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RESEARCH ARTICLE

HEAVY METALS CONCENTRATIONS AND GEO-ACCUMULATION INDEX AS INDICATORS, LAKE POLLUTION IN THE SEDIMENTS OF LAKE CHAD, NIGERIAN SECTOR

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ABSTRACT

This study was carried out to investigate the concentrations of Cadmium (Cd), Chromium (Cr), Copper (Cu), Manganese (Mn), lead (Pb) and Zinc (Zn) and the geo-accumulation index (Igeo) of Cd, Cr, Cu, Mn, Pb and Zn in the sediments of Lake Chad, Nigerian sector. The aims of the study wasto determine the heavy metals pollution in the sediment of lake chad, Nigerian sector and (2) to evaluate the degree of heavy metals pollution of the lake using the Geoaccumulation index. The concertation of the heavy metals, were determined using energy disperse x-ray fluorescence (EDXRF). Sediments sample were obtained at Dumba1, Baga, Lake Chad, Nigerian sector. The results indicated that the concentration of heavy metals in mg/kg as Cd (2.62 $\pm$ 0.20 mg/kg), Cr (63.73 ± 0.25 mg/kg), Cu (19.49 ± 0.23mg/kg), Mn (1325.00± mg/kg), Pb (133.33 ± 5.23mg/kg) and Zn (195.20 ± 5.20mg/kg) and they were compared with standard, average shale to determine the pollution status of the lake. The results shows that the sediments of the lake have been polluted by Cd, Mn, Pb, and Zn. The geoaccumulation index (Igeo) values for Cd, Cr, Cu, Mn, Pb, and Zn varied between 0.09 to 1.75. The Igeo, 0.09 for Cu indicated unpolluted sediments, the Igco values for Cr, Mn, and Zn indicated unpolluted to moderately polluted, while Cd and Pb Igeo values indicated moderately polluted sediments quality.

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INTRODUCTION

Heavy metal is defined as a naturally occurring element having a high atomic weight and high density which is five times greater than that of water (Bantalvi 2011). Some of the most common heavy metals are Lead(Pb), Nickle (Ni), Chromium (Cr), Cadmium (Cd), Arsenic (As), Mercury (Hg), Zinc (Zn) and Copper (Cu). Heavy metals forms part of the most vital aquatic contamination due their ability to persist for a long time in the environment, toxicity and accumulation by sediments and aquatic organisms. Heavy metals are non-biodegradable, they are deposited, assimilated or incorporated in water, sediments and aquatic animals, and their presence in aquatic environment is expanding at a disturbing scale and is a vital problem globally (Abdel-baki *et al*., 2011). Heavy metals enter the aquatic environment via natural and anthropogenic sources. The natural sources are rock and soil weathering, volcanic eruptions, forest fire and wind-borne soil particles. The anthropogenic sources are industrial and domestic untreated waste discharge, mine discharge, sewage sludge, storm runoffs.

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The agricultural activities such as the application of fertilizers and pesticides and metallurgical processes also lead to the increased heavy metals to different environmental compartments (Vhahangwele and Khathutshelo, 2018). Sediments are basic and integral parts of the aquatic environment since they help to evaluate the entire assessment of heavy metals in water as well as aquatic biota (Aboud and Nandini, 2009). Sediments are mostly formed from surface soil erosion which may be made up of minerals and organic components. Sediments are very important sinks for diverse pollutants such as heavy metals (Wang *et al*., 2010). The pollution status of aquatic environment by heavy metals can be investigated by analyzing water sediments and organists of both freshwater and marine water (Mohamed *et al*., 2014). Sediment perform a vital role in heavy metals movement in the aquatic environments. They transport a meaningful dimension of numerous pollutants. They are also responsible for heavy metal uptake, storage, release and transfer between different environmental compartments. Sediment Geoaccumulation index (Igeo) is used to measure the intensity of heavy metals pollution and analyze specific metals that appear in various levels of concentration in lake or aquatic sediment. Simply put, sediment Igeo is the perceptible check of heavy metal pollution in aquatic sediments.

The aims of this study are:

- To determine the heavy metals pollution in the sediment of Lake Chad, Nigerian Sector and
- To evaluate the degree or the intensity of heavy metals pollution in the Lake sediment using the geoaccumulation index (Igeo).

MATERIAL AND METHODS

This study was carried out at Dumba1, Baga, Nigerian sector of Lake Chad. Baga is in Kukawa Local Government Area of Borno State.Baga lies on latitude $12^0$55'N. The majority of people in Baga are engaged in stock breeding, farming, and fishing. The sediments samples were obtained at Dumba1, Baga Lake Chad, Nigerian Sector.

Sediments sampling and Sample Preparation for Heavy Metals Analysis: About 1.00kg of sediments was collected using hand shovel because the Lake is Shallow. A minimum of 5 samples were collected at different directions of the sampling site, about 25 meters in all direction of the sampling site were collected randomly (Keith, 1991). The samples collected were placed in a polyecthlene bag and were transported to the laboratory for further analysis. The sample were air dried until a constant weight is obtained. It was then ground to powder with a mortar and pestle. The dried powdered sediments were piled into a cone and were cut into quarters (Krumbein and Pettijohn, 1938). Two alternate quarters were removed, and the remaining two were recombined, replied into a cone and quartered again. The cone and quartering was repeated until a desired mass of sample is achieved, a grains size less than 125µm. A quantity of 0.50g of powdered sediments sample was mixed with tree drops of liquid organic binders, polyvinylchloride (PVC) and was pressed with 10 tons hydraulic press to produce pellets of 19mm diameter.

A modified version of emission -transmission (E-T) method (Kump, 1994; Angeyo *et al*., 1998 and Funtua, 1999) was used to analyzed the heavy metals in the sample. The resulting pellets were used to analyze 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. Sediment Geoaccumulation index (Igeo). The geoaccumulation index was introduced by Muller (1969). Igeo is used to evaluate the anthropogenic impact and to get a measurable part of heavy metal pollution in aquatic sediment in the sampling site.

Igeo is calculated using Igeo = $\log_2$ Cn/1.5Bn

Where Cn is the measure of metal concentration in the sediment, Bn is the background concentration of the element (average shale concentration by Turekian and Wedepohl, 1961) and 1.5 is factor compensating background data (correction factor) due to the lithogenic effect.

Igeo involves a log function and as background multiplication of 1.5. The Igeo allocation or classification consists of seven classes (0 – 6) signifying diverse degrees of heavy metal enrichment above the average shale values ranging from unpolluted to very high polluted sediment quality. Igeo class 0 (Unpolluted): Igeo value = ≤ 0; Igeo class 1 (unpolluted to moderately polluted: Igeo value = 0 – 1; Igeo class 2 (moderately polluted): Igeo value = 1-2; Igeo class 3 (moderately to strongly polluted): Igeo value 2 -3; Igeo class 4 (strongly polluted): Igeo value = 3 – 4; Igeo class 5 (strongly to extremely polluted): Igeo value = 4 – 5; Igeo class 6 (extremely polluted): Igeo value › 6.

Table 1. Geoaccumulation Index (Igeo) Classes with respect to Sediment quality

Igeo value	IgeoClass	Sediment quality
0 – 0	0	Unpolluted
0 – 1	1	Unpolluted to moderately polluted
1 – 2	2	Moderately polluted
2 – 3	3	Moderately to strongly polluted
3 – 4	4	Strongly polluted
4 – 5	5	Strongly to extremely polluted
› 6	6	Extremely polluted

(Source: Muller, 1969).

Statistical Analysis: Mean heavy metal concentrations and standard deviations were used to explain the results

RESULTS

The Mean Heavy Metal concentration levels in sediment samples, the geoaccumulation index (Igeo) and the,standard, Average Shale are presented in Table 2. The mean heavy metal concentration in the Sediments from Dumba1, Baga Nigerian Sector of Lake Chad are as follows:

Cd (2.62± 0.20mg/kg), Cr (63.73± 0.25mg/kg), Cu(19.49±0.20mg/kg), Mn (1325.00±10.00mg/kg), Pb(133.33±5.23mg/kg) and Zn(195.20±5.20mg/kg).

Municipal and industrial wastes discharges, sewage sludge, exhaust from cars as well as agricultural activities like the application of fertilizers and pesticides, mine drainage and storm run offs, are some of the most important anthropogenic sources which doubtlessly increased heavy metal pollution indiverse environmental compartments (WHO, 2004). The order of heavy metal concentration levels in the sediment is Mn >Zn>Pb>Cr>Cu>Cd. Sediment Pollution Analysis: The Geoaccumulation index (Igeo). The igeo was defined by Muller (1969), it applied to obtain a quantitative measure of the metal pollution in aquatic sediments the Igeo values were calculated using Igeo = $\log_2$Cn/1.5Bn. The content accepted as background is multiplied each time by the constant 1.5 so as to take into consideration natural fluctuations of a given substance in the environment as well as very small anthropogenic influences. The results for Igeo in this study are presented in Table 2.

They are as follows: Cd (1.75), Cr (0.14), Cu(0.09), Mn (0.31), Pb (1.34) and Zn (0.41). The calculated Igeo values were compared to the classification for the geoaccumulation index to confirm the pollution intensities of the sediment quality.

Table 2. Mean Heavy Metals Concentration (Mg/kg) and Geoaccumulation Index in Sediments of Lake Chad, Nigerian Sector with Standard Average Shale

Heavy metal (Mg/kg)	Sediments in this study	Geoaccumulation index	Average shale
Cd	2.62±0.20	1.75	0.30
Cr	63.73±0.25	0.14	90.00
Cu	19.49±0.25	0.09	45.00
Mn	1325.00±10.00	0.31	850.00
Pb	133.33±5.23	1.34	20.00
Zn	195.20±5.20	0.41	95.00

Turekian and Wedepohl (1961) Average Shale; World Geochemical Background Concentrations

DISCUSSION

Heavy metal concentration in sediment: Sediments are among the large storage places of heavy metals in the water bodies. Lake sediments are usually the ultimate route of both natural and anthropogenic elements produced. Sediment quality is a good indicator of pollution in water column, since it can concentrate heavy metals and other organic pollutants. The result of heavy metals levels in the sediments of Lake Chad, Nigerian Sector in this study was compared with standard guidelines, the average shade Table 2. The concentration levels obtained for Cd, Mn, Pb and Zn in this study were found to be higher than the average shale for each of them, while the concentration levels for Cr and Cu were lower. The high concentration levels for Cd, Mn, Pb and Zn could be attributed to agricultural activities along the bank of the Lake by farmers who might have applied fertilizers and pesticides. It could also be as a result of domestic and industrial waste waters discharged along the course of the Lake.

The mean concentration of Cd in the sediment in this study was 2.62±0.20mg/kg. this value was found to be above the permissible limit by average shale. This can be harmful to benthic organisms in the environment. Cd is an aftermath of Zn and Pb Mining and smelting, and is highly movable in the water bodies than the rest of heavy metals. It is persistent in the environments and bioaccumulative and toxic. Cd enters the aquatic environments through paints on fishing boats, galvanized popes and through Ni – Cd batteries. The mean concentration of Zn in the sediments in this study is 195.20± 5.23mg/kg and it was found to be above the permissible limit by Average shale Table 2, this could be of inimical after effect on aquatic organism. Applications of fertilizers and pesticides in agriculture, smelting, soil erosion, land construction activities and fossil fuel are the main sources of Zn.80mg/kg of Zn is found in the earth's crust. It is an essential heavy metal that have enzymatic and regulatory roles in biological system. High levels of Zn is toxic in plants and animals.

The mean concentration of Pb in this study is 133.33±5.23mg/kg and it is above the standard average shale table 2. The high levels of Pb in the sediments in this study could be attributed to agricultural activities as well as spills from leaded petrol of fishing boats and dust which holds large quantity of lead from exhaust of vehicles. Lead is among the most settled heavy metals ever established to man and it is harmful or poisonous in nature. The mean concentration of Mn in the sediments in this study is 1325.00±10.00mg/kg and it is above the permissible limit by average shale Mn is chiefly introduced into the water body via industrial and domestic wastes discharges, sewage sludge, storm runoffs and through the application of fertilizers, fungicides, and also in improved livestock's products. This result of this study indicated that the sediments of the Lake is polluted by Cd, Mn, Pb and Zn, while Cr and Cu have polluted the sediment lightly. This result agrees with Jonathan (et al, 2016).

Geoaccumulation Index (Igeo): The Igeo of Cd in this study is 1.75 which falls in Igeo class 2, indicating moderately polluted sediment. The Igeo value for Pb in this study is 1.34 and it falls in Igeo class 2, indicating moderatelte polluted sediment of the lake. The Igeo values for Cu, Cr, Mn and Zn are 0.09, 0.14, 0.31 and 0.41 respectively and they all fall in Igeo class 1, indicating unpolluted to moderately polluted sediments. This moderately polluted sediments of the alke, may contribute toxicity in the lake. The moderately polluted sediment of the alke could be at tribute to the anthropogenic sources.

Conclusion

The sediments samples obtained from Dumba1 Baga, Nigerian sector of Lake Chad, consist of the following heavy metals Cd, Cr, Cu, Mn, Pbb and Zn. The mean heavy metal concentrations (Mg/kg) in the sediments are as follows: Cd (2.62±20mg/kg),Cr (63.73±0.25mg/kg)Cu (19.49±0.20mg/kg), Mn(1325.00±10.00mg/kg), Pb (133.33±5.23mg/kg) and Zn (195.20±5.20mg/kg). Average shale standard guideline was used to determine the pollution status of the lake. The sediments of the lake were polluted by Cd, Mn, Pb and Zn, all of them have concentrations levels above the permissible limit by average shale, while Cr and Cu concentration are below the permissible limit by average shale. The geoaccumulation index (Igeo) values shows that the sediments of the Lake is moderately polluted by Cd and Pb, while the Lake is unpolluted to moderately polluted by Cu, Cr, Mn and Zn.The sediment is not therefore polluted by Cr and Cu in this study. The high levels of Cd, Mn, Pb and Zn in the sediments of the lake could be attributed to the increased anthropogenic sources in the study area.

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REFERENCES

Abdel – Baki, A.S., Dkhil, M.A and Al-Quaraishy, S. 2011. Bioaccumulations of some heavy metals in Tilapia Fish relevant to their concentration in water and sediment of Wadi Hanitah, Saudi Arabia, African J. of Bioaccumulation 10 13: 2541 – 2547.

Aboud, S.J and Nandini, N. 2009. Heavy Metals Analysis and Sediment Quality Values in Urban Lakes.American J. of Environmental Sciences 56: 678 – 687.

Angeyo, K.H., Patel, P., Mangala, J.M and Naroya, D.G.S 1998. Optimization of X – Ray Fluorescence elemental analysiss an example from Kenya. Appi Road 1sot, 49:885 – 891.

Banfalvi, G 2011. Cellular Effects of Heavy Metals, Netherlands, London, New York, Springer, 2011.

Funtua, I.I. 1999. Application of the Transmission Emission Method in EDXRF or the Determination of Trace Element in Geological or Biological Materials, J. Trace Microsprobe Tech. 17:293 – 297.

Jonathan, B.Y., Maina, H.M and Maitera, O.N 2016 Heavy Metal Pollution Assessment in the sediments of Lake Chad Nigerian Sector. *Bayero J. of Pure and Applied Sciences*, 91: 213 – 216.

Keith, L.H. 1991. Environmental Sampling and Analysis: A practical guide Lewis Pubi, CRC Press Boca Raton, Florida 143.

Krumbein, W.C and Petijohn, F.J 1938. Manual of Sedimentary Petrology, Appelton Centuty Crofts Inc. New York 549.

Kump, P. 1996 Quantitative Analysis of Environmental Samples QAES. Instruction Manual, Ljubljana.

Mohamed, E.G., Hassan, I.F., Mohamed, H.A and Salem, G.S 2014. Metal Pollution Assessment in the Surface Sediment of Lake Nasser, Egypt. Egyptian J. of Aquatic Research 40: 213 – 224.

Muller, G 1969. Index of Geoaccumulation in Sediments of the Phine River Geo J. 23: 108 – 118.

Turekian, N.K and Wedepohl, K.H 1961. Distribution of the elements in some major units of the Earth’s Crust. Geo Society of American Bulletin, 72: 175 – 191.

Vhahangwele, M and Khathutshdo, L.M. 2018 Environmental Contamination by Heavy Metals. Intech Open 76082:115-133.

Wang, S., Jia, Y., Wang, S. Wang, Z., Wang, H., Zhao, Z and Liu, B 2010. Fractionation of Heavy Metals in Shallow Marine Sediments from Jinzhou Bay. China J. Environ Sci 221: 23 – 31.

World Health Organization 2004 Guidelines for Drinking Water Quality. 2rd Edition 516.

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