International Journal of
AGRICULTURE AND BIOSCIENCES
www.ijagbio.com P-ISSN: 2305-6622 E-ISSN: 2306-3599 editor@ijagbio.com

RESEARCH ARTICLE

Bioaccumulation of Heavy Metals in Shellfish *Macrobrachium rosenbergi* in Niger River at Onitsha, Anambra State, Nigeria

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ARTICLE INFO

Received: January 10, 2014
Revised: February 12, 2014
Accepted: February 20, 2014

Key words:
Bioaccumulation
Health risks
Heavy metal
Macrobrachium rosenbergi
Niger River

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ABSTRACT

Seasonal bioaccumulation of heavy metals namely, Zinc (Zn), Iron (Fe), Copper (Cu), Lead (Pb), Mercury (Hg) and Arsenic (As) in the shellfish of *Macrobrachium rosenbergi* from Niger River at Onitsha were studied using Atomic Absorption Spectrophotometer (AAS). Results showed presence of all the analysed metals in the shellfish tissue. Mean concentrations of Zn (4.35±1.2mg/l), Cu (1.35±0.43), Cd (0.31±0.0421), Hg (0.16±0.0011) and As (0.04±0.001) in mg/l complied with the World Health Organization (WHO) standards in aquatic foods. However those for Fe (9.73±1.30) and Pb (0.24±0.04) mg/l exceeded the WHO standards. Furthermore, mean concentrations for Zn (0.321±0.09), Fe (1.52±0.07), Cu (0.035±0.006), Hg (0.076±0.007), As (0.016±0.007) and Cd (0.012±0.006) mg/l in the water columns were significantly lower ($P<0.05$) than the concentrations in the shellfish. Bioaccumulation of heavy metals in the shellfish studied indicated that Niger River at Onitsha is experiencing impairment. The result implies that prolonged consumption of shellfish and other aquatic foods contaminated with heavy metals, and through observed indiscriminate dumping of waste in the river, may constitute public health risks.

Cite This Article as: Nsofor CI, IO Igwilo, OO Ikpeze, CF Ikeogu, FO Umeoguagu and CJ Okonkwo, 2014. Bioaccumulation of heavy metals in shellfish *Macrobrachium rosenbergi* in Niger River at Onitsha, Anambra State, Nigeria. Inter J Agri Biosci, 3(1): 38-40. www.ijagbio.com

INTRODUCTION

Several studies show that the major water bodies in Nigeria are polluted with heavy metals (Fufeyin, 1998; Njoku and Keke, 2001; Nsofor and Aguigwo, 2005). Since heavy metals are persistent and non-degradable in the ecosystem, their bioaccumulation in aquatic organisms through environment pollution of aquatic organisms is hazardous to man. Heavy metals in the aquatic food chain eventually get into man on consumption of contaminated aquatic foods like fish, prawn, shrimps and sediments. Bioaccumulation denotes an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. The major sources of heavy metals in the environment are from natural and anthropogenic activities. Various industrial and agricultural activities by man in recent years have increased the quantity and distribution of these metals in the air, land and water bodies. Heavy metals are frequently present in water at very low concentrations that they are often difficult to be accurately determined due to problems of contamination or loss of analytes during sample collection, storage or analysis. However the use of aquatic organisms such as fish, prawns, or shrimps as indicators of heavy metal pollution of aquatic environment is a popular method. The higher concentrations that occur in bioaccumulator organisms provide better representation of biologically available metals in the environment (Philips, 1981; Fabris *et al*., 1994). This study was aimed at investigating the seasonal bioaccumulations of heavy metals namely, Zinc (Zn), Iron (Fe), Copper (Cu), Lead (Pb), Mercury (Hg) and Arsenic (As) in the shellfish *Macrobrachium rosenbergi* from the Niger River at Onitsha.

MATERIALS AND METHODS

Study area

The River Niger lies approximately between latitudes 5°N and 7°N and longitudes 7°E and 8°E in Southern Nigeria. It serves as a sink for effluents from and around Onitsha via master drainage systems which is made up of a network of underground channels which open into the river. The river flows through the city of Onitsha and offers adequate opportunity for the discharge and dumping of effluents and solid wastes from the numerous industries and homestead in Onitsha and its environs.

Study samples

The sample materials used in this investigation were water and shellfish *Macrobrachium rosenbergi* collected from Niger River at Onitsha. The sampling was carried out between November 2006 and October 2007, spanning through the dry and wet seasons. The shellfish is dominant in the river and are relished by the populace. Fifty gram (50 gm) of the shellfish was purchased monthly from the artisanal fishers at the Ose waterside fish-landing sites of the river during the study period. The shellfish purchased were transported from the collection centre in an ice-chest to the zoology laboratory at Nnamdi Azikiwe University, Awka. The shellfish were washed with clean water and dried to a constant weight of 80^{o}C in Arkson Scientific Oven. The dried samples were ground in a porcelain mortar and homogenised to fine powder with an electric blender. Two grams (2 g) of the samples were weighed into a 50ml Kjedahl flask for digestion using aqua regia (a mixture of concentrated nitric acid (HNO_3) and hydrochloric acid (HCl) in a ratio of 1:3) for one hour. The digested samples were stored in low density polythene plastic bottles prior to analysis with the atomic Atomic Absorption Spectrophotometer (AAS). The water samples from the river were also analysed using AAS. The heavy metals analysed in the shellfish and water samples are Zinc (Zn), Iron (Fe), Copper (Cu), Lead (Pb), Mercury (Hg), Arsenic (As) and Cadmium (Cd). The statistical analysis included determination of mean and standard deviation.

RESULTS AND DISCUSSION

The results of the heavy metal concentrations in the shellfish, *Macrbrachium* sp are shown in Figures 1 and 2 while the heavy metal concentrations in the water columns are shown in Figures 3 and 4. The results reveal both seasonal and annual significant difference ($P<0.05$) in the metal concentration in the shellfish and the water columns. The annual mean (AM) metal concentrations in the shellfish for Zinc (Zn), Iron (Fe), copper (Cu), lead (Pb), mercury (Hg), arsenic (As) and cadmium (Cd) in mg/l were 4.35±1.20, 9.73±1.30, 1.35±0.43, 0.24±0.04, 0.16±0.01, 0.04±0.011 and 0.31±0.04 respectively.

Figure 3 also revealed significant seasonal differences in the heavy metal concentrations in the water column with respect to Zinc (Zn), Copper (Cu) and Cadmium (Cd), with respective rainy season means (RSM) 0.364, 0.55 and 0.015 mg/l being significantly higher than their corresponding dry season means (DSM) 0.261, 0.009 and 0.008 mg/l.

Concentrations of Zinc (Zn), Copper (Cu) and Mercury (Hg) in the shellfish and water columns complied with the WHO standard (1996) for aquatic foods and waters. However, the concentrations of Iron (Fe) and Lead (Pb) were above the WHO standard for aquatic food.

The presence of analysed metals indicated an adverse effect of heavy metal pollution of the aquatic environment associated with urbanization, industrialization and other anthropogenic activities in Niger River. The river is a sink for untreated sewage disposal, industrial effluents, indiscriminate dumping of wastes, run-offs from agricultural farms characterized by indiscriminate applications of

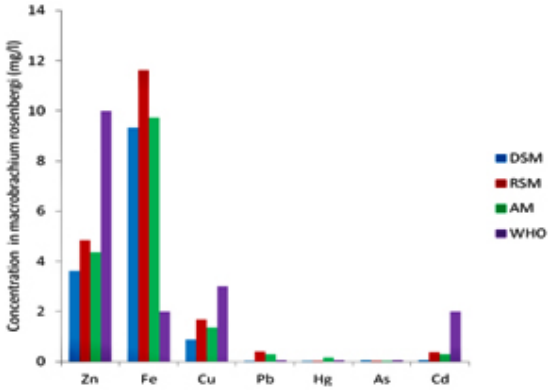

Fig. 1: The heavy metal concentrations in the shellfish of *Macrbrachium* sp. Where: DSM=Dry season means, RSM= Rainy season means, AM= Annual means, WHO= World Health Organization Standard

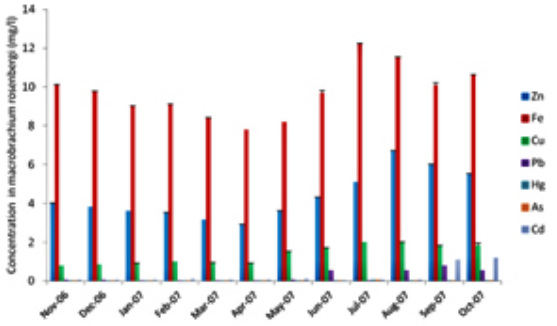

Fig. 2: Monthly heavy metal concentrations in the shellfish of *Macrbrachium* sp

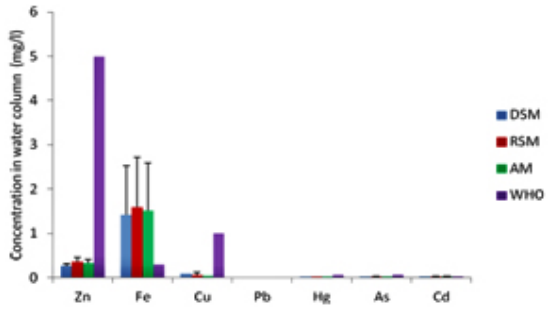

Fig. 3: The heavy metal concentrations in water columns. Where: DSM=Dry season means, RSM= Rainy season means, AM= Annual means, WHO= World Health Organization Standard

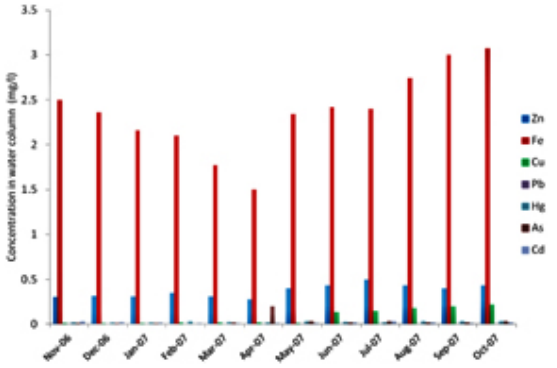

Fig. 4: Monthly heavy metal concentrations in water columns

inorganic fertilizers (Njoku and Keke, 2001; Nsofor, 2005). Heavy metals in the aquatic environment bio-accumulate in biota through absorption or ingestion. These heavy metals influence intrinsic biological factors of these organisms as well as contaminate them as human foods. The results revealed that the concentrations of these heavy metals in the water are lower than in the shellfish. This observation is in accordance with the findings of Fabris *et al.* (1994) who reported lower concentrations of Pb, Cd and Hg in the water of Dervent estuary compared to the higher values recorded in the tissues of the mussel, *Mytilus edulis planulasus* from the same estuary.

Obashan and Oronsaye (2000) as well as Nsofor and Aguigwo (2005) also reported higher concentrations of Fe, Cu, Zn and Cd in tissues of *Clarias gariepinus* from Ikpoba River and Niger River in Nigeria respectively. These observations may be due to the fact that heavy metals are frequently present in water at low concentrations. The higher metal concentration in shellfish was suggestive of the ability of the shellfish to bio-accumulate these metals above their concentrations in water. The lower concentrations of Zn, Cu, Pb and Hg in the shellfish compared to the WHO standard indicated mild input of these metals into the river.

These metals are mostly present in sewage, refuse dumps, human excreta, inorganic fertilizers, paper, pulp, battery and paint industries sited within and around the river. In contrast, Vasquez *et al.* (1995) reported elevated Zinc concentrations of 115 mg/l in oysters collected from a highly polluted lagoon in Mexico. The higher concentrations of Iron and Lead in the shellfish, and Iron and Arsenic in the water when compared with WHO standards indicated that the Niger River at Onitsha was polluted with elevated levels of these metal ions. The presence of Iron could be due to influx of Iron-rich effluents into the river. The high concentration of Iron in the shellfish could be due to its habitat effect since the shellfish is a bottom dwelling organism. Heavy metals and their ions usually sink to their bottom sediments which constitute the food of the benthic organisms. The higher concentration of lead in the shellfish compared to WHO standard of 0.05 mg/l in aquatic foods indicated an on-going significant pollution in relation to lead ion. This implies that consuming fish from the river could result to lead-induced health problems. Lead is a cumulative poison and potent enzyme inhibitor as it incorporates into enzyme structures. It inhibits the synthesis of heam in organisms and thus interferes with the effective utilization of iron and blood circulation (Hutton, 1987; Ademoroti, 1995). Lead from the river must have come chiefly from automobile exhaust pipes and lead deposits in soil which is washed into the river as run-offs during the rains. The bioaccumulation status of these heavy metals in the shellfish studied depicted the river as experiencing impairment.

Conclusion

The consumption of metal contaminated shellfish, fish, and other aquatic foods from the River Niger at Onitsha may likely cause health hazards to consumers over a period of time. The impairment of the sanitary quality of the river through indiscriminate waste dumping may increase the risk of water borne diseases such as typhoid and cholera to people who use the river for domestic and recreational purposes.

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