Assessment and Distribution of Metal Pollutants in the Sediments of River Ngadda and Alau Dam in Maiduguri, Borno State, Nigeria

[1]P. H. Bukar, [3]I. Y. Zakari [2]M. O. A. Oladipo, and [2]I. G. E. Ibeanu

[1]Nigerian Institute of Leather and Science Technology, Zaria
[2]Centre for Energy Research and Training, A.B.U. Zaria
[3]Department of Physics, A. B. u. Zaria
Corresponding author: paul.hena@yahoo.com

Abstract

The degree of deterioration of the Sediment of a river suggest to a large extent the level of contamination of its surrounding environment since sediments are the major sinks for heavy metals. The aim of this research was to determine the level of contamination of the sediments of River Ngadda with metal pollutants and the distribution of these metals in the various sites along the river in the study area. Twenty four metals namely Al, As, Ba, Br, Ca, Cr, Cs, Co, Dy, Eu, Fe, Hf, K, Mn, Na, Rb, Sb, Sc, Sm, Ta, Ti, TH, U, V Were determined using Instrumental Neutron Activation Analysis (INAA). The extent of deterioration of the sediment quality with some metal pollutants such as As, Co, Cr, Fe, Mn, Mg, and Zn in some of the sites was observed to be higher/lower than WHO standard guideline limits..The distribution of all the metals determined in the various sites in the study area were analyzed using WARD's method of cluster procedure which produced two clusters with an outlier with the cluster I consisting of sites SS1, SS4, SS5, SS6, SS8, and SS9; cluster two consisting of SS3and SS10 and the outlier SS2. This study is significant due to the extensive dry season farming along the bank of River Ngadda and Alau Dam which utilizes the water from both the Dam and the River for irrigation farming purposes and this may likely affect the food web of the study environment.

{**Citation:** P. H. Bukar, I. Y. Zakari, M. O. A. Oladipo, I. G. E. Ibeanu. Assessment and Distribution of Metal Pollutants in the Sediments of River Ngadda and Alau Dam in Maiduguri, Borno State, Nigeria. American Journal of Research Communication, 2016, 4(4):} www.usa-journals.com, ISSN: 2325-4076.

Introduction

The occurrence of heavy metals in water bodies are either of natural origin (eroded minerals within sediments, leaching of ore deposits and volcanism-eroded products) or of anthropogenic origin (solid waste disposal, industrial or domestic effluents, harbour channel dredging) (Marcovecchio *et al*, 2007 cited by Akan, *et al*, 2010). In recent years attention has been focused on the contamination of the environment because of the negative consequences being imposed on living organism on regular basis by it. It is a known fact that excess of some of the essential metals such as cobalt, iron, manganese and zinc can be toxic (Adepoju-Bello, *et al*, 2009).

Sediments represent significant sources of heavy metal pollution in the aquatic environment as a result of changes in pH, redox potential or diagenisis or physical perturbation within their primary sedimentary sinks (Akan *et al*, 2010). The occurrences of enhanced concentrations of heavy metals especially in sediments may be an indication of human induced perturbation rather than natural enrichment through geological weathering (Daves, *et al*, 2006, Binning and Baird, 2001, Eja *et al*, 2003). The significance of heavy metals in the environment is that they are non-biodegradable, persist in the environment and may become concentrated up the food chain (Eja, 2003). It is usually observed that sediments near urban areas contain high level of contaminants (Cooks and Wells, 1996; Lamberson, *et al*, 1992), which constitute a major problem to the environment being faced by many anthropogenically impacted aquatic environment (Magalhaes, *et al*, 2007). Sediments act as both carrier and sources of contaminants in aquatic environment (Shuhaimi, 2008), they considered as sink for heavy metals (Atta *et al*, 1997, Adeniyi and Yusuf, 2007, Chyne-Eng *et al*, 1987, Olowu *et al*, 2010). Pollutants released to surface water from industrial and municipal discharges, atmospheric deposition and run off from agricultural, urban and mining areas can accumulate to harmful levels in sediments (Chukwujindu, *et al* 2007). The study carried out in this research is significant in view of the location of River Ngadda since it transcend Maiduguri metropolis and a lot of activities that introduce metal pollutants directly or indirectly into the river do occur on a daily basis hence the need to the leves and distribution of heavy metals in the sediments of river Ngadda and Alau dam.

Materials and Methods

River Ngadda originates from River Yedzaram and Gadombole which meet at Sambisa both in Nigeria and flows as River Ngadda into Alau Dam and stretches down across Maiduguri Metropolis then emptied into Lake Chad. The river being that it transcends the Maiduguri town it receives all sorts of wastes from residential houses. Maiduguri, like other cities in developing countries there are few sanitary landfill sites. The waste dump sites are usually haphazardly located without careful consideration of environment and public health (Agunwamba, 2007). The study area lies between latidude 11^{o} 15$'$ N and longitude 30^{o}05$'$ E at an altitude of 345m above sea level and is located on sheet 90 North West on scale 1:50,000 Nigerian survey topographical map.

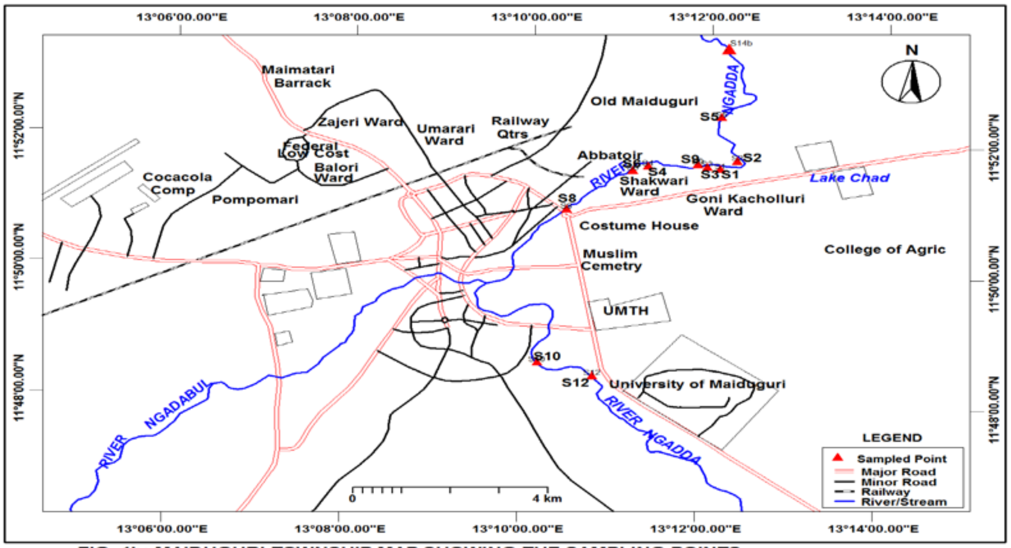

FIG. 1b: MAIDUGURI TOWNSHIP MAP SHOWING THE SAMPLING POINTS
Source: Adapted and modified from Maiduguri Township map

Samples Collection and Preparation

Sediment samples were collected at nine various points in River Ngadda and Alau Dam and labeled (SS1, SS2, SS3, SS4, SS5, SS6, SS8, SS9, SS10). The sediment samples were collected by gently scooping the sediments with clean plastic containers into a clean black polyethylene bags The sediments samples were then properly sealed and adequately labeled and then transported to laboratory where they were first air dried at ambient temperature to reduce the moisture content and thereafter oven dried at 70^{o}C - 80^{o}C for several hours.

Sample Preparation for Neutron Activation Analysis

Conventional method of sample preparation of geological samples for irradiation was adopted after which the samples were then put in an irradiation vial. The vial was then capped and sealed. Standard Reference Material which is a direct representative of the sediment sample was put in the same type of vial with that of the sample and then irradiated simultaneously.

Sample Analysis

The sample and comparator standards of known quantities of the elements in question **were** irradiated simultaneously in identical positions, followed by measuring the induced intensities of both the standard and the sample in a well known geometrical position. The sample and standard parameters were then related as

$$\frac{A_{sam}}{A_{std}} = \frac{\phi\omega\epsilon I N_A (1-e^{-\lambda t_{irr}})sam(e^{-\lambda t_d})sam(1-e^{-\lambda t_c})sam}{\phi\omega\epsilon I N_A (1-e^{-\lambda t_{irr}})std(e^{-\lambda t_d})std(1-e^{-\lambda t_c})std} \quad (1)$$

where A_{sam} is activity of the unknown sample, A_{std} is activity of the standard. The standard is irradiated and counted under similar conditions as the sample, therefore common parameters in equation (1) cancelled out then the mass of the element in the sample relative to the standard comparator is calculated using the equation.

$$\frac{A_{sam}}{A_{std}} = \frac{m_{sam}}{m_{std}} \frac{(e^{-\lambda t_d})}{(e^{-\lambda t_d})} \frac{sam}{std} \quad (2)$$

m_{sam} = mass of element in the sample, m_{std} = mass of element in standard, λ = decay constant for the isotope. For short irradiations, the irradiation, decay, and counting times are usually fixed the same for all samples and standards such that the time dependent factors cancel. Therefore equation (2) simplifies into

$$C_{sam} = C_{std} \frac{W_{std}}{w_{sam}} \frac{A_{sam}}{A_{std}} \quad (3)$$

Where C_{sam} = concentration of the element in the sample, C_{std} = concentration of the element in the standard, W_{sam} = weight of the sample, W_{std} = weight of standard,

Result

The data obtained was subjected to cluster analysis procedure using Ward's method so as to obtain the distribution of the various elements determined in the various site according to their similarity.. The Ward's method of clustering commence with the number of cluster equal to the number of samples and fuses together until only one cluster remains. The criteria for linking clusters are minimization of the error sum of squares (Oladipo, 1992) given as

$$SS = \sum_{clusters(A)} \sum [L_{ij} - L_{ij(s)}]^2 \text{ samples(i) elements(j)} \quad (4)$$

where Lij(A) = mean value of j for cluster say (A) to which i is assigned. WARD's method calculates the increase in SS with both joining samples to clusters and merging clusters. The cluster analysis was carried to show the similarity in the distribution of the various sites in terms of the content of the samples from each site which was the elements. The resulting hierarchical treatment is displayed in form of a dendrogram as shown in Figure 2

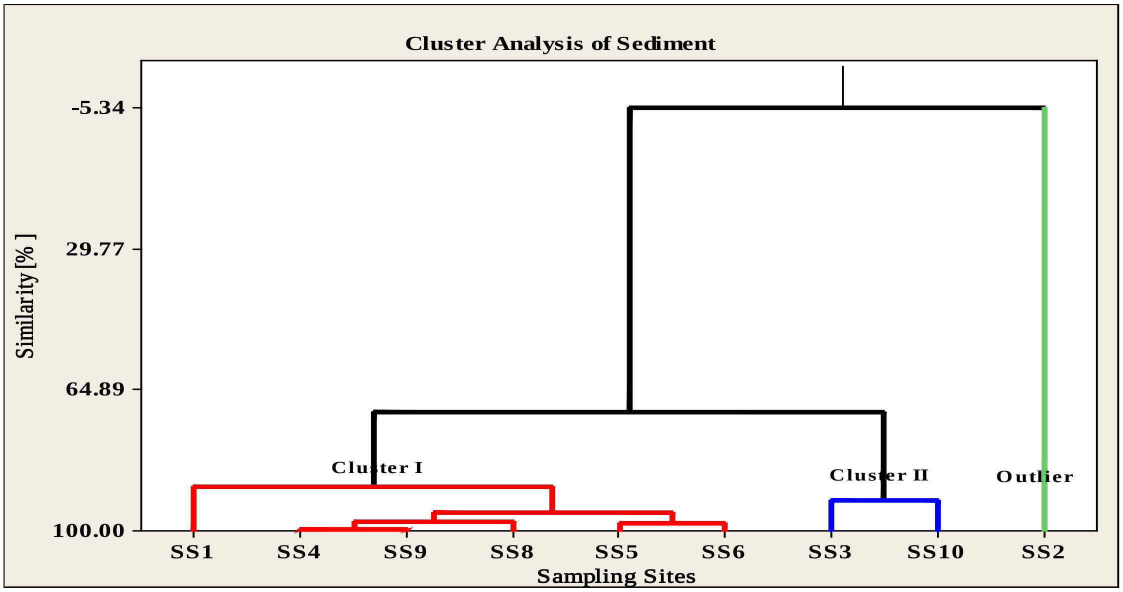

Figure 2: Dendrogram for Cluster Analysis of Sediment Samples Data.

Figure 2 showed the dendrogram for cluster analysis of sediment samples data. It clearly shows that the sampled sites have been divided into two major groups with an outlier and for convenience; the groups have been labeled as cluster I and II. The clusters produced represent the similarity in sources and or content of the variables in the samples that were grouped together as clusters. It can be clearly seen that site SS2 in this treatment came up as an outlier i.e not belonging to either of the groups. The first cluster constitutes sites SS1, SS4, SS5, SS6, and SS9, which suggests that the content of the samples from these sites i.e the elements in the samples have common or similar sources and it can be observed from the dendrogram that the similarity was about 89.07%, the second cluster consists of sites SS3, and SS10, with similarity at about 70.54% in their sources and content. The outlier could be associated with low value of the elemental concentration of Al in SS2 because outliers show disproportionate effect in multivariate analysis and do not tend to cluster at some levels with their sub-groups (Yarzab *et al*, 1980 cited by Ewa, 2004).

To obtain the structure of the dendrogram, normalised concentration values of the elements were plotted as shown in figure 3.

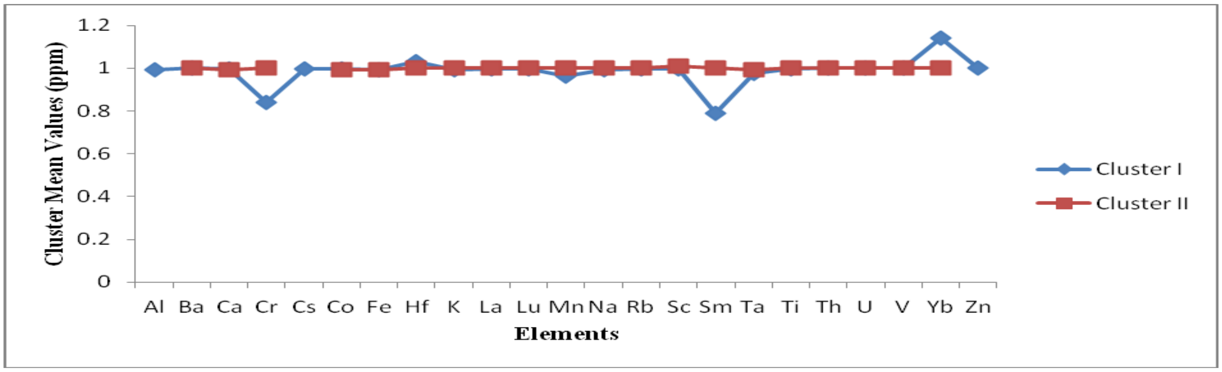

Figure 3: Normalized Concentration Profiles Obtained from the Cluster Analysis of Sediment Samples

Figure 3 displayed the structure of the sediment dendrogram. The deviating elements for cluster I was Cr, Sm, and Yb This deviation of the different elements i.e the content of the samples from cluster I were due to increase or decrease in the content of the samples from the mean values in the various sites i.e. high concentrations for values above the normalized value or low concentrations for values below the normalized value. The increase or decrease in values of these elements in the soil could be due to different factors such as natural or human activities which enhance or reduce deposition/accumulation of element at a particular site; for example wind storms which transport some of these elements in particulate form from one point to the other since the study area is closed to desert area, effect of erosion from rain water during rainy season, storms from the municipal, farming activities such as continuous application of chemical fertilizers that contain some of these elements, landfill processes with solid waste from the Metropolis for land reclamation which contained toxic elements. The concentrations of the elements of interest were compared with standard values as indicated in Figure 4a -c

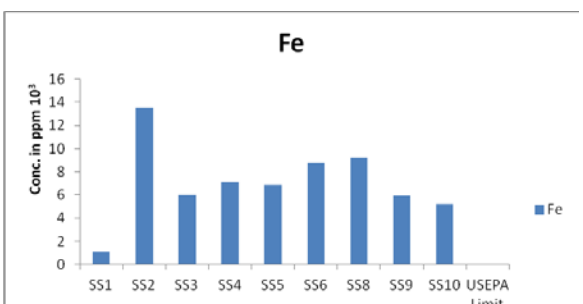

Fig. 4a: Concentration at Different Sites/USEPA Limit

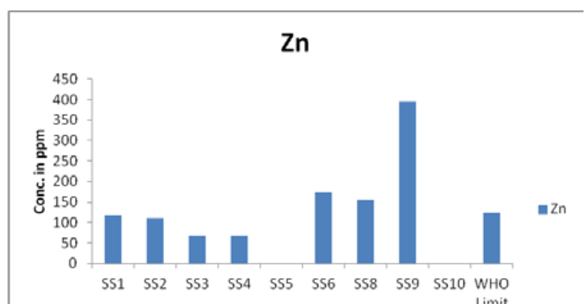

Fig 4c: Concentration at Different Sites/WHO Limit

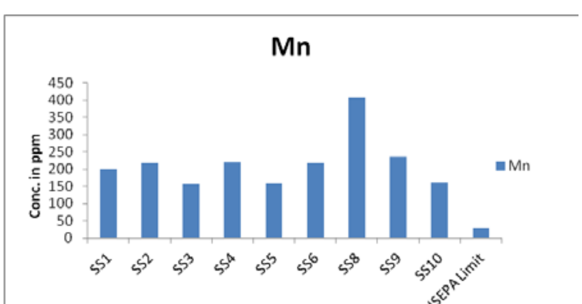

Fig4b: Concentration at Different Sites/USEPA Limit

Discussion

The result of the cluster analysis of the sediment data divide the study area into two clusters, cluster I and cluster II with an outlier to form a dendrogram as shown in Figure 2. The dendrogram indicates the similarity in the distribution of the various elements in the samples obtained from various sites along the bank of River Ngadda and Alau Dam in terms of the concentration of the elements in the soil and/or the origin of the sources of the elements. Cluster I showed a similarity of 96.5% for the content of the samples in the sites while cluster II showed a similarity of 90.8% for the content of the samples in the sites. It can also be observed from Figure 2 that, the first cluster consist of sampled sites SS1, SS4, SS5, SS6, SS8 and SS9 which constitute sampled sites from both Alau Dam area (SS8, SS9 and SS10) and sampled sites from Gongulon area (SS1, SS4, SS5 and SS6). Cluster II consist of sampled sites SS3 and SS10 with the site around Alau Dam area constituting sampled site SS10 while the sampled site around Gongulon area consist of site SS3. This clustering of the sediment collection sites in the same area appearing in different clusters could be attributed to the fact that the metal pollutants sources were heterogeneous implying that they are from more than one source which may include sources from town storm which end up in the stream, erosion from surface soil along roadside, windstorm that transport particulate element from one place to another and application of chemical fertilizer which may introduce some elements into the soil and then be eroded into the stream during rainy season..

It can be clearly seen from Figure 4(a - c) that the maximum concentrations of iron 13530 ± 203)ppm, and the minimum concentration (5238±152)ppm determined in the various sites in this study were above the USEPA guideline limit for sediment of (30)ppm while the maximum concentration of manganese (408±2)ppm and the minimum concentration of (157.2±1.4)ppm determined in this study were above the USEPA guideline limit of (30)ppm for sediment and the maximum concentration of Zinc (396±12)ppm determined in the sediment samples from various sites in this study and the minimum concentration of (66.89±0.61)ppm wer above for the maximum and below for the minimum for WHO guideline value of (123)ppm. The elemental investigation of the concentrations of Fe, Mn, and Zn in sediment samples obtained from River Ngadda and Alau dam and analysed using Atomic Absorption Spectrophotometer by Akan, *et al*, in 2010 showed that the maximum values of metal pollutants (Fe, Mn, Zn) in river Ngadda and Alau dam were Fe (9210 ± 182))ppm; Mn (408±2)ppm, and Zn (396±2)ppm and these values were above USEPA guideline limit and WHO recommended values for sediments.

Conclusion

From the results presented, it can be observed that the concentrations of the elements Fe, Mn, and Zn determined in the sediment of River Ngadda and Alau dam were above the USEPA and WHO guideline limits. Therefore, since the sediments were used by some aquatic animals it is expedient that such investigation be carried out periodically so as to be up to date with the level of concentrations of the elements involved and to try to abate the sources that introduce this pollutants so that the food web in this study environment does not be at the risk of the supply of heavy metal contamination.

References

Adeniyi, A. A. and Yusuf K. A. (2007): Environmental Monitoring Assessment 37 451-458.

Adepoju-Bello, A.A and Alabi, C. M. (2005): heavy Metals a Review. *The Nigerian Journal of Pharmacy* **37**: 41-45

Agumwamba, J.C and Udoh, O. N (2007): Effects of open dumps on Some Engineering and Chemical Properties of Soil. *International Journal of EnvironmentalIssues* **1**(1 &2) pp 61-67

Akan, J. C. Abdulrahman, F. I. Mamza, P. T. Aishatu, N. (2010): Effect of Environmental pollution on the quality of River Ngada Maiduguri Metropolis, Borno State, Nigeria. Global Science Books. *Terrestrial and Aquatic Environment Toxicology* **6** (11): 40-48.

Atta, M. B. El-Sebale, L. A. Naoman, M. A. and Kassab, H. (1997): Food Chemistry 58.1-4

Binning, K. and Baird d.(2001): Survey of heavy Metals in the Sediments of the Swatkops River estuary, Port Elizabeth South Africa. Water S. A 24 461-466.

Chyne-Eng, S. Poh-Eng, S. and Tian-Tse, A. (1987): MARINE Pollutant Bulletin **18** (1) 611-612

Chukwujindu, M. A., Iwegbue, G. E. N., and Francis, O. A. (2007): Assessment of contamination by Heavy Metals in Sediments of River Ase, Niger Delta. *Nigeria Resarch Journal of Environmental. Science,* **1 (5):**220 -228.

Cook, N. H. and Wells P. G. (1996): Toxicity of Halifax Habour Sediments; An Evaluation of Microlox Solid Phase Test. *Water Quality Research. Journal. Canada* 31(4): 673-708.

Davies, O. A., Alison, M. E., and Ugi, M. S. (2006): Bioaccumulation of Heavy Metals in Water Sediments and Periwinkle (*tymponotonus fuscatus Varnadula*) from the Elechi Creek, Niger Delta. *AfricanJjournal of Biotechnology* **5 (10)**: 969 -973.

Ewa, I.O.B and Oladipo, M.O.A (1992): *Journal of Environmental Science and Health*; **27** (1):1-11

Eja, C. E. Ogri, O. R. and Arikpo, G. E. (2003): Bioconcentration of Heavy Metals in Surface Sediments From the Great Kwa River Estuary, Calabar southeast, Nigeria. Nigeria *Journal Environmental. Science*. 1; 47-56.

Lamberson, J. O. Dewit T.H. Swartz, R. C. (1992): Assessment of Sediment Toxicity to Marine Benthos Incorporated: Burton G. A (Ed): Sediment Toxicity Assessment, Lewis Publish. Bcca Raton, Flpp 183-211

Magahaes, C, Coasta, J, Teixeira,C, Bordalo, A. A. (2007);Impact of Trace Metals on Dentrification in Estuarine Sediments of the Douro River Estuary, Portugal Marine Chemistry, 10; 332 341.

Marcovecchio,J. E, Botte, S.E, Frije, R.H (2007): Heavy Metals, Major, Metals, Trace Elements. In. Handbookof Water Analysis L.M. Nolet (2[ed]) Edn London CRC press. P275-311.

Oladipo, M. O. A (1992); Study of the Occupation site for the Ancient iron Smelters at Samaru-West, Nigeria, Using Neutron Activation Analysis.Fresenius journal of Anal. Chem. **341**Pp 280 -286.

Olowu, R. A. Ayejuyo, O. O. Adewuyi, G. O. Adejoro, A. A. B. Denloye, A. O. B. and Ogundajo, A. I. (2010): Determination of Heavy Metals in Fish Tissues, Water and Sediments from Epe and Badagry Lagoons lagos, *Nigeria. E-Journal of Chemistry* 7(1): 215-221

Shuhaimi, M. O. (2008): Metals Concentration In the Sediments of Richard Lake, Sudbury, Canada and Sediment Toxicity in an Ampipod Hyalelaacteca *Journal Environmental Science Technology*. 1: 34-41

USEPA (1999): Sediment Quality Guidelines develop by the National Status and Trend Program Report No. 6/1299