African Journal of Pure and Applied Chemistry Vol. 5(8), pp. 219-223, August 2011
Available online at http://www.academicjournals.org/AJPAC
ISSN 1996 - 0840 ©2011 Academic Journals

Full Length Research Paper

Monitoring metals pollution using water and sediments collected from Ebute Ogbo river catchments, Ojo, Lagos, Nigeria

A. A. Adeniyi[1]*, O. J. Owoade[1], I. O. Shotonwa[1], O. O. Okedeyi[2], A. A. Ajibade[1], A. R. Sallu[1], M. A. Olawore[1] and K. A. Ope[1]

[1] Department of Chemistry, Lagos State University, Ojo, P. M. B. 0001, LASU Post Office, Badagry Expressway, Ojo, Lagos, Nigeria.
[2] Department of Chemistry, University of South Africa, P. O. Box 392 UNISA, Pretoria, 003, South Africa.

Accepted 16 June, 2011

The levels of Cu, Pb, Cd, Zn and Ca in water and sediments collected from the Ebute Ogbo River catchments, Ojo, Lagos, Nigeria were determined by flame atomic absorption spectrometry. The samples were collected in year 2008 and 2009. The results obtained showed a decrease in the Cd, Pb and Ca levels in water samples for 2009 compared to year 2008. However, Cu and Zn levels were in the increase. Nevertheless, metals burden in the sediment samples revealed decreased concentrations for the year 2009 samples. Data obtained were compared with the WHO limits and the Nigeria's background values (NBV). Statistical t-test was used to test statistical differences in the samples.

Key words: River, pollution, metals, monitoring.

INTRODUCTION

The rivers and other water bodies are the ultimate repository of man's wastes (Kucuksezgin et al., 2010; Nassif and Saade, 2010; Xianfei et al., 2009; Adebowale et al., 2008; Adeniyi et al., 2008; Awofolu et al., 2005; Usero et al., 2005; Yusuf and Osibanjo, 2004; Biney et al., 1994). The highly dynamic nature of the marine environment allows for a rapid assimilation of waste materials by processes such as dilution, dispersal, oxidation and degradation into sediment. The occurrence of elevated levels of metals especially in the sediments can be ascribed to anthropogenic influences rather than natural enrichment of the sediment by geological weathering (Bai et al., 2010; Wang et al., 2010; Adebowale, et al., 2008).

Sediments aggregates contaminants over time, and are in constant flux with the overlying water column (Bai et al., 2010; Deng et al., 2010; Ayejuyo et al., 2010; Usero et al., 2005; Martin and Whitefield, 1983). The analysis of metals in sediments permits detection of pollutants that may be either absent or in low concentration in the water column (Adeniyi et al., 2008; Yusuf and Osibanjo, 2006; Martin and Whitefield, 1983).

The distribution of metals in water and sediments provides a record of the spatial and temporal history of pollution in a particular region or ecosystem (Xianfei et al., 2009; Awofolu et al., 2005; Biney et al., 1994; Martin and Whitefield, 1983). Cadmium and lead are stable and persistent environmental pollutants, and are known to exhibit extreme toxicity even at low levels under certain conditions. Interest in metals like copper and zinc which are required for metabolic activity in organism lie in the narrow "window" between their essentiality and toxicity (Fatoki and Mathabatha, 2001). Whereas, calcium is believed to have antagonistic effect on the potential bioavailability of cadmium and zinc (VanAardt and Booysen, 2004; Sanders et al., 1999; Everall et al., 1989). Calcium is involved in many chemical cycles that take place in water bodies.

Lagos coastal waters are under increasing pressure from industrial pollution and urbanization (Ayejuyo et al., 2010; Adeniyi et al., 2008). Such pressures pose potential threat to entire ecosystems – vital not only to wildlife but also for the economy and human well being.

*Corresponding author. E-mail: lekeadeniyi@yahoo.com.

Abbreviations: NBV, Nigeria's background values; **MPI,** metal pollution index; **WHO,** World Health Organization.

Many inhabitants in the Ebute Egbo river catchments rely on it for their socio-economic well being. The river also serves as receptor for domestic and industrial wastes from the adjoining communities. These sources are most likely going to introduce noxious metals into the water bodies. It is therefore imperative to continuously monitor the levels of metal pollution in this river system. This study reports the levels of metals – cadmium (Cd), lead (Pb), zinc (Zn), copper (Cu) and calcium (Ca) in water and sediments, collected from the Ebute Ogbo river, Ojo, Lagos. This is with a view to provide data that will assist in the river's water quality evaluation.

MATERIALS AND METHODS

Description of the study area

The study area is the Ebute Ogbo River in the Ojo Local Government Area of Lagos State. This river empties into the Atlantic Ocean at the Bight of Benin. The main sources of pollution in the river catchments are socio-economically related. Several motorized boats convey inhabitants and their goods from the mainland to the different riverside settlements scattered along the river banks. The natives also depend on the river for fishing and source of water for domestic purposes. They are also involved in commercial sand dredging. Some industrial concerns within the vicinity of the river catchments empty partially treated effluents into the river. Domestic waste discharges and makeshift latrines are evident in the river banks.

Sampling and analysis

Ten composite (5 each year) samples of water and sediment were collected randomly between the period of January – March, 2008 and January – March, 2009, respectively. The water and sediment samples were collected following the standard procedure described by America Public Health Association (1998) and Department of Water Affairs and Forestry (DWAF) (1992). Water samples were collected in clean plastic containers, acidified with conc. $HN0_3$ and brought to the laboratory and refrigerated. Sediment samples were collected in plastic containers and refrigerated, the samples were air dried and passed through a 2 mm sieve.

A Jenway 3505 pH meter was used to determine the pH of the water and sediment sample in accordance with the method previously reported (Adeniyi et al., 2008). The samples were prepared for metal analysis using acid digestion as described earlier (Usero et al., 2005; Awofolu et al., 2005; Adeniyi and Oyedeji, 2001). Five metals- Cd, Pb, Zn, Cu and Ca were determined in an air-acetylene flame (Buck Scientific 200 A, Atomic Absorption Spectrophotometer).

To compare the total metal content at the different sampling cycle, the metal pollution index (MPI) was used (Usero et al., 1997). The MPI equation is as shown below:

$$MPI = (Cf_1 \times Cf_2 \ldots Cfn)^{1/n}$$

where Cfn = concentration of the metal n in the sample.

Reagents and quality assurance

High purity chemicals and reagents (purchased from Merck and Aldrich Chemical Company), together with distilled-deionised water were used. Stock solutions (Merck) of 1,000 mg/L of the different metals were used to prepare the calibration standards (concentration ranges from 0.20 – 150.0 mg/L). The potential contamination of samples was evaluated by analyzing one acid blank in every batch.

Statistical analysis

Student's t-test was used to study differences in metal concentrations in water and sediments (Pentecost, 1999).

RESULTS

Table 1 shows the pH, copper, lead, cadmium, calcium and zinc concentrations (mg/L) of the river water samples collected between January and March of year 2008 and 2009, respectively. The metal pollution index (MPI) of the sampling events is also indicated. The values obtained for the water samples are compared with the Nigeria's background values (NBV) and the World Health Organization (WHO) limits for drinking water. The t-test statistical difference at 95% confidence level for samples collected in year 2008 and those of year 2009 are equally captured in Table 1.

Table 2 on the other hand reveals sediment samples pH and metals concentrations. The respective MPI and NBV values are shown along with the t-test statistics comparing the year 2008 and 2009 samples.

The t-test statistical analysis (95% confidence level) of metals concentration in water vs. sediments samples for each year is provided in Table 3.

DISCUSSION

The pH and metal concentrations for the water and sediment samples for year 2008 and 2009 are given in Tables 1 and 2. The values for water (2008) ranges from 7.01 - 7.31, while that of 2009 ranges from 7.38 - 7.79. Similarly, that of sediments ranged from 6.49 to 6.89 (2008) and 4.02 - 5.20 (2009). In acidic conditions, there are enough H^+ ions to occupy many of the negatively charged surfaces of clay and organic matter (sediments).

Therefore, little room may be left to bind metals; as a result, more metals remain in the soluble phase (Jain and Singhai, 2005; Licata et al., 2003). The pH values for water samples fall within the WHO limit of 6.50 – 8.50 for drinking water (WHO, 1996). There was a decrease in the pH of sediment samples from 2008 to 2009, and this poses a major threat to aquatic life as decrease in pH aggravates toxicity (Demiraka et al., 2006; Licata et al., 2003).The water and sediments samples of 2008 showed a generally higher concentration of metals than those of 2009. This may be attributed to the relatively higher levels of industrial activities in the river catchments area in 2008 compared to year 2009. The Ebute Ogbo river

Table 1. Concentration of metals (mg/L) and t-test statistical analysis of the 2008 and 2009 water samples.

Sample	pH	Cu	Pb	Cd	Ca	Zn	MPI
1	7.23 (7.38)	0.04 (0.26)	0.46 (ND)	0.07 (ND)	330.00 (189.50)	0.10 (1.98)	0.53 (2.50)
2	7.01 (7.79)	0.13 (0.30)	0.20 (ND)	0.08 (ND)	323.00 (160.75)	0.11 (0.31)	0.59 (1.72)
3	7.31 (7.73)	0.08 (0.09)	0.28 (ND)	0.06 (ND)	285.00 (233.00)	0.17 (0.05)	0.58 (1.00)
4	7.13 (7.61)	0.12 (ND)	0.32 (ND)	0.07 (ND)	286.00 (143.75)	0.04 (0.31)	0.50 (2.14)
5	7.15 (7.66)	0.09 (0.03)	0.26 (0.26)	0.08 (0.03)	298.00 (305.50)	0.09 (0.29)	0.55 (0.46)
NBV	5.70-7.56	0.0003-0.24	ND-0.23	0.0001-0.35	38.60-127.90	0.02-0.76	
WHO limit(WHO,1996)	6.50-8.50	5.00	0.05	0.005	75.00-200.00	5.00	
t-test (95% confidence level)	5.40*	1.19 ^{ns}	3.58*	9.52*	3.21*	1.38 ^{ns}	

Notes: Values in parentheses are for 2009 samples; NBV, Nigeria's background values for some rivers (Ayejuyo et al., 2010; Adebowale et al., 2008; Adeniyi et al., 2008; Yusuf and Osibanjo, 2004); WHO, World Health Organization limits for drinking water; ND, not detected; ns, non significant differences at p = 0.05, t_{tab} at p = 0.05 (2.31); * significant differences at p = 0.05

catchments experienced reduced industrial activities in 2009 because of Nigeria's infrastructural challenges.

In Table 1, water samples showed a general increase in the concentrations of Cu and Zn, while there was a decrease in those of Cd, Pb and Ca from 2008 to 2009.

The level of Pb in the year 2008 water samples (0.26 - 0.46 mg/L) exceeds the limit of 0.05 mg/L set for drinking water by WHO (1996). Similarly, the levels of Cd and Ca in the water samples generally exceed the WHO limits for drinking water (0.005 mg/L, Cd) and (75 – 200 mg/L, Ca).

The concentrations of Zn in the water samples (0.04 - 0.17 mg/L, 2008 and 0.05-1.98 mg/L, for year 2009), respectively fall within the limit of 5.00 mg/L set for drinking water by WHO (1996).

The levels of Pb in water samples exceed the reported Nigeria's values of ND – 0.23 mg/L in a number of instances (Table 1). However, concentrations of Cd and Zn in the water samples fall within the NBV of 0.0001 – 0.35 mg/L (Cd) and 0.02 – 0.76 mg/L (Zn), respectively (Ayejuyo et al., 2010; Adebowale et al., 2008; Adeniyi et al., 2008; Yusuf and Osibanjo, 2004). The water MPI for the respective samples in year 2009 are generally higher than those of 2008.

The concentrations of Pb, Cd and Zn in the sediment samples fall within the Nigeria's background values for river sediments. The MPI is higher for the year 2008 sediment samples as captured in Table 2 for the respective samples.

The statistical data (Table 3) showed a significant difference at 95% level of confidence in the concentrations of Pb and Ca for both years. Whereas, Cd and Zn are statistically significant in the 2008 samples. In the event of pollution in an aquatic ecosystem, sediments are known to habour more of the contaminants (Adeniyi et al., 2008; Yusuf and Osibanjo, 2006; Monteiro and Roychoudhury, 2005; Awofolu et al., 2005; Ikem et al., 2003). The significant differences observed are therefore not unexpected.

The 2008 and 2009 water and sediment samples have different amounts of Cu, Pb, Cd, Ca and Zn (Tables 1 and 2). These differences were found to be statistically significant (p = 0.05; Tables 1 and 2), for Pb, Cd and Zn (water) Pb and Zn (sediments), respectively. We can therefore infer that the river's metal pollution burden for these metals is still of concern (Adeniyi et al., 2008, Usero at al., 2005).

Conclusion

Metals (copper, lead, cadmium, zinc and calcium) determined in the Ebute Ogbo's river water and sediment samples were found at elevated levels. This gives cause for concern. The socio- economic activities around the river catchment are the probable sources of these contaminants.

Elevated levels of metals in water have been implicated as risk to human health and the "health" of the aquatic system. The continuous monitoring of metal pollution of the river system is essential. Activities that predispose

Table 2. Concentration of metals (µg/g) and t-test statistical analysis of the 2008 and 2009 sediment samples.

Sample	pH	Cu	Pb	Cd	Ca	Zn	MPI
1	6.82	2.08	2.80	ND	87.50	4.32	4.67
	(4.33)	(0.56)	(ND)	(ND)	(3.38)	(3.38)	(1.14)
2	6.80	7.22	1.00	0.08	12.90	2.00	1.72
	(4.17)	(0.52)	(ND)	(ND)	(1.04)	(1.04)	(0.88)
3	6.89	10.30	1.40	ND	12.40	5.32	3.94
	(5.20)	(0.78)	(ND)	(ND)	(0.46)	(0.46)	(0.81)
4	6.49	34.76	2.10	ND	13.50	4.63	5.39
	(4.25)	(10.21)	(ND)	(ND)	(1.30)	(1.30)	(1.68)
5	6.71	8.41	0.90	ND	10.50	9.10	3.73
	(4.02)	(ND)	(ND)	(ND)	(1.86)	(1.86)	(1.13)
NBV	6.23-8.73	-	0.01-9.27	0.001-0.79	0.24-3.68	0.04-57.80	
t-test	9.06*	2.12 ^{ns}	4.58*	1.11^{ns}	1.82 ^{ns}	2.76*	

Notes: Values in parentheses are for 2009 samples; NBV, Nigeria's background values for some rivers (Ayejuyo et al., 2010; Adebowale et al., 2008; Adeniyi et al., 2008; Yusuf and Osibanjo, 2004); ND, not detected; ns, non significant differences at p = 0.05, t_{tab} at p = 0.05 (2.31); * significant differences at p = 0.05

Table 3. t- test statistical analysis of metals concentration in water vs. sediment samples.

Year	Element				
	Cu	Pb	Cd	Ca	Zn
2008	2.18 ^{ns}	3.72*	2.72*	15.63*	4.32*
2009	1.02 ^{ns}	9.31*	2.22 ^{ns}	7.12*	1.67 ^{ns}

Notes: ns, non significant differences at p = 0.05; t_{tab} = 2.31 at p = 0.05; *significant differences at p = 0.05.

point source and diffuse contamination should be discouraged by the appropriate governmental agencies.

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