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Distribution of Trace Metals in Water and Sediments of Qua Iboe River Estuary, Nigeria

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Abstract Surface water and sediments collected from three stations along Qua Iboe Estuary, Niger Delta between January and June 2013 were analyzed for Iron (Fe), Zinc (Zn), Lead (Pb) and Cadmium (Cd). The trace metal concentrations (mg/L) in surface water were 0.08, 0.17, 0.01, 0.004 for Fe, Zn, Pb and Cd, respectively and 0.59, 0.33, 0.04 and 0.02 mg/kg in sediments respectively for the same metals. There were significant differences (p<0.05) in the trace metals for all seasons except Pb in water (p>0.05). Positive significant correlations (p<0.05) exist between the metals in sediments which revealed their co-accumulation potentials. Trace metal concentrations in water and sediment were below the maximum permissible level recommended by national and international standards except for lead in water. Thus Qua Iboe estuary is relatively suitable for fish production and domestic use despite effluent discharges into the estuary.

Keywords water permissible level; surface water; sediment; Qua Iboe; Niger Delta

1 Introduction

Increasing population growth, with urbanization and industrialization at the coastal regions in recent decades have regularly introduced toxic pollutants especially metals into the aquatic ecosystem (Montalvo et al., 2014; Conceiçã o et al., 2013; Adekola et al., 2003; Anikwe and Nwobodo, 2002). Metals are important environmental contaminants due to their toxicity, persistence and their tendency to accumulate in aquatic organisms. They are transported as dissolved species in water or as an integral part of suspended sediments (Ataluegwu, 2005).

Metals are deposited in bottom sediments via complex physical, chemical and biological processes (Bader et al., 2015; Wen and Allen, 1999; Leivouri, 1998). Sediments play an important role as a sink for pollutants and may be remobilized by natural and man-made processes, which can pose risk to the aquatic ecosystem. Sediments have recently been considered as diffused sources of environmental contaminants and can endanger public health by being incorporated into the food chain or released into overlying waters which serve as drinking water supplies (Aguilar et al., 2012, Wogu and Okaka, 2011 Baudo et al., 1990).

Organisms require trace metals such as cobalt, iron, magnesium, manganese, zinc, copper, for their normal physiological functioning. However, non-essential trace metals are sometimes present in the food chain and may become toxic at higher concentrations. The environmental risks of trace metals have been, and will continue to be, an important issue of great concern and significance.

Estuaries are rich in nutrient and serve as breeding site for fishery resources. Qua Iboe River estuary is an important estuary in Niger Delta because it serves as a major source of water for the predominantly rural population of the area; supports the artisanal fisheries; water ways and cultural values of the people. Despite the importance of the estuary, there are massive infrastructural and industrial developments of the region by government and private individuals. The estuary is situated in close proximity to the Exxon-Mobil oil effluent treatment and discharge plant. Their treated and untreated industrial wastes are discharged into the Atlantic Ocean but may recede into the estuary due to tidal motion. The shoreline of Qua Iboe estuary is occasionally inundated by spilled oil when it occurs. Oil spill can cause not only hydrocarbon contamination but metal and other
complex compound contamination (Chaerun et al., 2004).

Hence, the present study evaluates the trace metal concentrations of Qua Iboe estuary and to assess its suitability for fish production and as well as its safety as source of drinking water.

2 Materials and Methods

2.1 Study Area
Qua Iboe estuary, situated close to the Exxon-Mobil oil effluent treatment and discharge plant, receives water from Qua Iboe River (confluence of rivers from different sources) flowing into the Gulf of Guinea (Atlantic Ocean). The substratum consists mainly of fine sand and mud, with decaying macrophytes and debris. The estuary receives municipal wastes, urban runoff, industrial discharges as well as other solid wastes (garbage, metal scraps, etc.). The structure and hydrology of the estuary is described by Uwah et al. (2013) and Oze et al. (2006).

Three sampling stations were established through Global Positioning System (GPS) (Figure 1). Station 1 situated on longitude 7°58.555’ in the East, and latitude 4°34.085’ in the North, has a water depth of 0.43-0.68 m and sediment type of fine sand mixed with mud. It is located within Ukpene Kang an area considered to be heavily perturbed by human activity. Station 2 (7°59.1874’ E; 4°33.7639’ N) is located at the mouth of Stubbs Creek about 1,300 km from station 1. The water depth ranged from 0.28-0.41 m and the sediment is characterized mainly of mud. The area is minimally impaired by human activity. Station 3 (7°59.0832’ E; 4°033.7639’ N) is located at Qua Iboe jetty about 1,100 km from station 2 where human activity is also minimal but the station is closest to Exxon-Mobile crude oil effluent processing and treatment facility. The water depth ranged from 0.35-0.59 m and the river bed is covered with mud and occasionally with silt.

2.2 Sample collection

Sample collections were carried out between January and June 2013 from three stations (Figure 1) during the dry (January-March) and wet (April-June) seasons. One hundred and eight (108) surface water and sediment samples were obtained separately in triplicates from each location for six months.

Surface water samples for trace metal analysis were collected at a depth of 15 cm in opposite direction to the flow of the river with well labeled plastic bottles. All samples were acidified with 4 mL concentrated HNO₃ in order to stabilize the metal ions and prevent precipitation. Sediment samples were obtained with the aid of an improvise bottom grab device. The content of the grab were emptied into well-labeled black polyethene and sealed. The samples were immediately transported to the laboratory in an ice box and stored at 4°C in the refrigerator prior to chemical analysis. The chemical analysis was analyzed at the Akwa Ibom State Water Corporation Central Laboratory, Uyo using standard methods (AWWA, 1980).

2.3 Determination of Trace Metal

Nitric-perchloric acid digestion was performed, following the method recommended by AOAC (1990). Ten milliliter of concentrated HNO₃ and 5mL of concentrated HClO₄ were added to One gram of dried ground sediment samples in 100mL beaker. The mixture was placed on a hot plate in a fume cupboard and heated to near dryness. Heated mixture was allowed to cool before leaching the residue with 5mL of 20% HNO₃. The mixture was filtered using Whatman 42 filter paper and the volume of the filtrate made up to 50 mL with distilled water and analyzed for metals using Atomic Absorption Spectrophotometer (HACH DR/2010 model).

Hundred milliliter of the water sample was placed in 125ml conical flask and digested with concentrated HNO₃ until a clear solution was obtained. The solution was then filtered using a 0.45µm membrane filter. The filtrate was made up to a 50 mL with distilled water in volumetric flask and analyzed for metals using Atomic Absorption Spectrophotometer (HACH DR/2010 model).

The instrument was calibrated according to manufacturer specifications and the corresponding wavelength for each metal was selected. The instrument was standardized using a standard blank cuvette, making it ready for measurement. The standard cuvette was removed and another cuvette filled with 25ml of the filtrate was inserted into the instrument. It was then delayed for about 30 seconds before pressing ‘read direct’ and results were obtained on the display screen (AWWA, 1980). The methods were confirmed using
certified reference materials for sandy clay (CRM 049-050). There were no significant differences (p<0.05) between determined and certified metal concentrations.

2.4 Statistical Analysis
The results obtained were subjected to statistical evaluation using Minitab © version 15. One-way Analysis of variance (ANOVA) was used to evaluate significant difference in mean values of the trace metals in the estuary. Mean separation was carried out using the Turkey test. Correlations were performed in a pair wise fashion employing Pearson correlation procedure.

3 Results
Trace metal concentrations in water are summarized in Table 1 for the three stations. The general trend of metals in water was in the following order: Fe>Zn>Pb>Cd. The minimum and maximum mean values (mg/L) for the metals in water ranged from 0.12 to 0.20 for iron; 0.06 to 0.09 for zinc; 0.01 to 0.02 for lead and 0.003 to 0.01 for cadmium. The results of water samples showed variations in the distributions of Fe, Zn, Pb and Cd. Significant variations (P<0.05) occurred in Fe and Pb, while variations in Zn and Cd were not significant across the sampling stations. Except for Cd, the mean values of Fe, Zn and Pb in wet season (0.19, 0.10, and 0.01 respectively) were comparatively higher than those of dry season (0.14, 0.06 and 0.01 respectively) (Figure 2). However, Fe, Zn and Cd showed significant variations (P<0.05) in seasons except for Pb which indicated no significant differences.

The spatial variations of metals in sediment are presented in Table 2. Similar trend (Fe>Zn>Pb>Cd) was observed in sediment. Except for iron, spatial variation of heavy metals across all stations were not significant (P>0.05). The concentrations of Fe ranged from 0.09 – 3.6 mg/kg in sediment. The lower limit of Fe in sediment was determined at station 1 and the upper limit at station 2. Zn concentrations ranged from 0.01 in station 3 to 1.27 in station 2. Pb concentrations ranged from 0.01 – 0.17 mg/kg in the sediment. The lower limit of Pb was determined at station 1 and upper limit at station 2. Concentrations of Cd ranged from 0.001 – 0.08 mg/kg in sediment, with lower limit determined at station 1 and upper limit at station 3.

Metal values obtained in dry season were relatively higher than those in wet season. Fe, Zn, Pb and Cd were 0.99, 0.51, 0.05 and 0.03 respectively for dry season while the same metals were 0.19, 0.15, 0.02 and 0.01 in wet season (Figure 3).

The correlation coefficient between the metal levels in water and sediments for the six (6) month is presented in Table 3. High significance variation were obtained at p<0.05. Fe in water showed a significant positive relationship with Zn (r=0.67); Pb (r=0.68) and Cd (r=0.713) and negative correction with other metals in sediments. The relationship between Pb and Zn was significantly positive (r=0.559) in water and (r=0.84) in sediments. Cd on the other hand showed a significant positive correlation with Zn (r=0.612) and Pb (r=0.592) in water.

4. Discussions
Qua Iboe estuary is one of the estuaries in the Niger delta of Nigeria that provides essential breeding and nursery grounds for fishes in Gulf of Guinea. Despite the significant role estuary plays, metals from naturally occurring deposits, natural processes and anthropogenic activities are in the estuaries. Metals analyzed in sediments were higher than those in water which confirmed that sediments are important sink for toxic metals and tend to pose threats to aquatic life as a result of re-suspension into the water column. It shows that some trace metals that may not be detected or in low concentration in the water column can be observed in the sediments.

Iron which is the fourth most abundant element in the Earth’s crust plays a role in many redox reactions in metabolic functions in human. Concentration of iron in water from this study was below the NIS maximum permissible level for drinking water. No guideline value for iron in drinking-water is proposed by WHO, they stated that it was not of health concern at levels found in drinking-water. However, concentration of 0.3 – 1.0 mg/l are satisfactory level but may cause staining and objectionable taste, while Fe values of > 1.0 are unsatisfactory in drinking water (WHO, 2011). The lowest concentration of Fe in sediment was determined at station 1 and the highest level was at station 2. The could be as a result of anthropogenic inputs such as the discharge of Fe-laden wastes and
effluents replete with iron scales from corroded iron pipes, containers and scraps into the water body including the Stubbs creek which empties into the estuary close to sampling location 2 of this study. However, these values are lower than values obtained in other studies in the region and Canada sediment quality criteria (Udosen and Benson, 2006; CEQC, 1991).

Mean zinc concentration range of 0.12 to 0.20mg/L in water, were below the maximum contamination level of 15 and 3.0 mg/l recommended by WHO (2011), and NIS (2007) respectively. Zn is present in large amount in natural water and next to Fe in terms of concentrations in this study. These values were lower than mean concentration of 10mg/kg obtained from Bodo creek in the Niger Delta (Vincent-Akpu et al., 2015). The relatively low Zn level suggests that the domestic and industrial effluents reaching the estuary conceivably contained low concentration of the metal. Drinking-water containing <3 mg/l zinc may not be acceptable to consumers (WHO, 2011).

The mean Pb concentration (0.01- 0.02mg/l) recorded in Qua Iboe water is slightly higher than 0.01 mg/l recommended by WHO (2011), and NIS (2007). Study by Lawson, (2011) showed that the concentrations of Pb were very low and could not be detected in water from the swamps of Lagos lagoon, and attributed it to the absence of dry cell batteries manufacturing industries from catchment areas of the lagoon. This finding is contrary to those documented for Qua Iboe river estuary (Ebong et al., 2004); Stubbs creek (Udosen and Benson, 2006); Niger Delta mangrove creek (Oribhibor and Ogbeibu, 2009), and Ikpoba reservoir (Wangboje and Ekundayo, 2013), who report that Pb concentrations in their study exceeded the WHO maximum permissible level for drinking water.

Pb concentrations ranged from 0.006 – 0.171 mg/kg in the sediment. According to the Nigerian Industrial Standard (NIS), the adverse health impacts of Pb include interference with vitamin D metabolism, indenting the mental development of infants, carcinogenic activity and toxicity to the central and peripheral nervous systems. Low levels of Pb recorded in this study are consistent with previous studies in Niger Delta (Vincent-Akpu and Yanadi 2014; Adeleye et al., 2011).

The mean Cd concentration (0.003 mg/l) in water was recorded for station 2 while 0.01 was recorded for stations 1and 3. The work of Fakayode, (2005), documented lower mean Cd concentration of 0.004 mg/l for the Alaro River and Cd value of 0.036±0.036 mg/l recorded for Qua Iboe river estuary (Ebong et al., 2004), while mean Cd range of 1.50mg/l to 2.60mg/l was recorded for the Delimi River, Jos, Nigeria (Njoku and Keke, 2003).

Sources of Cd include batteries, fossil fuels, fertilizers, plastics, alloys and paints. Cadmium accumulates primarily in the kidneys and has a long biological half-life in humans of 10–35 years (WHO 2011).

The observed seasonal differences in trace metals in sediments and water depict the influence of runoffs which contribute to the dilution of these metals during
Table 1 Mean concentrations of trace metal (mg/L) in water of Qua Iboe estuary during the study period compared with Standards

<table>
<thead>
<tr>
<th>Trace</th>
<th>Station 1</th>
<th>Station 2</th>
<th>Station 3</th>
<th>WHO (2011)</th>
<th>NIS (2007)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metals</td>
<td></td>
<td></td>
<td></td>
<td>Permissible level</td>
<td>permissible level</td>
</tr>
<tr>
<td>Fe</td>
<td>0.20±0.13&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.12±0.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.18±0.04&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.05-0.56)</td>
<td>(0.04-0.27)</td>
<td>(0.12-0.23)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td>0.09±0.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.06±0.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.09±0.03&lt;sup&gt;c&lt;/sup&gt;</td>
<td>15.0</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>(ND-0.3)</td>
<td>(ND-0.15)</td>
<td>(0.02-0.15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pb</td>
<td>0.02±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.01±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.01±0.01&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.01</td>
<td>0.01</td>
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<tr>
<td></td>
<td>(ND-0.03)</td>
<td>(ND-0.02)</td>
<td>(0-0.02)</td>
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<tr>
<td>Cd</td>
<td>0.01±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.003±0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.01±0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.003</td>
<td>0.003</td>
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<tr>
<td></td>
<td>(ND-0.02)</td>
<td>(ND-0.01)</td>
<td>(ND-0.01)</td>
<td></td>
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</tbody>
</table>

abc= mean values in the same row with different superscript are significantly different at α= 0.05. NIS (Nigerian Industrial Standard); ND - not detected

Table 2 Trace metal concentrations in sediment of Qua Iboe estuary during the study

<table>
<thead>
<tr>
<th>Metals</th>
<th>Station 1</th>
<th>Station 2</th>
<th>Station 3</th>
<th>DPR (2002)</th>
<th>CEQC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td>0.47±0.54&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.739±1.21&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.553±0.70&lt;sup&gt;c&lt;/sup&gt;</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(0.09-1.67)</td>
<td>(0.1-3.6)</td>
<td>(0.1-2.13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td>0.27±0.31&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.35±0.42&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.37±0.41&lt;sup&gt;a&lt;/sup&gt;</td>
<td>50 - 300</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>(0.06-0.99)</td>
<td>(0.07-1.27)</td>
<td>(0.01-1.27)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pb</td>
<td>0.02±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.04±0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.05±0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2 - 20</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>(0.01-0.03)</td>
<td>(0.01-0.17)</td>
<td>(0.01-0.17)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cd</td>
<td>0.015±0.019&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.019±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.020±0.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.03 - 0.3</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>(0.001-0.06)</td>
<td>(0.003-0.075)</td>
<td>(0.002-0.08)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

abc= mean values in the same row with different superscript are significantly different at α = 0.05. CEQC - Canadian environment quality criteria 1991

Table 3 Correlation matrix of trace metals in Qua Iboe estuary

<table>
<thead>
<tr>
<th></th>
<th>Fe</th>
<th>Zn</th>
<th>Pb</th>
<th>Cd</th>
<th>Fe(sed)</th>
<th>Zn(sed)</th>
<th>Pb(sed)</th>
<th>Cd(sed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td>0.67*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pb</td>
<td>0.68*</td>
<td>0.56*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cd</td>
<td>0.71*</td>
<td>0.61*</td>
<td>0.59*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe(sed)</td>
<td>-0.10</td>
<td>-0.15</td>
<td>-0.06</td>
<td>-0.05</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zn(sed)</td>
<td>-0.13</td>
<td>-0.12</td>
<td>-0.09</td>
<td>-0.07</td>
<td>0.94*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pb(sed)</td>
<td>-0.16</td>
<td>-0.18</td>
<td>-0.09</td>
<td>-0.10</td>
<td>0.86*</td>
<td>0.843*</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Cd(sed)</td>
<td>-0.15</td>
<td>-0.15</td>
<td>-0.11</td>
<td>-0.097</td>
<td>0.94*</td>
<td>0.981*</td>
<td>0.841*</td>
<td>1</td>
</tr>
</tbody>
</table>

*Significantly correlated at P=0.05

wet season. This study has shown that the concentrations of trace metals like Fe, Zn, Pb, and Cd in both water and sediment of Qua Iboe estuary were below or slightly higher than the permissible standard limits recommended for polluted water. Bader et al (2015) explained why the concentrations of metals measured in water do not reflect the relative contributions of pollution from the activities in the estuary. This they said may be caused by the action of some physicochemical process such as precipitation, trapping, settling and storage of pollutants in sediments and bioaccumulation in aquatic organisms. Qua Iboe estuary is tidal with continuous ebb and flood flows which ensure proper flushing of the estuary.

Matrices of correlation coefficient between the metal levels in the water and sediments for the six (6) month variation show high significance (p<0.05) which is the direct correlation between some of the metals. Fe in water showed a significant positive relationship with other metals. Significant correlation among the variables indicates that there are linear relationships between the parameters. The relationship between Fe and other
metals were higher, indicating the importance of Fe in the accumulation of element in sediments.

Although the results obtained showed that the metal levels posed no danger to users of the water from this estuary but the possibility of deleterious effects after long period cannot be ruled out. This is because the water body serves as the receptor for domestic and industrial wastes as well as runoff from agricultural land. Therefore, there is need to conserve the conditions of the estuary in view of its uniqueness and the importance of estuaries globally in the life cycle of many aquatic species.

Authors' contributions

VIF designed, supervised and carry out the statistical analysis. OUS collected the samples and did the measurement. All authors read and approved the final manuscript.

Acknowledgments

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References

Canadian Council of Ministers of the Environment (CCME), 1991, Interim Canadian environment quality criteria for contaminated sites, Report CCME EPC-C534, Winnipeg, Manitoba

http://dx.doi.org/10.4314/gjas.v10i4.6446
Leivouri M., 1998, Heavy metal contamination in surface sediment in the Gulf of Finland and comparison with the Gulf of Bothnia, Chemosphere, 36: 43-59
http://dx.doi.org/10.1016/S0045-6535(97)00285-3
http://dx.doi.org/10.5539/cp
Oribahobor, B.J., and Ogbeibu, A.E., 2009, Concentration of Heavy Metals in a Niger Delta Mangrove Creek, Nigeria, Global Journal of Environmental Sciences, 8 (2): 1-10
http://dx.doi.org/10.3923/tasr.2006.292.300
http://dx.doi.org/10.5539/cp.v2n1p110
http://dx.doi.org/10.1080/02772248.2015.1151576
http://dx.doi.org/10.1016/S0048-9697(99)00002-9
Wogu M.D., and Okaka C.E., 2011, Pollution studies on Nigerian Rivers: Heavy metals in surface water of Warri River, Delta state, Journal of Biodiversity and Environmental Sciences, 3: 7-12
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