INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Concentrations of Heavy Metals in Selected Macro-Invertebrates of Dadin Kowa Dam, Gombe State, Nigeria

Ezekiel, Buzi
Post Graduate Student, Department of Fisheries and Aquaculture, College of Forestry and Fisheries, University of Agriculture Makurdi, Benue State, Nigeria
Annune, Paul. A.
Professor, Department of Fisheries and Aquaculture, College of Forestry and Fisheries, University of Agriculture Makurdi, Benue State, Nigeria
Solomon, S. G.
Professor, Department of Fisheries and Aquaculture, College of Forestry and Fisheries, University of Agriculture Makurdi, Benue State, Nigeria

Abstract:
Macro-invertebrates may serve as vectors of fish and human exposure to heavy metals and little or no information exist on the heavy metals concentrations in macro-invertebrates of Dadin kowa Dam. Therefore, the need to determine the heavy metals concentration in the most available macro-invertebrates (Anax junius, Pontala flavescences, Lanistes libycus, Nepa cinerea, Dyticus dauricus) of the Dam. All samples were analyzed using atomic absorption spectrophotometer (Bulk scientific, model 205). The result indicates that the concentration pattern of heavy metals in all the macro-invertebrates were in the order of Mg>Mn>Co>Cr>Ni>Cu>Cd>Pb. The bio-concentration factors were calculated in order to know the relationship between the concentrations of heavy metals in the macro-invertebrates and their surrounding environment (sediment). The pattern of bio-concentration factors in A. junius, P. flavescences, L. libycus, N. cinerea and D. dauricus were in the order of Co>Mn>Cu>Cr>Mg>Cd>Ni>Pb,Cu>Mn>Co>Cr>Mg>Cd>Ni>Pb,Co>Mg>Mn>Cu>Cr>Cd>Ni>Pb,Cu>Mn>Cr>Mg>Co >Ni>Cd>Pb and Mn>Cu>Cr>Mg>Cd>Pb>Co>Ni respectively. The result suggests that heavy metals uptake by the macro-invertebrates do not exclusively depend on the concentration levels by sediment exposure alone but may largely depends on their feed, feeding habits and biochemical needs of individual macro-invertebrates. The bio-concentration factors estimated here provide a useful tool for predicting fish and human exposure to Heavy metals via macro-invertebrates.

Keywords: *Bio-concentration, Heavy metals, macro-invertebrates, Aquatic pollution*

1. Introduction

The term “heavy metals” refers to any metallic element that has a relatively high density and is toxic or poisonous even at low concentration (Lenntech, 2004). The heavy metals are lead (Pb), silver (Ag) chromium (Cr), cadmium (Cd), copper (Cu), zinc (Zn), mercury (Hg), arsenic (As), iron (Fe), and the platinum group elements of the periodic table.

The presence of heavy metals in aquatic ecosystems is as a result of natural occurring deposits and or anthropogenic activities (man-made). The main sources of heavy metals contamination to life forms are invariably the result of man-made activities (Kennish, 1992; Francis, 1994). The unselective discharged and release of industrial effluents, petroleum wastes and crude oil spills which contain great amount of heavy metals gives rise to consequences which are very harmful to the health of the environment (Francis, 1994). In addition, high influx of run-off delivers into the water bodies suspended solids, agricultural wastewater containing pesticides and fertilizers and effluents of industrial activities, supply the aquatic environments with large quantities of inorganic matter and heavy metals (ECDG, 2002; Nwajei *et al.* 2012).

These heavy metals have the ability to bio-accumulate in the various aquatic organisms, and the accumulation depends upon the intake and the elimination from the body (Karadede *et al.* 2004). Aquatic organisms such as phytoplanktons, zooplanktons, fishes and other macro-invertebrates may incorporate these heavy metals into their bodies during feeding and these may remain for a very long time. The accumulated heavy metals in the tissues of these organisms can passed on in the food chain. Macro-invertebrates and fish, being major components of most aquatic habitats have also been acknowledged to be good bio-accumulators of organic and inorganic pollutants (King and Jonathan, 2003).

2. Materials and Methods

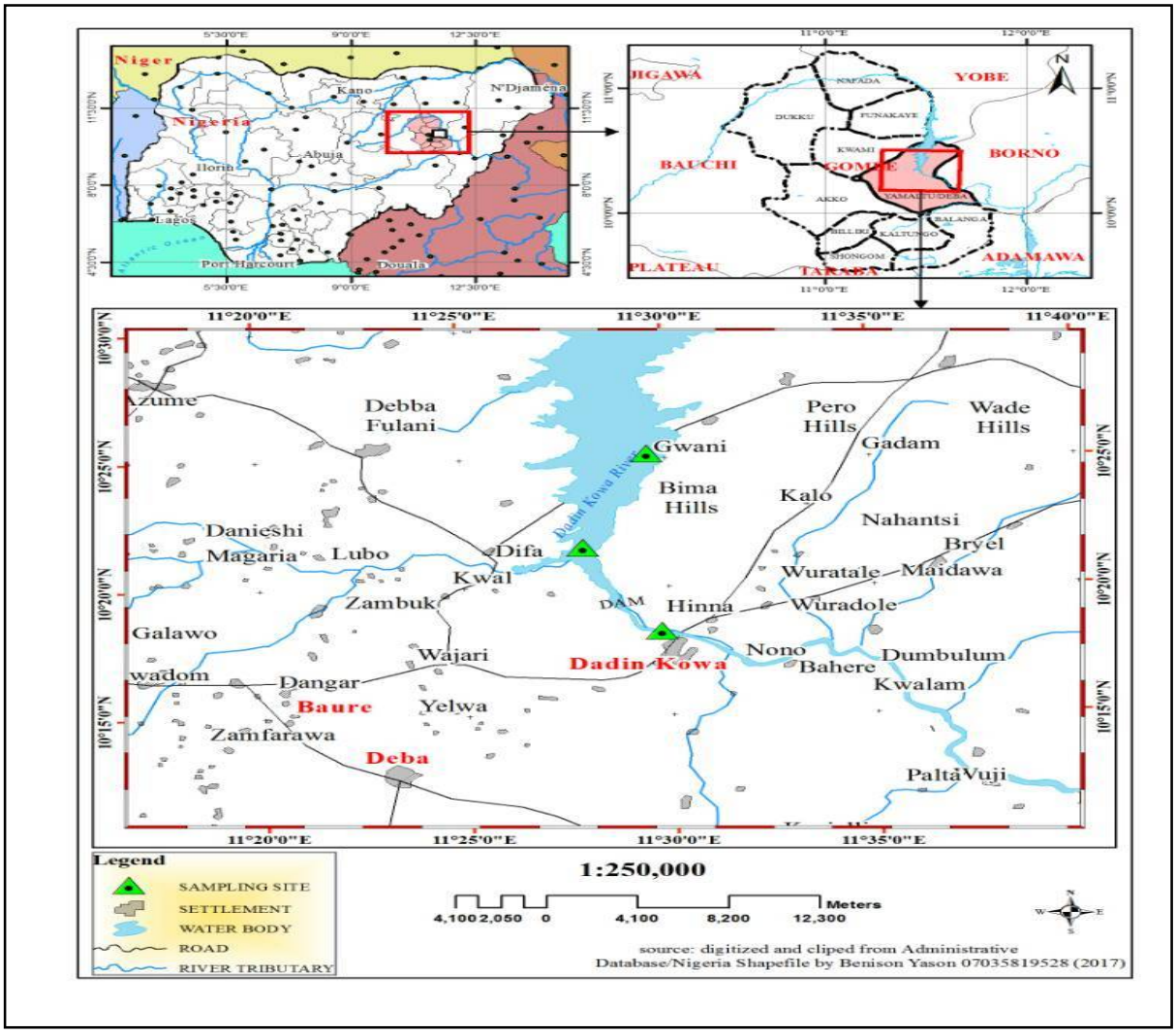

Figure 1: Map of Dadinkowa Dam, Gombe State Nigeria. Showing the sampling stations

Dadin Kowa Dam is located 5km North of Dadin Kowa village (along Gombe-Biu road, about 37km from Gombe town) in Yamaltu Deba local Government Area of Gombe State. The area lies within longitude 11°28'11.31''E, and Latitude 10^0 28'10.65''18N of the equator (UBRDA, 1980).

Five notable species (*Anax junius*, Pontala flave scences, *Lanistes libycus*, *Nepa cinerea* and *Dyticus dauricus*) were obtained from three different sampling stations for eight months. These were done based on their abundance in the area. The complete bodies of each species were used during this study. Each sample was washed with de-ionized water and then placed differently on a foil paper and put in an oven at a temperature of 105^0C for 24 hours to obtain a constant weight (AOAC, 1993).

Powdered samples (2g of each sample) of macro-invertebrates and sediments were weighed accurately with a weighing balance (Ohaus Model- AR 2130) and put into a round bottom flask. Concentrated acids of 6 ml nitric acid (HNO3, 65%) and 3 ml of hydrochloric acid (HCl, 37%) was prepared in a measuring cylinder and added to each sample and shaken. It was then placed on a hot plate (Kjabahl litter) to digest until a transparent or clear solution was attained. The solution was allowed to cool then filtered with what man No.1 filter paper. The filtrate was then filled up to a mark of 100ml using deionized water. The solution was then transferred into a labelled sample bottle for analysis.

An atomic absorption spectrophotometer (Bulk scientific, model 205) was used for the analysis. The metals analyzed for were Cadmium, Copper, chromium, cobalt, nickel, magnesium Lead and Manganese.

2.1. Bio-concentration Factor

The Bio-concentration Factors were determined using this formula:

$$Cf = \frac{Cm}{Cs}$$ (Vanleeuwen *et al.* 1986)

Where

Cf = Concentration factor

C_0 = Concentration of metal in macro-invertebrate
C_{wa} = concentration of metal in test sediment

2.2. Data Analysis
Means of significance were separated using Duncan multiple range test (P=0.05) to assess variability between species. All statistical calculations were performed with Statistical Package and Service Solution (SPSS version 20.0) for Windows.

3. Result and Discussion

Species	Cu	Pb	Cr	Co	Ni	Cd	Mn	Mg
L. libycus	0.103±0.01	0.006±0.00^{ab}	0.228±0.04	0.506±0.08	0.117±0.00	0.017±0.00	1.410±0.09^{a}	64.53±0.07^{b}
P. flavescens	0.110±0.02	0.004±0.00^{a}	0.343±0.06	0.426±0.02	0.192±0.06	0.024±0.00	1.263±0.07^{a}	45.57±0.14^{a}
A. junius	0.111±0.02	0.003±0.00^{a}	0.325±0.07	0.678±0.13	0.167±0.04	0.021±0.00	1.568±0.07^{a}	46.62±0.13^{a}
N. cinerea	0.132±0.03	0.002±0.00^{a}	0.365±0.08	0.651±0.14	0.192±0.08	0.018±0.00	1.504±0.04^{a}	46.56±0.14^{a}
D. dauricus	0.113±0.02	0.012±0.00^{c}	0.333±0.07	0.643±0.13	0.133±0.01	0.018±0.00	3.154±0.34^{b}	44.97±0.14^{a}

Table 1:Mean Heavy Metal Concentrations (mg/kg) in Macro-invertebrate Obtained from Dadin Kowa Dam, Gombe State

Mean in the same column with different superscripts differ significantly (P<0.05)

Metals	Cu	Pb	Cr	Co	Ni	Cd	Mn	Mg
concentrations	0.238±0.04	0.070±0.02	0.897±0.19	1.036±0.07	0.918±0.12	0.090±0.01	3.048±0.13	133.05±0.61

Table 2: Mean Heavy Metal Concentrations (mg/kg) in Sediments Obtained from Dadin Kowa Dam, Gombe State

Species	Cu	Pb	Cr	Co	Ni	Cd	Mn	Mg
L. libycus	0.433±0.18	0.086±0.16	0.254±0.12	0.488±0.78	0.127±0.25	0.189±0.57	0.461±0.12^{a}	0.485±0.03^{b}
P. flavescens	0.462±0.22	0.057±0.17	0.382±0.07	0.411±0.75	0.209±0.18	0.267±0.85	0.414±0.10^{a}	0.343±0.01^{a}
A. junius	0.466±0.12	0.043±0.17	0.362±0.12	0.654±2.11	0.182±0.81	0.233±0.86	0.514±0.13^{a}	0.350±0.06^{a}
N. cinerea	0.555±0.18	0.029±0.11	0.407±0.06	0.209±2.40	0.209±1.13	0.200±0.87	0.493±0.12^{a}	0.350±0.02^{a}
D. dauricus	0.475±0.10	0.171±0.29	0.371±0.11	0.145±2.39	0.145±0.33	0.200±0.64	1.035±0.28^{b}	0.338±0.02^{a}

Table 3:Mean Bio-concentration Factors of Heavy Metals inMacro-invertebrate from Dadin Kowa Dam, Gombe State
Key: Mean in the same column with different superscripts differ significantly (P<0.05); ND=Not Detected

Aquatic macro-invertebrates serve as food to most carnivorous fish species, thereby transferring the acquired heavy metals along the food chain. The highest concentrations of Cu (0.132±0.03mg/kg), Cr (0.365±0.08mg/kg) and Ni (0.192±0.08mg/kg) in macro-invertebrates obtained from Dadin kowa Dam were found in *Nepa cinerea*; this could be as a result of the concentrations of these metals in the benthic zone where the specie reside and could also be as a result of the feed and feeding habit of the specie. The lowest concentrations of Cu (0.103±0.01mg/kg), Cr (0.228±0.04mg/kg), Ni (0.117±0.00mg/kg) and Cd (0.017±0.00mg/kg) in Lanistes libycus could be as a result of their feeding habit because they feed mostly on plants and plants materials which contain lesser heavy metals. However, there were no significant differences (P>0.05) between the five species in the concentrations of Cu, Cr, Co, Ni and Cd which indicates that the route of uptake of the heavy metals by these macro-invertebrates were not species specific. The concentrations of Cu, Cr, Pb, Cd and Mn were lower than the concentrations in *P. aurita*as reported by Samuel *et al*, (2015) of Ologe Lagoon, concentrations in *Callinectes spp* as obtained by Banjo *et al*, (2010) in South Western Nigeria, concentrations in *Mercenaria spp* as reported by Glenn *et al*, (2009) at Manila bay, Philippines and concentrations in freshwater snail (*Melanoides tuberculata*) as obtained by Emmanuel and Tonye (2014) at Alaro Stream. The concentrations of Ni in this study were also lower than the concentration ranges of (3.20–10.4mg/kg) as reported by Wegwu and Wigwe (2006) but fall within the concentration in*Archachatina marginata* as reported by Chukwujindu *et al*, (2008) in Southern Nigeria
The maximum daily intake of Mn varies from 2.5 to 7.0 mg (Sivaperumal *et al*, 2007; however, the concentrations of Mn from this study were less than 0.67–1.27 mg/kg in*Archachatina marginata* asobtained by Chukwujindu *et al*, (2008) in Southern Nigeria but falls within the range of 0.08–3.7mg/kg as reported for some mollusc species in India (Sivaperumal *et al.* 2007).
The bio-concentration factors of heavy metals in macro-invertebrates obtained from Dadin Kowa Dam was shown in table 3. The highest bio-concentration factors of Cu (0.555±0.18), Cr (0.407±0.06) and Ni (0.209±1.13) were found in *Nepa cinerea*, Pb (0.171±0.29) and Mn (1.035±0.28) were discovered in *Dyticus dauricus* while that of Co (0.654±2.11), Cd (0.267±0.85) and Mg (0.485±0.03) were found in *Anax junius*, *Pontala flavescens* and *Lyticus libycus* respectively. This showed that the rate of uptake of Cu, Cr and Ni from the sediment, were higher in *N. Cinerea*, Pb and Mn were higher in *D. dauricus* compare to the other macro-invertebrates. This could be as a result of the feed and feeding habits of the species and its ability to move away from pollutants. It has also been indicated that bio-concentration factors change according to the type of pollutants available in the environment, the degree of pollution and the metabolite properties of the tissues (Ayas, 2007; Ojebah and Emumejaye, 2015). There were no significant differences (P>0.05) in the bio-concentration factors of all the metals in the studied macro-invertebrates except in Mn and Mg. however, these values were in agreement with the study of Parisa, (2013) on macrobenthos.

4. Conclusion

There were no significant differences between the five macro-invertebrates except in Pb, Mn and Mg. The differences in the metal concentration levels of the macro-invertebrates could be attributed to differences in their metabolic rates, different food requirements as well as the degree of organism's exposure to the metal as influenced by its metabolic characteristics and its position in the food chain. Although, the levels of the heavy metals were found to be within permissible limits, bioaccumulation and magnification is capable of leading to toxic level of these metals in the macro-invertebrates of the Dam. Therefore, the use of organic fertilizers should be encouraged in order to reduce the use of chemical fertilizers and biological method of controlling agricultural pests and diseases should also be encourage in order to reduce runoff of chemicals into the Dam.

5. References

i. AOAC, 2000. Official Methods of Analysis. Association of Official Analytical Chemists, Washington, DC. Begum A, Amin N, Kaneso S, Ohta K (2005). Selected elemental composition of the muscle tissue of three species of fish, Tilapia nilotica, Cirrhina mrigala and Clarius batrachus from the fresh water Dhanmondi Lake in Bangladesh. Food Chem. 93: 439-443.

ii. Banjo A.D., Lawal, A., Fasunwon, B.T. and Alimi, G.O (2010), Alkali and Heavy Metal Contaminants of Some Selected Edible Arthropods in South Western Nigeria.American-Eurasian Journal of Toxicological Sciences 2 (1): 25-29, 25

iii. Chukwujindu M., Iwegbue, A., Francis O. Arimoro, Godwin E. Nwajei, Osa Eguavoen (2008). Heavy Metal Content in The African Giant Snail Archachatina Marginata (Swainson, 1821) (Gastropoda: Pulmonata: Achatinidae) In Southern Nigeria. Folia Malacologiga Vol. 16 (1): 31-34

iv. ECDG. (2002). European Commission DG ENV. E3 Project ENV. E.3/ETU/0058. Heavy metals in waste. Final report.

v. Emmanuel Teryila Tyokumbur and Tonye Grace Okorie (2014) Bioconcentration of trace metals in the freshwater snail Melanoides tuberculata (Mollusca: Thiaridae) from Alaro stream ecosystem of South West Nigeria. Advances in Bioscience and Bioengineering ISSN 2201-8336 Volume 2, Number 1, 51-65

vi. Francis, B.M, (1994). Toxic substances in the Environment, John Wiley and Sons, Inc, New York, pp.363.

vii. Glenn Lo Sia Su, Elena Ragragio and Arnold V. Hallare (2009), Assessing heavy metals in the waters, fish and macroinvertebrates in Manila bay, Philippines Journal of Applied Sciences in Environmental Sanitation Volume 4, Number 3: 187-195,

viii. Karadede H, Oymak SA, Ünlü E (2004). Heavy metals in mullet, Liza abu, and catfish, Silurus triostegus, from the Atatürk Dam Lake (Euphrates), Turk. Environ. Int. 30: 183-188.

ix. Kennish, M.J. (1992). Ecology of Estuaries: Anthropogenic effects. CRC Press Boca Raton Ann Arbor, London, pp. 494.

x. King, R. P. and Jonathan, G. E. (2003). Aquatic environment perturbations and monitoring: African experience, USA.

xi. Kwansa-Ansah EE, Akoto J, Adimalo AA, Nam D (2012). Determination of Toxic and Essential Elements in Tilapia species from Volta Lake with Indictively Coupled Plasma-Mass Spectrometry. Int. J. Environ. Prot. 2:30-34.

xii. Lenntech Water Treatment and Air Purification (2004). Water Treatment, Published by Lenntech, Rotterdamseweg, Netherlands (www.excelwater.com/thp/filters/Water-Purification.htm).

xiii. Nwajei G., Obi–Iyeke G. and Okwagi P. (2012). Distribution of Selected Trace Metal in Fish Parts from the River Nigeria. Res. J. Recent Sci., 1(1), 81-84.

xiv. Parisa Nejatkhah Manavi (2013) Heavy Metals in Water, Sediment and Macrobenthos in the Interdidal Zone of Hormozgan Province, Iran Marine Science, 3(2): 39-47 DOI: 10.5923/j.ms.20130302.01

xv. Samuel, O. B., Osibona, A. O. And Chukwu, L. O (2015), Study of Heavy Metals in the Gastropod, Pachymelania Aurita (Muller, 1774), Sediment and Water from Ologe Lagoon, Southwestern Nigeria Ife Journal of Science vol. 17, no.3 pp365-

xvi. Sivaperumal P., Sankar T. V., Viswanathan Nair P. G. (2007). Heavy metal concentrations in fish, shellfish and fish products from internal markets of India vis-a-vis international standard. Food Chem. 102: 612–630.

xvii. Upper Benue River Basin Development Authority (UBRDA) 1980). Dadin-Kowa Resettlement Project, Draft final report. Vol. 2.

xviii. Vanleeuwen, c.j., Vanameren, P., Bogers, M., and Griffioen, P.S. (1986). Uptake, distribution and retention of Zine B and Ziran in Rainbow Trout (salmo gairdneri). Toxicology, 42, 33-46.

xix. Wegwu M. D., Wigwe I. A. (2006). Trace metal contamination of African giant snail (Archachatina marginata) from southern Nigeria. Chem. Biodivers. 3: 88–93