ORIGINAL PAPER

Seasonal Assessment of the impacts of Heavy Metals Deposits in *Crassostrea gasar* (adanson, 1757) from the Mangrove Swamp of the Lagos Lagoon, Lagos, Nigeria

ABSTRACT

The Mangrove Oyster, *Crassostrea gasar* is one of the most economically important shell mollusc in Nigeria. In the present study, investigations were made on the accumulation of seven (7) heavy metals, Lead (Pb), Chromium (Cr), Nickel (Ni), Iron (Fe), Cadmium (Cd), Copper (Cu) and Zinc (Zn) in water, sediment and *Crassostrea gasar* (flesh and shell) inhabiting Ebute – Oko, Tomaro and Agala axis of the Lagos Lagoon. The analyses, conducted using standard method revealed lower heavy metal concentrations in the flesh of *C. gasar* during wet season while the concentrations in oyster shell, lagoon water and sediment were higher during dry season. Fe was recorded with the highest mean concentration in all the samples throughout the seasons. The lagoon sediments had the highest concentrations of all the metals in all the three sites examined. The bio-water accumulation factors showed that the oyster flesh accumulated all the seven heavy metals detected in the lagoon but in varying concentrations with Fe (> 20mg/l) as the highest while Cd (≤ 0.6mg/l) was recorded as the lowest accumulated heavy metals. The bio-sediment accumulation factors in the oyster flesh were less than 1 (< 1mg/l). The results of heavy metals concentrations obtained in this study were within the limit of FAO and WHO recommended for bivalves consumption, therefore, the oysters' flesh were safe for consumption and can also serve as a good bio-indicator for pollution monitoring in our aquatic ecosystem.

Keywords: Fe, Lagos Lagoon, Mangrove oyster, Pb, Pollution

INTRODUCTION

Aquatic pollution is one of the principal environmental and public health problems Africa and the Middle East regions are facing (Anwar, 2003). Aquatic pollution does not only damage the aquatic ecosystems but also the terrestrial ecosystem when there is spill-over of these water bodies to the land or when the water is been consumed by humans and animals, thereby severely damaging and threatening the ecosystem (Authman *et al.*, 2013). The aquatic ecosystem is constantly polluted with a variety of solid and liquid wastes, and every waste is ultimately dumped or emptied into natural water bodies (Garg *et al*., 2009). Human activities in the coastal area and marine water contribute to the discharge of various kinds of pollutants such as heavy metals into the marine ecosystems (Ansari *et al.*, 2004). The main reason for the metal contamination is considered as persistent and due to their toxic properties, could create several problems for different kinds of marine ecosystems and could be accumulating in marine organisms (Amiard *et al*., 2000). Moreover, their accumulation in marine organisms and biomagnification throughout the food chain may be harmful for human health (Biney *et al*., 1994).

The disposal of toxic wastewater into the aquatic ecosystem is harmful about its possible hygienic and aesthetical effects and its impact on fauna and flora of the aquatic environment (Bahnasawy *et al*., 2009). About 2000 medium and large-scale industries in Lagos State discharge untreated effluents directly or indirectly into the Lagos Lagoon (Uaboi-Egbenni *et al.*, 2010). The Ogun River carries wastes from hinterland and discharge into the Lagoon and the effluents from Agbara Industrial Estate also drains into Lagos Lagoon through discharge into Ologe Lagoon, which is linked to Lagos Lagoon through Badagry creek (Uaboi-Egbenni *et al.*, 2010).

The sewage effluents with their microbial and heavy metal contents represent the most dangerous chemical source of pollution for fish (Mansour and Messeha, 2001). Heavy metals are toxic at high doses but some heavy metals such as iron and copper are essential for the growth and well-being of living organisms including man (Ibrahim and Mahmoud, 2005). Other elements such as lead and cadmium are not essential for metabolic activities or growth, exhibit toxic properties and inhibit the photosynthesis, phytoplankton and fish growth at low concentrations (FAO, 1992). Heavy metals in sewage have been discharged into aquatic environments and have accumulated in sediments, where they have affected the ecology of the environment, with long-term impacts on fishes (Silva and Martinez, 2007).

The Phylum, Mollusc is known to radiate successfully into a variety of habitats; the great majority of which are aquatic while some are found mostly in shallow waters and sometimes in intertidal zones where they burrow into the mud in the beds of the river which serves as their habitat (Akinjogunla and Moruf, 2019). Shellfishes are used in many pollution monitoring and assessment studies because they have wide geographical distribution and are relatively stationary. They reflect traces of contamination better than finfishes because they are sediment dwelling and have pronounced ability to concentrate pollutants from sediments and water (Zhou *et al*., 2008). Clams, oysters and mussels are bivalve molluscs which are highly popular, nutritious and commercially available in western and southern parts of Nigeria. They are relatively cheap source of animal protein and the shells have been affirmed as good feedstuff in animal feed formulation (Moruf and Akinjogunla, 2018).

Bioaccumulation is the ability of a pollutant to accumulate in living tissues at levels higher than those in the surrounding environment. They are chemical pollutants that enter into the body of an organism and is not excreted but rather collected in the organism's tissue (Zweig *et al*., 1999). Low chemical and biological degradation rates have led to their accumulation in biological tissues and the subsequent magnification of concentration in organisms, progressing through to the food chain (Helberg *et al*., 2005). They can be recycled through food chains with significant magnification of the original concentration at the end of the chain (Doong *et al*., 2002). They are resistant to natural breakdown processes and are extremely stable and persistent in the environment, highly toxic and bioaccumulate in the fatty tissues of animals and humans (Ritter *et al*., 1995).

Apart from its great value as food, mangrove oyster contributes to the maintenance of healthy ecosystem through filter feeding activity (Onwuteaka *et al.,* 2015). Concerning its ecological importance, mangrove oyster, *Crassostrea* spp. stands out as an indicator of environmental quality and measures the degree of contamination of aquatic ecosystems, since it accumulates polluting substances that may lead to chromosomal changes and mutations (Gunther *et al*., 1999). Oysters have been recognized, long before now as good accumulators of organic and inorganic substances, they take in nitrogenous compounds such as nitrates and ammonia, thereby cleaning the water body of nitrogenous compounds and in the process, they take in food with contaminants present in the water body (Gunther *et al*.,1999). Accumulated substances are transferred to other animals including humans in food chains since it is a delicacy in some coastal communities (Onwuteaka *et al.,* 2015). Heavy metals discharge as waste into water has significant effect on fish and other aquatic organisms and may endanger the human populace who through consumption of contaminated animals acquire the metals (El-Shenawy, 2002).

With respect to Lagos Lagoon, information exist on the impact of organic pollution on the bacterial plankton and benthic population (Akpata *et al*., 1993), Occurrence of heavy metals and their compounds as well as bacterial pathogens and sawdust (Odiete, 1999), Inventory on the fisheries and fishes (Oribhabor and Ezenwa, 2005), ecological disruption based on heavy metals toxicity, accumulation and distribution (Otitoloju *et al*., 2007), changes in the physico-chemical and macrobenthic invertebrates characteristics (Edokpayi and Nkwoji, 2007; Lawson, 2011) and occurrence and distribution of heavy metals in sediments in Lagos Lagoon (Don-Pedro *et* al., 2004; Uaboi-Egbenni *et al*., 2010,). However, there is a dearth of information on the heavy metals accumulation in the flesh and shells of mangrove oysters collected from the mangrove swamps of the Lagos Lagoon which necessitated this research.

The mangrove oyster (*C. gasar*) is a bivalve of high economic seafood value in Lagos and Niger Delta areas of Nigeria (Ajana, 1980; Akinrotimi *et al.*, 2009). They are filter feeders, which can serve as bio-indicator of heavy metal in the marine environment. It is of vital importance therefore that studies are conducted on regular basis to ascertain the level and concentrations of the contaminants in this species from the Lagos Lagoon. This study therefore investigated the seasonal variations in the levels of heavy metals (Pb, Cr, Ni, Fe, Cd, Cu and Zn) in the water, sediments, and their bioaccumulation in the flesh and shell of the mangrove oyster (*Crassostrea gasar*) from Lagos Lagoon

MATERIALS AND METHODS

THE STUDY AREA

Lagos Lagoon lies between latitude 6^o 26' - 6^o 37' N and longitude 3^o 23' - 4^o 20' E (Table 1) in the western part of Nigeria, covering a surface area of 208 km^2 (Figure 1). It is the largest of the ten coastal lagoons (Lagos, Yewa, Badagry, Apẹsẹ, Iyagbe, Ologe, Kuramo, Epe, Lekki and Mahin Lagoons) of South-Western Nigeria (Onyema and Emmanuel, 2009). The lagoon is characterized with seasonal fluctuation in salinity, high brackish water during the dry season (December – May) and freshwater conditions exists in the rainy season (June – November) (Lawal-Are and Akinjogunla, 2012). It receives freshwater from Lekki Lagoon via Epe Lagoon in the North West and discharges from the Majidun, Agboyi and Ogudu creeks as well as Ogun and Aye Rivers in the North-West (Soyinka, 2008; Akinjogunla *et al*., 2017).

WATER AND SEDIMENT ASSAY FOR HEAVY METALS

Water and sediment samples scooped from Ebute-Oko, Tomaro and Agala of Lagos Lagoon were collected for heavy metal analysis into 70 ml plastic bottles and polythene bags respectively. To prevent adsorption of metals into the walls of the 70 ml containers, the samples were acidified with 2 drops of concentrated HNO_3 (APHA, 2005) and stored in a refrigerator at temperature of 4^oC while the sediments in polythene bags were stored at 0^oC in a refrigerator before analysis. Water and sediment samples were collected monthly between the hours of 6.00 and 8.00 am for 12 months.

Heavy metals analysis in water and sediment sampled from Lagos Lagoon in two different seasons were carried out using Atomic Absorption Spectrophotometer (AAS) as prescribed by American Public Health Association (APHA, 2005). Each of the samples (water and sediment) was acidified with concentrated nitric acid (HNO_3) and hydrochloric acid (HCl) successively in a ratio of 3:1 in a beaker. The beaker was swirled and heated gently on an electro thermal heater (200^oC) for

15 minutes until the content was completely digested. The mixture was reduced to a volume of 1 ml, diluted with double distilled water and then filtered through Whatman filter paper (No. 42). The filtrate was transferred to 100 ml volumetric flasks and diluted to the mark with distilled water (100 ml).

CRASSOSTREA GASAR ASSAY FOR HEAVY METALS

Crassotrea gasar samples were collected for a period of 12months (December 2018 – November 2019). The animals were collected by scooping from the water bed at low tides and dislodgement from mangrove branches and roots. The collected samples were taken to the laboratory and stored in the freezer prior to digestion for analysis of the heavy metal content. All samplings were carried out between the hours of 6.00 and 8.00am.

The tissues of *C. gasar* were removed from their shells; the extracted tissues were rinsed with distilled water to remove debris, plankton and other external adherents. Both the flesh and the shell were then separately dried in an oven at 105^0C until constant weight was obtained and later separately homogenized using mortar and pestle. 10g of each homogenate was separately digested as described by APHA (2005). The sample was digested using 1:5:1 mixture of 70% perchloric acid, concentrated nitric acid and sulphuric acid at 80^0C in a fume chamber until a colourless liquid was obtained. Atomic Absorption Spectrophotometer (Analyst 600 Perkin Elmer) model at 200λ was used to determine the metal concentrations. Levels of heavy metals were expressed in mgL^- dry weight.

DETERMINATION OF BIOACCUMULATION FACTORS

The bioaccumulation factors of the heavy metals in the flesh, water and sediment were determined using the method of Samuel *et al*. (2015).

$$\boldsymbol{BWAF} = \frac{\boldsymbol{Heavy\ metal\ concentration\ in\ flesh}}{\boldsymbol{Heavy\ metal\ concentration\ in\ water}}$$

$$\boldsymbol{BSAF} = \frac{\boldsymbol{Heavy\ metal\ concentration\ in\ flesh}}{\boldsymbol{Heavy\ metal\ concentration\ in\ sediment}}$$

DATA ANALYSIS

Data generated from this study were analyzed as mean ± standard error using Microsoft Excel 2010. All means recorded were determined considering a level of significance less than 5% ($p < 0.05$) at 95%. It was used to test for significant relationship among heavy metals levels in flesh, shell of oyster, water and sediment of the three sites of Lagos Lagoon.

RESULTS

The results of heavy metals concentrations in flesh and shell of *C. gasar*, water and sediment from Ebute-Oko during wet season are presented in Table 2. The mean concentration (mg.kg^{-}) of Pb (0.36±0.12), Cr (0.76±0.05), Ni (0.52±0.03), Fe (57.6±0.26), Cd (0.30±0.02), Cu (2.81±0.02) and Zn (34.8±0.17) in the flesh of *C. gasar* were low during the wet season. The shell of *C. gasar* bio-accumulated heavy metals in descending order were as follows: Fe (37.0±0.10 mg.kg^{-}) > Zn (8.85±0.05 mg.kg^{-}) > Cu (1.60±0.01 mg.kg^{-}) > Pb (1.54±0.03 mg.kg^{-}) > Cr (0.51±0.02 mg.kg^{-}) > Cd (0.43±0.02 mg.kg^{-}) > Ni (0.39±0.02 mg.kg^{-}). The concentration of heavy metals in water ranged from Cr (0.09±0.02 mg.l^{-}) to Fe (2.36±0.04 mg.l^{-}), while in the sediment, the heavy metal concentration ranged from Ni (0.95±0.02 mg.kg^{-}) to Fe (106±2.3 mg.kg^{-}).

The order of heavy metals concentrations (mg/kg) in *C. gasar* flesh from Tomaro decreased as follows: Fe (53.5±0.15) > Zn (36.2±0.25) > Cu (2.80±0.1) > Cr (0.62±0.03) > Ni (0.49±0.03) > Pb (0.39±0.03) > Cd (0.37±0.02). The heavy metal with the highest mean concentration in the shell was Fe having the mean value of 34.5±0.5 mg.kg^{-}, followed by Zn (10.8±0.20 mg.kg^{-}) and Pb (1.68±0.02 mg.kg^{-}), while the mean value (mg/kg) of Cu, Cd, Ni and Cr was 1.60 ± 0.05, 0.51 ± 0.01, 0.38 ± 0.03 and 0.43 ± 0.01 respectively.

The values of heavy metals in the water and sediment from Tomaro are also shown in Table 2. In comparison, higher values of heavy metals (Pb, Cr, Ni, Fe, Cd, Cu and Zn) were obtained in the sediment than in the water. The mean concentration of heavy metals in water, sediment and *C. gasar* flesh and shell samples from Agala during wet season ranged as follows: Pb (0.27 ± 0.02 to 2.47 ± 0.01), Cr (0.07 ± 0.03 to 1.33 ± 0.02), Ni (0.33 ± 0.02 to 0.70 ± 0.02), Fe (2.29 ± 0.02 to

94.7 ± 1.53), Cd (0.21 ± 0.01 to 1.02 ± 0.03), Cu (0.24 ± 0.01 to 6.30 ± 0.02) and Zn (1.98 ± 0.02 to 69.0 ±0.36).

The results of mean heavy metals concentrations in flesh and shell of *C. gasar*, water and sediment from Ebute-Oko, Tomaro and Agala during dry season are presented in Table 3. The mean heavy metal concentrations (mg.kg^{-}) in *C. gasar* flesh and shell obtained at Ebute-Oko ranged from Cd (0.33 ± 0.02) to Fe (60.6 ± 0.21) and Ni (0.39 ± 0.02) to Fe (37.5 ± 0.35) respectively, while in the water and sediment samples, the mean heavy metal concentration ranged from Cr (0.11 ± 0.02 mg.l^{-}) to Zn (3.02 ± 2.3 mg.l^{-}) and Ni (0.99 ± 0.02 mg.kg^{-}) to Fe (111.0 ± 3.61 mg.kg^{-}) respectively (Table 3). The mean concentration (mg/kg) of heavy metals decreased in the sequence for the *C. gasar* flesh as Fe > Zn > Cu > Cr > Ni > Pb > Cd, while the decrease in the sequence of heavy metals in the *C. gasar* shell was as Fe > Zn > Cu > Pb > Cr > Cd > Ni (Table 3).

The mean heavy metal concentrations (mg/kg) in *C. gasar* flesh and shell obtained at Tomaro ranged from Cd (0.39 ± 0.02) to Fe (55.5 ± 3.07) and Ni (0.38 ± 0.02) to Fe (36.5 ± 0.26) respectively, while in the water and sediment samples, the heavy metal ranged from Cr (0.08 ± 0.01 mg/l) to Zn (3.22 ± 0.02 mg/l) and Ni (0.90 ±0.03 mg.kg^{-}) to Fe (106.0 ± 2.57 mg.kg^{-}) respectively (Table 2). The mean concentration (mg/kg) of heavy metals reduced in the order for the *C. gasar* flesh as Fe > Zn > Cu > Cr > Ni > Pb > Cd, while the reduction in the order of heavy metals in the *C. gasar* shell was as Fe > Zn > Cu > Pb > Cd > Cr > Ni.

The heavy metals concentrations (mg.kg^{-}) in *C. gasar* flesh from Agala decreased as follows: Fe >Zn > Cu > Cr > Ni > Pb > Cd. The heavy metal with the highest mean concentration (mg.kg^{-}) in the shell was Fe with the mean value of 33.9 ± 0.5, followed by Zn (12.0 ± 0.10) and Cu (1.80 ± 0.15), while the mean value of Pb, Cr, Ni and Cd was 1.57 ± 0.01, 0.51 ± 0.03, 0.40 ± 0.02 and 0.55 ± 0.02 respectively. The mean values of heavy metals in the water and sediment from Agala are also presented in Table 3. In comparison, higher values of heavy metals (Pb, Cr, Ni, Fe, Cd, Cu and Zn) were obtained in the sediment than in the water.

The seasonal variations in bio-accumulation factors of different heavy metals from water, sediment to *C. gasar* flesh and shell during the wet and dry seasons are presented in Tables 4 and 5. During the wet season in Ebute-Oko, the bio-water accumulation factors (BWAF) of Fe was > 20, Zn was > 15, Cu and Cr were between 8.444 and 9.065, Pb and Ni were between 1.106 and 1.333, while Cd was ≤ 0.492. During the wet season in Tomaro, the BWAF of Fe was ≥ 22, Zn was > 14, Cu and Cr were ≥ 10, Pb and Ni were between 1.3 and 1.4, while Cd was ≤ 0.587. In Agala, the BWAF of Fe was > 20, Zn was > 15, Cu and Cr were between 10.143 and 11.292, Pb and Ni were between 1.333 and 1.424, while Cd was ≤ 0.477.

During the wet season in Ebute-Oko, the bio-sediment accumulation factors (BSAF) of Fe, Ni and Cr were > 0.5, while the BSAF of Pb, Cd, Cu and Zn were < 0.5. Similarly, in Agala, BSAF of Fe, Ni and Cr were > 0.5, while the BSAF of Pb, Cd, Cu and Zn were < 0.5. Of the seven (7) heavy metals in samples from Tomaro, only Cr, Ni, Fe and Zn had BSAF greater than 0.5, while Pb, Cd and Cu had BSAF less than 0.5 (Table 4).

The BWAF of heavy metals during the dry season in Ebute-Oko, Tomaro and Agala ranged as follows: Pb (1.154 to 1.257), Cr (7.364 to 10.857), Ni (1.104 to 1.457), Fe (22.448 to 23.130), Cd (0.532 to 0.600), Cu (9.194 to 10.033) and Zn (11.677 to 17.039). During the dry season in Ebute-Oko, the BSAF of Fe, Ni and Cr ranged from 0.506 to 0.546, while the BSAF of Pb, Cd, Cu and Zn ranged from 0.170 to 0.485. Of the seven (7) heavy metals in samples from Tomaro, only Cr, Ni, Fe and Zn had BSAF ranging from 0.521 to 0.556, while Pb, Cd and Cu had BSAF < 0.5. Similarly, in Agala, BSAF of Fe and Ni were > 0.5, the BSAF of Cr, Cu and Zn ranged from 0.419 to 0.487, while Pb and Cd had BSAF > 0.25 (Table 5).

DISCUSSION

The results showed that there was roughly the same level of heavy metals contamination in all the three sites examined. Fe had the highest mean concentrations in all the samples throughout the seasons. The Lagoon sediments had the highest concentrations of all the seven heavy metals. This was in agreement with the study of Onwuteaka *et al.* (2015), they also reported Fe with the highest level of contamination in both water and sediment of the brackish water creek system of the Niger Delta. Uaboi-Egbenni *et al*. (2010) also reported Fe with the highest heavy metals concentrations in Lagos Lagoon.

The heavy metals concentration recorded in the oyster flesh, shell, Lagoon water and sediment during the wet season were lower than the dry season, this may be due to rainfall and river overflow that normally occur during the wet season, which as a result reduce the heavy metals concentrations. This was contrary to results reported by Chattopadhyay *et al*. (2002) and Akinrotimi *et al*. (2015). The differential concentration of metals observed in each site is a reflection of the commercial and municipal activities in the different areas that supply their run offs to the different sections of the Lagoon. The results obtained in this research were within the limit of WHO and FAO standard for bivalves. This was contrary to the work of Uaboi-Egbenni *et al.*, (2010) who reported heavy metals concentration higher than the standard limit. This is an indication that the location of the research was contaminated but not polluted with all the heavy metals detected.

The bio-water accumulation factors (BWAF) of the heavy metals showed that the oyster flesh accumulated all the seven heavy metals detected in the lagoon but in varying concentrations with Fe (>20mg/l) as the highest while Cd (≤0.6mg/l) was recorded as the lowest accumulated heavy metals. The accumulation of the heavy metals in the flesh of the species was slightly higher during the dry season than the wet season. The bio-sediment accumulation factors (BSAF) of all the heavy metals in the oyster flesh were less than 1 (<1mg/l). Though the sediment had the highest heavy metals concentration, the bioaccumulation results indicated that the oyster accumulated most of the detected heavy metals from the Lagoon water. This could be explained as the presence of higher metal contents in soluble form in water than in the sediment. This is in support by Scanes (1993), who detected that the immediate source of metals for bivalves is the water soluble metals.

CONCLUSION

This oyster, *C. gasar* has the ability to accumulate metals (trace or heavy) and can tolerate very high concentrations, without any detrimental effect(s) on the organism(s), this qualified the organisms to be one of the best molluscs to be used as bio-indicator in pollution monitoring exercises in the lagoon ecosystem. In this present study, it was shown that the bioaccumulation of the heavy metals in the flesh of the *C. gasar* were within the standard concentrations for bivalves consumption. Therefore, oysters harvested in these study areas are safe for consumption but they should still be well cooked, roasted or fried before consumption. It is not advisable to be eaten raw. Although, research shows that there were low bioaccumulation of metals in the flesh of *C. gasar*, however, further dumping of toxic wastes or residues could lead to bio-concentration of these toxic residues to man through the food chain.

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