish homogenate,' Technical ReportIAEA-407, IAEA/AL/144(IAEA/MEL/72), IAEA, Monaco, 2005.

[17] A. Gupta, D.K. Rai, R.S. Pandey and B. Sharma, 'Analysis of some heavy metals in the riverine water, sediment and fishes from River Ganders at Allahabad.'Environ. Monit. Assess. vol.157, pp. 449 – 458, 2009.

[18] A.C. Chindah andS.A. Braide, 'Cadmium and lead concentrations in fish of a brackish wetland/ upper Bonny Estuary Niger Delta,'JNES, vol. 2, no. 3, pp. 5 -11, 2003.

[19] G.A. Dimari, F.L. Abdulkarim, J.C. Akan and S.T. Garba, 'Metalconcentrations in tissues of Tilapia gallier, Clariaslazera and Osteoglosidaecaught at Alau dam, Maiduguri, Bornu State, Nigeria,'American J. Environ. Sci. vol. 4, no. 4, pp. 373 – 379, 2008.

[20] A. Uzairu, G.F.S. Harrison, M.I. Balarabeand J.C. Nnaji, 'Concentration levels of trace metals in fish and sediment from Kubani River, Northern Nigeria,'Bull. Chem. Soc. Ethiopia, vol. 23, no.1, pp. 9 -17, 2009.

[21] P. Vijayakumar, R. Lavanya, N. Veerappan and T. Balasubramanian, 'Heavy metal concentrations in three commercial species in Cuddalore Coast,

Tamil Nadu, India,' J. Exp. Sci. vol. 2, no. 8, pp. 20 – 23, 2011.

[22] F. Yilmaz, 'The comparison of heavy metal concentrations (Cd, Cu, Mn, Pb and Zn) in tissues of three economically important fish (Anguillaanguilla, Mugilcephalus and Oreochromisniloticus) inhabiting Koycegiz Lake-Mugla (Turkey),' Turkish J. Sci. Technol.vol. 4, no. 1, pp. 7- 15, 2009.

[23] V. Kalfakakourand K. Akrida – Demertzi, Transfer factors of heavy metals in aquatic organisms of different trophic levels. HTML Publications, vol. 1,pp. 76 – 78, 2000.

[24] T.J.K Ideriah, S.A. Braide andA.O. Briggs, 'Distribution of lead and total hydrocarbon in tissues of Periwinkles (Tympanotonusfuscatus and Pachymelaniaaurita) in the upper Bonny River, Nigeria,'J. Appl. Sci. Environ. Mgt. vol. 10, no. 2, pp. 145 – 150, 2006.

[25] FAO/WHO, Expert Committee on Food Additives. Summary and conclusion, 53rd meeting, Rome, 1-10 June, 1999.