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A Study on the Pollution Status of Akata Lake Sediments, Katsina-Ala Benue State, Nigeria

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Abstract: Heavy metals accumulation in biological system are by inhalation of contaminated air, intake of contaminated food or drinking water has been considered to be an ecological menace to man and other organisms. This study was carried out to ascertain the pollution status of Cr, Pb, Zn, Cu and Cd in sediment of Akata Lake, Katsina- Ala Benue State, Nigeria. Sediment samples were collected, digested using 30% H_2O_2 followed by 0.5M HCl and the metal concentrations were determined with Varian AA240 Atomic absorption spectrophotometer equipped with Zeeman's background correction (Varian, New Jersey, USA). The mean level of the heavy metals, Pb, Zn, Cu, Cd and Cr are 31.05, 2.72, 19.22 and 0.88 mg/kg while the concentration of Cr was below the detection limit of the instrument. The values obtained were compared with the established soil and sediment standard by World Health Organization (WHO). The contamination factors value for Zn, Cu and Cd are <1 while that of Pb is >1, hence it shows that the sediment is polluted by lead. The pollution load index (PLI) and Geo-accumulation index (Igeo) levels for Cr, Zn, Cu, Cd heavy metals in sample A - E were less than 1 except for Pb which is >1, this show that, the sediment were polluted with Pb.

Keywords: Pollution, Heavy Metals, Sediment, Concentrations, Environment.

1. Introduction

Heavy metals are metals whose densities are five times more than that of water. They occurred in nature from land-dwelling environs, rocks, plants, top soil and dregs. Anthropogenic activities has upsurge the metals concentrations in the environments which has led to the pollution of the environment [1].

Conversely, heavy metals pollution of top soil, water, atmosphere and sediments can cause serious health defect on biotic system [2]. Due to the increase demand of industrial products by man, the production of different chemical compounds has led to the released of some undesirable pollutants which are detrimental to food chain [3].

The sediment geological and chemical features in a municipal are not influence by the levels of pollution types, but also on time-span of development, modernization and meager farming rehearses. The high level of heavy metals in the environs are mostly found in the developed nations, while the low level are predominantly in developing nations (e.g. South America). Hence, the risk of heavy metals effluence depend on the upsurges in advance and community economics undertakings, [4].

Increased industrial activities has led to heavy metals pollution today, and their rates of utilization and carriage in the ecosystem have significantly enhanced in the meantime [5]. Metal absorptions above normal levels disturb the biological equilibrium of soils and can decrease their potency [6]. Heavy metals producing from varied conservational activities are conveyed through different means predominantly, overflow water to marine environments where they are eventually dumped. The heavy metals thus deposited are used up by different type of organisms present in that environment. Bioaccumulation of toxic heavy metals in aquatic organisms may have antagonistic influence on food chain [7].

The toxicity, tenacity of heavy metals and their potential to bioaccumulate present a serious challenging of conservational effluence [8–10]. However, miniature is identified in respects to the effect of potential hazard due to heavy metals pollution in the lowest sediments.

The parameters used to describe heavy metal effluence of sediments encompassed pollution load index (PLI) and geoaccumulation index (Igeo). However, these parameters enable the assessment and characterization of pollution status [11-14]. In this paper, we assessed the pollution site using the following parameters; contamination factor (CF), pollution load index (PLI), geoaccumulation index (Igeo). The aim of this work was to assess the concentration of heavy metals in Akata lake sediments Katsina-ala, hence determine their pollution status.

2. Methodology

Study Area Akata Lake is situated in a geo-political entity called Katsina- Ala Local Government Area located at longitude 7° 9.77" N and longitude 9° 17 4.74"E. Katsina-ala Local Government is situated at the eastern part of Benue State in North Central of Nigeria. The Local Government lies between latitude 5° 31` N to 50 45` N and longitude 7° 34` E and 7° 67` E of the Greenwich meridian. Katsina-ala Local Government is about 5704 km² (2556 sq. m). The Council area lies in the Guinea Grassland flora while the eastern part consisting of surging hills with flowering shrub. Yearly rain ranges between 159 mm to 180 mm, projecting topographical structures in the area are River Katsina – Ala and the Harga Hills of igneous rock origin.

2.1. Sampling

Sediment samples were collected manually with perforated hand trowel at the site where the water tide is low. A total of 25 samples locations were mapped out for sampling and was subdivided into 5 units at a distance of 200 meters from each other, and samples were collected randomly from each of the 5 units in the lake and packed into a polythene bag labelled A, B, C, D and E. The samples were sealed and transferred to the laboratory.

2.2 Samples Pre-treatment.

2.2.1 Drying

Sediment samples were room-dried on laboratory trays for three days and subsequently kept in an oven at 65°C for six hours for removal of water contents associated with the sediments.

2.2.2 Grinding/Sieving

The dried sediments were crushed into fine powder and homogenized using an acid-washed clean agate mortar and pestle. Dried sediment samples were sieved with 125μm nonmetallic sieve and kept for further analysis.

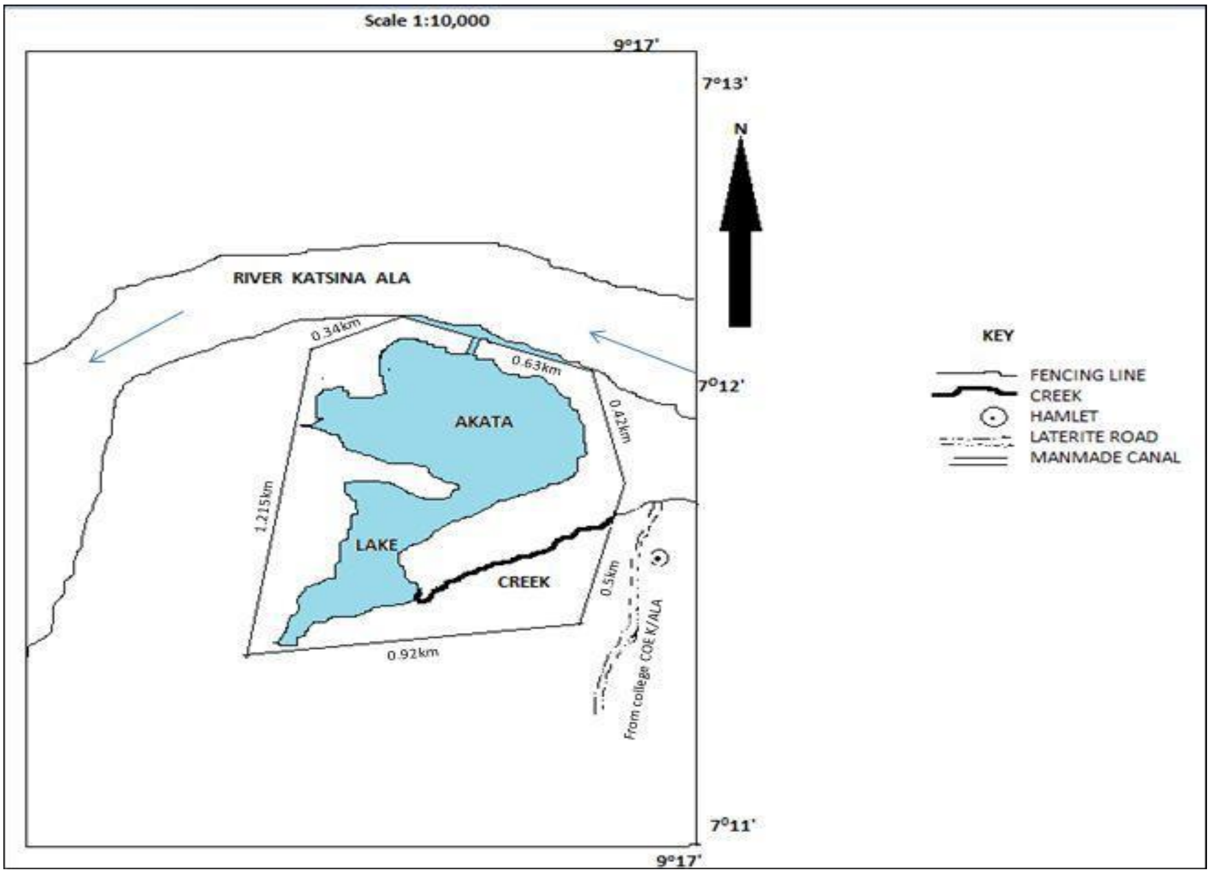

Figure 1 Map of Lake Akata Source: Ministry of Agriculture and Natural Resources, Makurdi, Benue State.

2.2.3 Digestion of Sample

5g sieved sample were placed into a 100 mL Pyrex beaker. 3 mL of 30% H_2O_2 was added to dissolve any organic matter. This was left to stand for 60 minutes and then extracted with 75 mL of 0.5M solution of HCl, and then the content was heated at low temperature (90˚C) on hot plate for about 2 hours. The digest was then filtered into 50 mL standard flask. The beaker was then rinsed with small portions of deionized water and then filtered into the flask [15].

3. Results and Discussion

3.1 Determination of Heavy Metal Concentration

The heavy metals studied in this work include chromium (Cr), cadmium (Cd), lead (Pb), copper (Cu) and zinc (Zn). The difference in the mean values of their absorption and assessment with reference standards of World Health Organization is shown in Table 1 below.

The mean concentration of heavy metals in sample A ranged from 0.77 to 31.28 mg/kg. The concentration of Pb was high while Zn has the least concentration. The mean concentration of the heavy metal increases in the Pb> Cu> Cd> Zn. In sample B, the concentration ranged from 0.83 to 59.02 mg/kg and the highest concentration was observed in Pb (59.02 mg/kg), while Cd has the lowest concentration (0.83 mg/kg). The mean concentration of the heavy metal upsurges in the order: Pb> Cu> Zn > Cd.

The mean concentration of heavy metals in sample C ranged from 0.78 to 18.94 mg/kg as showed in table 1. The mean concentration of the heavy metal increases in the Cu> Cd> Zn, Pb was not detected and Cu has the highest concentration level.

The concentration of heavy metals in sample D and E ranged from 133.6 to 33.64 mg/kg. The highest value was observed in Pb and the lowest one was that of Cd. The mean concentration of the heavy metal increases in the Pb> Cu> Zn>Cd.

However, the very high concentration of Pb, Cu and Zn in the study area could be as a result of mining activity, dissolution of rock or sulphide minerals along the upper Benue trough and sediment as ultimate sink for heavy metals [16, 17]. However, in this study, mean concentration of Pb was 311.2 mg/kg which is three times greater in magnitude than in upper continental crusts and WHO threshold limit [18] and also closer in magnitude to EU regulation commission safe limits in sediments [19]. This indicates high level of Pb in the lake. Lead gets accumulates in plants and animals through water and aquatic organisms which passes across to humans especially children [20]. In humans, Pb has been reported to cause brain and kidney problems [21]. Comparing the mean concentration of the heavy metals investigated in sample A to E with WHO standard showed that, the level of Zn, Cu and Cd in Akata lake sediment are within the WHO permissible limit while Pb is above the WHO threshold limit [22, 23] Cr was not detected.

3.2 Contamination factor

The contamination factor (CF) for sample A to E are showed in Table 2 below. The pollution standards based on contamination factor was proposed by Foley *et al*., [24]. The present study indicate that, the CF standards for the heavy metals in sample A, B, C, D and E varied from (0.005 - 2.234), (0.015 - 4.216), (0.005 - 0.743), (0.044 - 2.403) and (0.013 - 2.236) respectively.

According to Omotoso and Ojo [25], sample A, D and E were moderately contaminated with Pb while sample B is highly contaminated with Pb.

Table 1 Mean Concentration (mg/kg) of Heavy Metals

SAMPLES	HEAVY METALS				
	Cr	Pb	Zn	Cu	Cd
A	ND	311.2±8.9.12	0.770±0.002	16.81±0.900	1.120±0.100
B	ND	259.0±34.10	2.420±0.060	19.12±0.090	0.780±0.010
C	ND	ND	0.810±0.050	18.94±0.088	0.780±0.005
D	ND	133.6±32.90	7.370±0.100	20.72±1.100	0.830±0.002
E	ND	131.3±23.67	2.230±0.070	20.52±1.000	0.870±0.150
WHO	5.000	100.0	300.0	100.0	3.0

Table 2 Contamination factor (CF) for the heavy metals of Akata lake

SAMPLES	HEAVY METALS				
	Cr	Pb	Zn	Cu	Cd
A	ND	2.230	0.005	0.659	0.269
B	ND	4.220	0.015	0.749	0.199
C	ND	ND	0.005	0.743	0.187
D	ND	2.400	0.004	0.813	0.187
E	ND	2.240	0.001	0.805	0.209

Table 3 Geo-accumulation indices (Igeo) of heavy metals of Akata lake

SAMPLES	HEAVY METALS				
	Cr	Pb	Zn	Cu	Cd
A	ND	1.448	0.001	0.132	0.054
B	ND	1.846	0.003	0.151	0.039
C	ND	ND	0.001	0.149	0.038
D	ND	1.482	0.009	0.163	0.038
E	ND	1.449	0.003	0.162	0.042

Table 4. Values for metal Pollution load index (PLI) of Akata Lake

SAMPLES	PLI
A	1.083
B	1.394
C	0.032
D	1.016
E	0.347

3.3 Geo-accumulation index of heavy metals.

The Igeo values for sample A to E are presented in Table 3 below. The geo-accumulation obtained from this study is compared with Muller's classification for geo-accumulation index for ascertain the metals status [26].

The present study indicates that, the Igeo standards for the heavy metals in sample A, B, C, D and E varied from (0.001 - 1.448), (0.003 - 1.846), (0.001 - 1.149), (0.001 - 1482) and (0.003 - 1.449) respectively. The Igeo values decreased in the order Pb>Cu>Cd>Zn for sample A, B, D and E. In sample C, Pb was not detected and Igeo values upsurges in the order: Cu>Cd>Zn. The Igeo values for all the heavy metals in sample A - E showed that, the sites are slightly contaminated with Pb only according to Muller's classification [26].

3.4 Pollution load index (PLI)

The values of pollution load index is shown in Table 4. The PLI values decreased as follows B>E>A>C>D. If PLI value is > 1 it indicates pollution while PLI value < 1 means no pollution.

The results obtained in this work showed that the PLI of sample A-E varied from 0.016 to 0.394. The utmost pollution load index was recorded in sample B and the lowest value was observed in sample D. According to Onjefu *et al.,* [27], the pollution load index for this study showed that, the sediments of Akata Lake was slightly polluted.

4. Conclusions

The pollution status of heavy metal (Pb, Cd, Zn, Cu, and Cr) in Akata lake sediments were determined in five sampling sites. The concentrations level of studied heavy metals follows the order: Pb > Cu > Zn > Cd for sample B, D and E. Pb > Cu > Cd > Zn for sample A while Cu > Zn > Cd for sample C.

According to sediment quality guidelines, Akata lake sediment was found to be unpolluted. According to CF, Pb is moderately polluted while Cd, Zn, Cu have level of contamination. The Igeo values indicates that Akata lake sediments quality was unpolluted for all the heavy metals.

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Conflict of interest

The authors have no conflicts of interest to declare that they are relevant to the content of this article.

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