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HEAVY METAL POLLUTION ASSESSMENT IN THE SEDIMENTS OF LAKE CHAD, NIGERIAN SECTOR

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ABSTRACT
Sediments were collected from Dumba and KwataYobe of Lake Chad, Nigerian Sector.The aim was to assess the pollution statusof the sediments of the lake. The concentration of heavy metals, Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Manganese (Mn), Nickel (Ni), lead (Pb), Zinc (Zn) and Arsenic (As) were analysed using energy dispersive x-ray fluorescence (EDXRF). The mean concentration of heavy metals varies between 0.01 to 80877.06 ±10.12mg/kg, were compared with standard average shale to assess the pollution status of the sediments. The degree of pollution in Dumba and KwataYobe sediments for Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn and As was assessed using geo-accumulation index (Igeo). The results indicated that the sediments have been polluted with Cd, Cr, Fe, Mn, Pb, Zn and As. The Igeo values for Cd, Cr, Cu, Fe, Mn, Ni and Zn at KwataYobevaries between 0.007 to 0.630, indicating unpolluted sediments, while Igeo values for Cd at Dumba and Pb in both sites varies between 1.002 + 01.550 indicating moderately polluted sediments.Igeo values for As varies between 10. 411 to 13.20 in both sites indicating very highly polluted sediments. The Igeo values for Cd at Dumba, Pb and As in both sites indicated that the sediments were polluted.
Keywords:Assessment,Average shale, Geo-accumulation index, Heavy metal pollution, Sediments.

INTRODUCTION

Lake Chad is one of the largest natural lakes in the world. It extends to four African countries of Chad, Niger, Cameroon and Nigeria. The Chari River in Cameroon provides over 90% of Lake Chad's waters. Lake Chad is shallow and remains freshwaters lake (UNEP, 2007).Heavy metals are one of the serious pollutants in our natural environment because of their toxicity, persistence bioaccumulation and biomagnifications in food chain (Ozturk, *et al.,* 2009; Censi*et al.,* 2006).Heavy metals are usually present at low concentrations in aquatic environments but deposits of anthropogenic origin have raised their concentrations, causing environmental problems in lakes (Ntakirutimana*et al.*, 2013). Theheavy metals enter the aquatic environment from both natural sources, such as rock weathering, soil erosion and the dissolution of water-soluble salts and anthropogenic sources such as agricultural activities, and residential and industrial waste products (Forstner and Wittman, 1981).When heavy metals enter the environment, they are distributed between the aqueous phase and the suspended sediments during their transport. Heavy metals are non-biodegradable; they are not removed from water as a result of self purification. Once they are discharged into water bodies, they are adsorbed on sediment particles, accumulate in lakes, rivers and enter the food chain (Loska and Wiechula, 2003).

Sediments, as basic components of the aquatic environment, play an important role in elemental cycling and they are responsible for transporting a significant amount of pollutants and nutrients. They serve as important sinks for various pollutants such as heavy metals and pesticides. Aquatic sediment accumulates persistent and toxic chemicals to levels many times higher than the water Colum concentration (Milenkovic*et al.,* 2005). Heavy metals tend to be assimilated in sediment with organic matter, Fe/Mn oxides, sulphide, and clay thereby forming several reactive components, which are harmful to the environment. Hence, sediment is always regarded as the potential reservoir for heavy metals and plays an important role in adsorption of dissolved heavy metals (Praveena*et al,* 2010). Under different physical and chemical conditions, heavy metals in sediment may leach out into the water column as free ions. In turn, polluted sediments also act as sources of heavy metals when released into the lake or river water. Heavy metals concentration in lake or river water can be regarded as a good indicator of the lake or river pollution.(Praveena*et al,* 2010). Polluted sediments can threaten biota in the benthic environment, exposing them to hazardous concentration of toxic heavy metals. Some kinds of toxic sediments kill benthic organisms, reducing the food available to larger animals such as fish (Abida*et al,*2009). Geo-accumulation index (I_{geo}) was used to assess heavy metals accumulation in sediments as introduced by Muller (1969) to measure the degree of heavy metals pollution in aquatic sediments (Chakravarty and Patgiri, 2009).

The objectives of this study were to determine the concentrations of Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn and As in the sediments and the pollution status of Lake Chad, Nigerian Sector.

MATERIALS AND METHODS

This study was carried out at Baga, Nigerian sector of the Lake Chad. Baga is in Kukawa Local Government Area of Borno State. It lies on latitude 12°55′ and longitude 13°35′E. The major economic activities of the population in Baga are agriculture, stock breeding and fishing. The sampling sites are Dumba and KwataYobe.

The geo-accumulation index (I_{geo}) was calculated using the formula $Igeo = log_2(\frac{C_n}{1.5B})$ (Müller, 1969).Where, $C_n$is the measured concentration of heavy metal in sediments, $B_n$is the geochemical background concentration of the elements and 1.5 is the background matrix correction due to terrigeous effects. The I_{geo} classification consists of seven Classes(0-6), ranging from background concentration to very heavily polluted: less than zero, < 0 (Class 0) is background concentration, 0-1 (Class 1) is unpolluted to moderately polluted sediments, 1-2 (Class 2) is moderately polluted, 2-3 (Class 3) is high pollution, 3-4 (Class 4) is heavily polluted, 4-5 (Class 5) is highly to very heavily polluted, 5-6 (Class 6) is very heavily polluted (Kumar and Edward, 2009).

Sediment Sampling and Sample Preparation for the determination of Heavy Metal

Sediment samples were collected between January, 2012 and March, 2012 using hand trowel (10-20cm). The samples collected were placed in polyethylene bag and were transported to the laboratory for further analysis. A modified version of emission-transmission (E-T) method (Kump, 1996: Angeyo*et al*, (1998) and Funtua, (1999) was used to analyzed the sample. A quantity of 1.00kg of the sediments was air-dried until a constant weight was obtained. It was then ground to powder with a mortar and pestle to grain size less than 125μm and was homogenized by it, because metals are known to adhere to fine particles. A quantity of 0.5g of powdered sediments samples were mixed with three drops of liquid organic binders, polyvinyl chloride (PVC) and were pressed with 10 tons hydraulic press to produce pellets of 19mm diameter. Three replicates of pellets of the sample were prepared. The resulting pellets were used to analyse the heavy metals in the samples. Pellets of sediment was put into the x-ray fluorescence spectrometer sample holder and was bombarded with ^{109}Cd as the excitation source that emits Ag-K x-rays (22.1kev) in which case all the elements with lower characteristic excitation energies were accessible for detection in the sample. Fluorescent x-rays was produced which passes to the Si (Li) detector, through Mo target. The intensity of the fluorescent x-rays on the detector is proportional to the concentration of the individual element of interest in the sample.

Map of Lake Chad, Nigerian Sector and Surrounding Regions was presented in Figure 1.

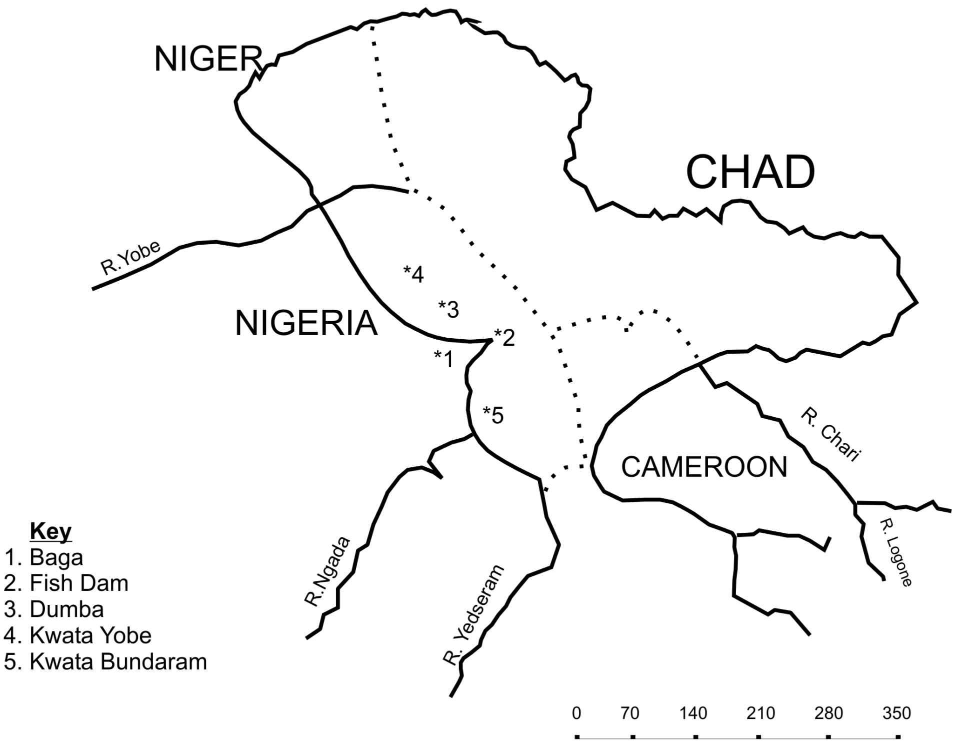

Fig. 3.1: Map showing location of sampling area in Lack Chad, at Baga Nigerian Portion
(***Source:*** *World Lake Database, 1983)*

Figure 1: Map of Lake Chad, NigerianSector Indicating Sampling Sites and Surrounding Regions (Source: World Lake Datbase, 1983)

STATISTICAL ANALYSIS

Mean heavy metal concentrations and standards deviations were used to explain the results.

RESULTS FOR HEAVY METALS IN SEDIMENTS

The mean heavy metal concentrations in Dumba and KwataYobe sediments ranged between 0.01 to 3.64 ± 0.13mg/kgCd; 66.07 ± 5.80 to 98.75 ± 0.25mg/kgCr; 19.35 ± 5.01 to 19.39 ± 3.03mg/kgCu; 44327.94 ± 8.80 to 80877.06 ± 10.12mg/kg Fe; 1167.12 ± 10.15 to 1247.06 ± 10.12mg/kg Mn; 31.42 ± 2.03 to 45.25 ± 4.77mg/kg Ni; 100.23 ±10.23 to126.83 ± 10.24mg/kg Pb; 101.13 ± 10.55 to 148.94 ±13.62mg/kg Zn and 674.90 ± 15.18 to 858.06 ± 20.06mg/kg As. Cd and Cr at Dumba, Fe at KwataYobe, Mn, Pb, Zn and As concentrations in both sites were highest. Cd at KwataYobe, Cu in both sites, Fe at Dumba, Ni concentrations in both sites were lowest when compared to the standard average shale as presented in Table1.

Table 1: Mean Concentration (mg/kg) of Heavy Metal in Sediments of Lake Chad, Nigerian Sector and their Average Shale.

Sampling Sites				Heavy	Metals(mg/kg)				
	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Zn	As
Dumba	3.64 ± 0.13	98.75 ± 0.25	19.39 ± 3.03	44327.94 ± 8.80	1167.12 ± 10.15	45.25 ± 4.77	126.83 ± 10.24	148.94 ± 13.62	674.90 ± 15.18
KwataYobe	0.01	66.07 ± 5.80	19.35 ± 5.01	80877.06 ± 10.12	1249.06 ± 10.12	31.42 ± 2.03	100.23 ± 10.23	101.13 ± 10.55	858.06 ± 20.06
Average Shale	0.3	90.00	45.00	46,000.00	850.00	68.00	20.00	95.00	13.00

Values are mean ± Standard Deviation Average Shale, World geochemical background Concentration

DISCUSSION

The results indicated that heavy metal pollution can be assessed with respect to average shale which was widely used (Harikumar*et al.,* 2009). In this study average shale was used as a standard in comparison of the mean concentration of heavy metals in the core sediments (Table 1) (Ong and Kamaruzzaman, 2009), which indicates that all the sites were heavily polluted with As and Pb. Fe was heavily polluted at KwataYobe and Cd at Dumba. Cr was moderately polluted at Dumba, while Mn at both sites. Cd and Cr at KwataYobe were unpolluted, and Fe at Dumba. Cu and Ni in both sites were unpolluted and Zn was moderately polluted in both sites. The high mean concentration of heavy metals in sediments can often be attributed to terrigenous input and anthropogenic influences. It can be a good indication of man-induced pollution (Mohammed, 2005).

Heavy metals are widespread and persistent in aquatic ecosystem, potentially toxic, and can be accumulated in food web. Industrial and agricultural activities and atmospheric deposition are some of the many way through which sediments are found to have been polluted(Tang*et al*, 2014a).Economic development and population growth also influence the distribution of heavy metals in the sediments; heavy metals in the sediments can accumulate relatively large amounts in aquatic organisms such as fish, resulting in a threat to human health (Tang*et al*, 2014b).

RESULTS FOR THE DEGREE OF POLLUTION IN SEDIMENTS

The degree of pollution in sediments can be assessed further by indices such as geo-accumulation. Igeo values was based on $C_{n,}$ the measured concentration of heavy metals in sediments using X-ray fluorescence to$B_{n,}$ the geochemical background concentration of the elements (average shale), that is the international standards of each elements of the background and 1.5 is the background matrix correction due to terrigeous effects. Igeo values have no units, it is a ratio. The average shale was presented in Table 2. The Igeo values of Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn and As varies between 0.007 to 1.55 Cd, 0.147 + 00.150 Cr, 0.086 Cu, 0.195 + 00.353 Fe, 0.293 to 0.630 Mn, 0.092 to 0.133 Ni, 1.002 to 1.275 Pb, 0.213 to 0.314 Zn and 10.411 to 13.200 As, and the results was presented in Table 2

Table 2: Sediments Geoaccumulation Index of the Heavy Metals from Lake Chad, Baga, Nigerian Sector.

Sampling Sites	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Zn	As
Dumba	1.55	0.150	0.086	0.195	0.630	0.133	1.275	0.314	10.411
KwataYobe	0.007	0.147	0.086	0.353	0.293	0.092	1.002	0.213	13.20
*Average Shale	0.30	90.00	45	46000	850	68	20	95	13

Average Shale, World geochemical background Concentration
Turekian and Wedepohl (1961)

DISCUSSION

The Igeo values of Cr, Cu, Fe, Mn, Ni and Zn in both sites fall in class 1, indicating unpolluted to moderately polluted sediments. Cd at Dumba and Pb in both sites are moderately polluted sediments. As in both sites are very heavily polluted sediments. The moderately and the very heavily polluted sediments are attributed principally to anthropogenic activities such as agricultural practices, industrial effluents, vehicular emission and terrigenous influx. These results suggest that a significant portion of the heavy metals originated from anthropogenic sources. The Igeo values give the advantage of not aggregating all the pollutants into one value and therefore treating each heavy metal independently, giving a good picture of the extent of individual heavy metal pollution.The assessment of natural background concentrations of each heavy metal is to provide the exact identification of anthropogenic sources.

CONCLUSION

The results of this study provide valuable information about some heavy metal concentrations in the sediments of Lake Chad, Nigerian Sector. The sediments in Dumba and KwataYobehave accumulated heavy metals from the surrounding environment. The Igeo values indicated widespread pollution by Pb and As.

Recommendations

I recommend that this research should be carried out on farm lands.

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