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Full Length Research Article

Heavy Metals Pollution Status of Sediments of Ahmadu Bello University Dam, Zaria-Nigeria

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ABSTRACT: Pollution status of the sediments of Ahmadu Bello University (ABU) dam, Zaria-Nigeria, was assessed. Twenty-four samples were collected from specified stations and analyzed for the concentrations of Ni, Pb, Cd, Co, and Cr, using Atomic Absorption Spectrometer. The concentrations of the analyzed heavy metals ranged between 1.162±0.006(A) and 49.878±0.685(K); 53.262±0.075(H) and 105.546±0.842(I); 2.427±0.001(F) and 3.343±0.002 (J); 1.083±0.006(A) and 0.100±0.002(H); 7.572±0.042(E)) and 27.222±0.053 mg/kg (K), respectively. All values were below the permissible limits declared by World Health Organization (WHO) (2006). Pollution load index (PLI) and geo-accumulation index (I-geo) were employed to assess the pollution status of the dam across the sampling stations. The PLI values obtained across the sampling stations ranged between 5.94×10^{-7} (A)and8.19×10^{-5} (K).The I-geo found for the concentrations of Ni, Pb, Cd, Co and Cr in the sediments ranged between -6.597(A) and -1.173(K); -3.564(H) and -2.2.577(I); -5.715(F) and -5.297(L); -5.893(D & E) and - 4.047(J) respectively. Results obtained indicate that none of the sampling stations was polluted. The data obtained was subjected to statistical analysis (ANOVA) and P values > 0.05 obtained for the analyzed metals indicate that there were no significant differences in the concentrations of the analyzed metals across the sampling points
Keywords: ABU dam, Sediments, Heavy metals, Pollution index (PLI), Geo-accumulation index (I-geo)

INTRODUCTION

Pollution of the natural environment is a major concern all over the world. Naturally, heavy metals find their way into the aquatic system through run-offs and geologic processes of leaching, weathering, erosion and anthropogenic activities (Butu *et al.,* 2013). The release of trace metals into the water body and consequently fish will depend on the chemical fractionation of metals a d othrr factors such as sediment pH, the physical and chemical charscteristics of the aquatic system (Morgan and Stumm, 1991; Uzairu et al., 2009). Heavy metals in the dam environment tend to settle down to the bottom of the water and consequently trapped within the dam sediment by processes of adsorption, flocculation and co-precipitation, (Barakat *et al.,* 2012). Sediments in aquatic environments, therefore, serve as a pool that can retain metals or release metals to the water column by various processes of remobilization (Caccia *et al*., 2003; Marchand *et al.,* 2006). Sediments act as non point source of pollution and have the potential to release the sediment-bound metals and other pollutants to overlying waters and in turn adversely affect aquatic organisms (Wang, et al., 2012).

The contamination levels of the aquatic environment by heavy metals can be estimated by analysing water, sediments and marine organisms (El Nemr et al., 2012). Analysis of sediments samples in aquatic environments, therefore, provides a basis for the assessment of the pollution status of the aquatic environment.

Variety of methods have been adopted for the risk assessment of heavy metals in sediments, these include; index of geological accumulation, pollution load index and enrichment factor (Tessier et al., 1996; Ali and Dzombak, 1996).

The geo-accumulation index (I-geo) was proposed by Muller (1986) to assess heavy metal contamination of sediments and it builds on the background level of natural fluctuations including very low anthropogenic input (Muller 1986). I-geo is a powerful tool in the assessment of pollution levels of dams and rivers (Rabee *et al.,* 2011).
Geoaccumulation index (1-geo) is classified into seven grades as could be observed in the Table 1.

Table 1: Terminologies for pollution classes on single and integrated indices

CF classes		I-geo classes			PLI	
CF Value	Pollution	I-geo	class	Pollution	PLI	Pollution
CF <1	Low	<1	0	unpolluted	0	Perfection
1 ≤CF≥3	Moderated	0-1	1	Unpolluted to moderated	< 1	Base levels
3 ≤CF≥6	Considerable	1-2	2	Moderated	> 1	polluted
CF>6	Very high	2-3	3	Moderated to highly		
		3-4	4	Highly		
		4-5	5	Highly to extremely		
		5-6	>5	Extremely		

Retrieved from the work of **Mohamed et al., 2014**, Egyptian J. Aquatic Research, 40, 213 -224.

Pollution load index (PLI) is a pollution evaluation method developed by Tomlinson *et al.*(1980). PLI provides simple but comparative means for assessing a site quality for levels of pollutants present.PLI < 1 denotes no pollution; whereas PLI > 1 denotes pollution.

The PLI is aimed at providing a measure of the degree of overall contamination at a sampling site. The objective of this work was to calculate and apply PLI and I-geo in the establishment of the recent environmental conditions of Ahmadu Bello University Dam which shall form a basis for its monitoring in order to advice relevant authorities on regulatory enforcement of action plan to protect the Dam from further degradation. Results obtained in the study shall be a useful tool for safety assessment of human health of the population that depends on the Dam for their domestic and other use.

The heightened human activities such as industrial, agricultural and domestic waste generation within the ABU, Zaria community poses a challenge to the possible pollution of the University Dam. This underscores the relevance of this research.

Description of study area

The Ahmadu Bello University Dam is the major source of water supply to the University and other neighboring villages. Basically, the Dam was constructed to meet the water needs of ABU, Zaria community.

The metal pollutants of the Dam and their sources are traceable to refuse dumps, farmlands, public drains and effluents which showed higher level of concentrations in the Dam than the ones that are gradually released from the soil regolith system (Butu and Ati, 2013). Since human activities around ABU, Zariado not seem to abate but rather increase, the Dam is under the threat of being gradually polluted.

The ABU, Zaria Dam is situated on Latitude: 11°8'3.18" and Longitude: 7°39'15.67".It has a length of 800 meters and a concrete section of 10.36 meters above the river bed (Ologe, 1973). The Dam has an average depth of 6 meters, its water level during the wet season is 644.1 meters (Adekole and Abulude, 2012).

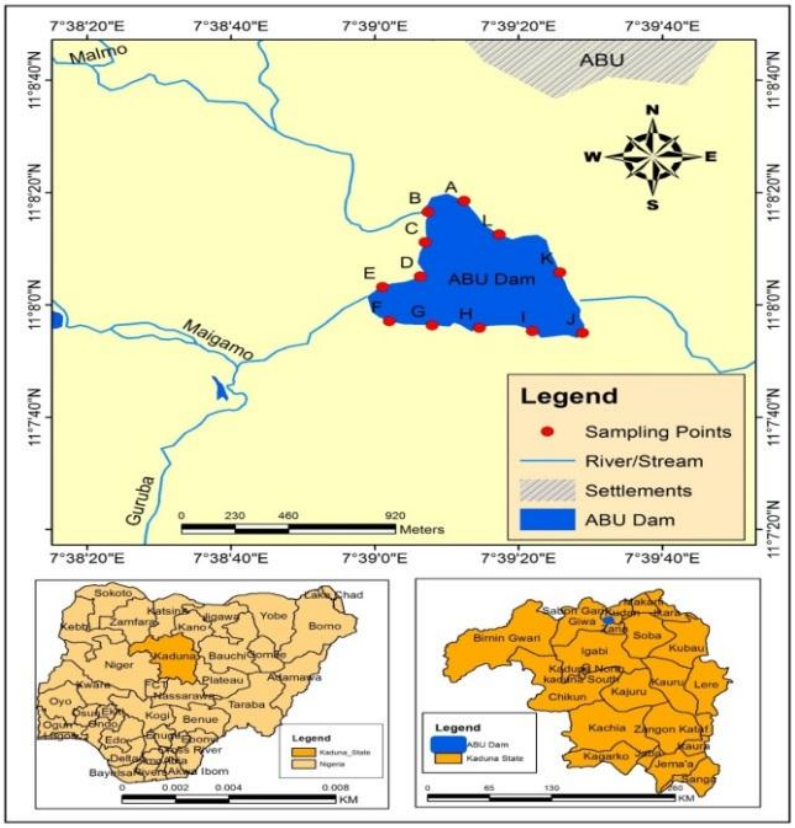

Figure 1: Map Showing the Location of Ahmadu BelloUniversity Dam and Sampling Points

MATERIALS AND METHODS

Twenty four sediment samples were collected during the dry season across the twelve sampling points as indicated in the map, two samples from each sampling location using standard analytical method during the dry season. The collected samples at each point was placed in air tight clean polythene bags, labeled and transferred to the laboratory. The individual samples were air dried at room temperature and grinded with clean ceramic Teflon pestle and mortar and reserved for wet digestion. The ground samples were digested according to the method described by American Public Health Association (APHA, 1989).

The heavy metal contents of the digests were determined using atomic absorption spectrophotometer, (Varian AA 240 FS, USA) in the Multi-User science Research Laboratory of the Chemistry Department, Ahmadu Bello University, Zaria. Working standard solutions of cadmium, lead, chromium, cobalt and nickel were prepared. This was done by diluting a stock solution containing 1000µg of single element AAS grade standard of each element with de-ionized water. In each case (cadmium, lead, chromium, cobalt and nickel), a set of standards solutions ranging from 0.5µg to 10µg as applicable was prepared from the corresponding 1000µg of stock by serial dilution. Each set of standards was analyzed with AA240FS atomic absorption spectrophotometer (AAS) to obtain a calibration curve. The digested samples in each case were subsequently analyzed with the AAS.

The Pollution Load Index (PLI) and Geo-accumulation (I-geo) Index of the sample stations were determined according to the relation:

$PLI = \sqrt[n]{(CF1 \times CF2 \times CF3x \ldots xCFn)}$ ..... (1)

Where,

CF = C metal / C background value, CF = C metal / C background value, CF = contamination factor,

n = number of metals, C metal = metal concentration in polluted water, Cb = background value of that metal as reported in Allen, 1974.

$I\text{-geo} = \log 2 (Cn / 1.5 Bn)$ .....(2)

where,

Cn = Measured concentration of heavy metal in the water, Bn = Geochemical background value as reported in Allen,1974.

Statistical Analysis of results

Analysis of variance (ANOVA) for sediment samples were performed at 95% (P = 0.05) on the data obtained using the Statistical Package for the Social Sciences (SPSS).

RESULTS

Figure 1, shows the mean concentration of Ni, Pb, Cd, Co, and Cr in sediments from ABU dam. The concentrations of Ni and Pb across the sampling points were in the ranges of 1.162 ±0.006mg/L (1) to 49.878 ±0.685mg/L (11) and 53.262 ±0.075mg/L (8) to 105.546 ±0.842mg/L (9), respectively. Similarly, the concentration ranges of Cd, Co and Cr were 2.427 ±0.001 (6) to 3.343 ± 0.002 mg/L (10), BDL (5,9,10,11,12) to 1.683 ±0.008mg/L (6) and 7.572 ± 0.078 (5,6) to 27.222 ±0.053mg/L (11) respectively. Geo – accumulation index (I - geo) for Ni, Pb, Cd, Co and Cr for heavy metals in sediments of A.B.U dam were calculated.

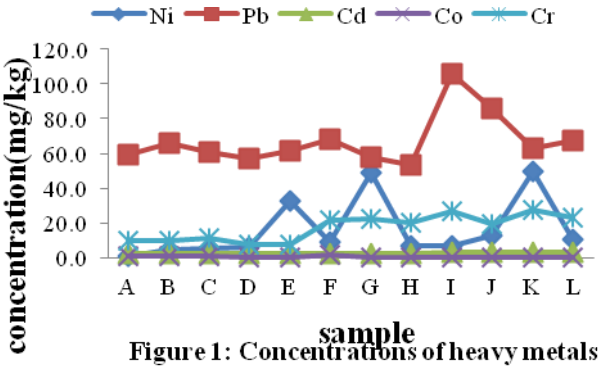

Figure 1: Concentrations of heavy metals in sediment samples of Ahmadu Bello University, Dam

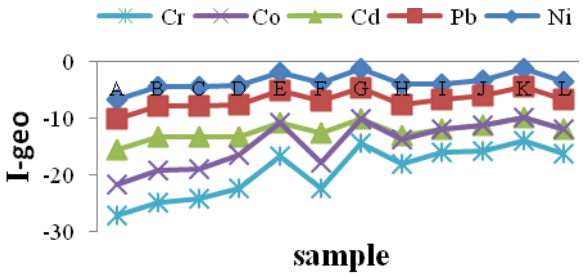

Figure 2: Geo-accumulation indices of sediments across the sampling points

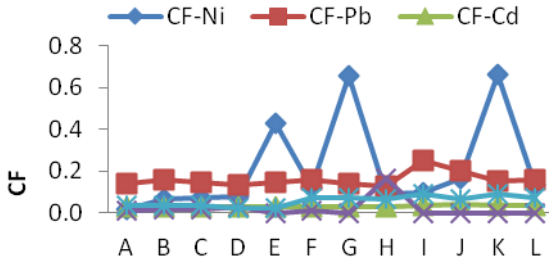

Figure 3: Contamination factors (CF) of the analysed heavy metals across the sampling points.

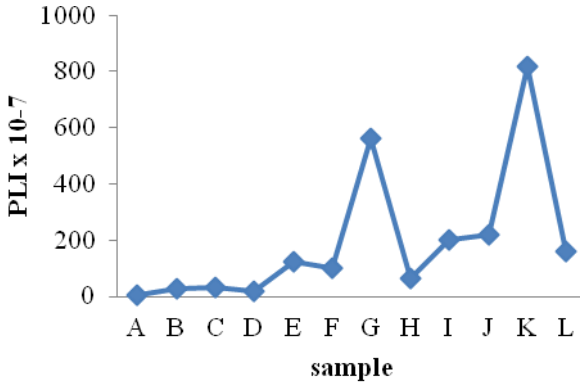

Figure 4: Pollution load indices (PLI) of heavy metals across the sampling points

The results as shown in Figure 2 indicate that the geo-accumulation Range of Ni was – 6.597 (A) to – 1.134 (K) while the geo-accumulation range of Pb, Cd and Cr were -3.564 (H) to – 2.578 (I), -5.715 (F) to 5.253 (J) and -5.893 (D) to 4.058 (I) respectively.

Figure 3 shows the contamination factor (CF) and pollution load index (PLI) for the analyzed heavy metals in sediments from A.B.U dam. The contamination factor (CF) for Ni ranges from 0.015 (A) to 0.665 (K). While those of Pb and Cd ranges from 0.127 (H) to 0.251 (I); 0.0297 (D), to 0.039 (J) respectively. The CF range of Co was 0096 (F) to 0.0305 (D) across the sampling points. The CF for Cr across the sampling points ranges from 0.025 (D,E) to 0.091 (K) The highest CF value was recorded for Ni in sample station A, while the lowest CF value was recorded for the same Ni in sample station A. The maximum PLI value of 8.189×10^{-5} was recorded at sample station K whereas the minimum value of 5.940×10^{-7} was recorded at sample station A as presented in the Figure 4.

DISCUSSION

The mean concentrations of Ni, Pb, Cd and Cr obtained across the sampling points for ABU Dam sediments are below the WHO, 2001 permissible limits of 75, 420,85 and 300mg/L respectively. These results suggest that the sediments samples across the sites studied were not polluted. The concentration of the Cr recorded in this work compares favorably with the results obtained by Butu and Ati (2013). In their work, the concentration of Cr ranged from 14 - 28mg/L. The range of Ni concentration was lowest at sample station 1(entry point of effluent) and highest at sample station 11. The values obtained at sample points further away from the entry point were higher. These unexpected variations could be attributed to the water current/velocity as it enters the dam and sweeps its load across station 1 to the rest part of the dam before settling to the bottom.

The same trend as in Ni was observed for Pb, Cd and Cr. The concentrations of these metals were low at the entry point and highest at sample stations 9 to 12. Again, this was as the consequence of the water current/velocity as explained for Ni above.

The source of the Cr detected in the sediment samples could possibly come from the gradual release of this metal through the soil regolith system and drained into the Dam through base or subsurface flow. Another possible source could be from leather tanning processes of the Nigeria Institute of Leather and Science Technology (NILEST), Zaria-Nigeria whose waste also flows down into the ABU dam. Again, chromium electroplated materials generated in the busy and populated area of ABU main campus and the Samaru urban settlement could be another possible sources.

The geo-accumulation indexes (I-geo) for heavy metals are less than zero (I-geo < 0). This indicates that the sediments of the sampled stations of ABU, Zaria Dam were not polluted that is the analyzed elements are unchanged by anthropogenic influences. Comparatively, the I-geo values obtained for sediment samples in this work were similar to those obtained by Rabee *et al.* (2011). All values for both research work were below zero indicating a condition of no pollution.

Contamination Factor (CF) and Pollution Load Index (PLI) for heavy metals in ABU Dam (Sediment) across the sampling points was calculated and results shown in Figure 3. The values equally reflected that the sediments of ABU dam were not polluted for the fact that all the values for Ni, Pb, Cd, Co and Cr were less than One (1). The PLI and 1- geo values for sediments obtained in this work were compared with the work of Rabee *et al.,* (2011). The results significantly agree with each other. In Rabees work, the I-geo for Ni, Pb, and Cd were -2.14; -2.12; -0,11 respectively.

CONCLUSION

Geo-accumulation (1-geo) and pollution load indices (PLI) were employed in the study of the pollution status of the sediments from 12 sampling sites of the Ahmadu Bello University Dam, Zaria. Results shows that none of the sample site was polluted as the mean concentrations of the heavy metals were lower than the WHO permissible limits. Similarly, the I-geo values obtained were compared with the standard of the published work of Rabee et al., (2011) and were found to be less than zero (I-geo<0) and the PLI values also were less than one (PLI< 1) further confirmation that the sediment of the Dam was not polluted.

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