Geochemical Assessment of Anthropogenic Influence on Pollution Status of Cobalt, Chromium, and Copper in Sediments of some Rivers in Lokoja, Kogi State, Nigeria.

Patricia A. Ekwumemgbo, Ph.D.*[1]; Israel K. Omoniyi, Ph.D.[1]; and B. Isuwa, PGD[2]

[1]Department of Chemistry, Faculty of Science, Ahmadu Bello University, Zaria, Nigeria.
[2]Department of Crop Protection, Ahmadu Bello University, Zaria, Nigeria.

E-mail: pat_adamma@yahoo.com

ABSTRACT

River flooding in 2012 displaced hundreds of people in Nigeria and submerged several kilometers of land. Although, this incidence was predicted, no positive action was taken to avert the menace. This study assessed the pollution status of sediments of River Niger (RN), River Benue (RB), and after Confluence Point (CP) in Lokoja, Nigeria with respect to Co, Cr, and Cu concentration levels using Pollution Load Index [PLI] and Geoaccumulation Index [I_{geo}] after the 2012 flood.

Sediment samples were collected quarterly, digested with acid mixture and elemental quantification carried out using Atomic Absorption Spectrophotometer. Results showed significant difference in the concentrations of these metals in sediments of the three studied sites. The PLI of all the samples studied indicated low (0-1) to moderate degree of pollution (1-2) while I_{geo} study also indicated low to moderate degree of pollution ($0 < I_{geo} < 1$) of some of the samples. These results suggest that pollutants from anthropogenic activities within the metropolis might have probably been leached into the rivers by the flood. Authors recommend control of flooding of these Rivers to prevent leaching of pollutants from anthropogenic sources into these rivers.

(Keywords: river sediment, heavy metals, pollution, anthropogenic, River Niger, River Benue, Confluence Point)

INTRODUCTION

Extreme environmental events such as cyclones, floods, droughts, and heavy precipitation have caused havoc to lives and properties in recent years. The potential consequences of these events are profound, particularly on people in less developed countries. Research and development, workshops, conferences, seminars have focused on these global phenomena with the intention of seeking permanently solution to these environmental menaces. The concern is that the world may be getting close to extinction through natural disasters unless immediate actions are taken; and the signs are just too apparent to be ignored.

Flooding is an unusual high rate of discharging of water from a water body, which often leads to inundation of land adjacent to that water body usually caused by intense or prolonged rainfall [1]. It was defined as a natural hazard which occurs as an extreme hydrological (runoff) event and as a large amount of water covering an area that was usually dry [2]. It is a natural consequence of stream flow in a continually changing environment and occur when a body of water moves over and above an area of land which is not normally submerged and it could also be seen as the inundation of an area not normally covered with water, through a temporary rise in level of stream, river, lake or sea.

Floods are among the most devastating natural disasters in the world [3]. There is a clear nexus between environmental degradation and natural disasters in many regions of the world and countries that suffer most from disasters are also those in which environmental degradation is proceeding most rapidly. The flood menace in Nigeria has become a normal and reoccurring phenomenon. Some of the likely causes of this problem apart from the extreme environmental events are rapid population growth [4], urbanization, lack of good governance, poor drainage facilities, decaying infrastructures, lack of proper environmental planning and management strategies, poor practice of dumping

waste/refuse, coupled with inadequate preparedness. The resultant effects are wide spread of diseases, loss of thousands of lives and destruction of properties.

During flooding, environmental components including anthropogenic fraction of street/road deposited sediments (RDS/SDS) [5] which contains various chemical constituents heavy metals inclusive [6,7], fluvial suspended sediments [8] originating from human related activities [9,10] are leached into the water bodies and some of them settle on the sediments thereby altering the natural composition of the sediment.

Humans require varying amounts of some heavy metals for instance iron, cobalt, copper, manganese, molybdenum, and zinc. All metals are toxic at higher concentrations. Excessive levels could be detrimental to health. Other heavy metals such as mercury, arsenic, cadmium and lead are toxic and have no known vital or beneficial effects on organisms and their accumulation over time in the bodies of animals could have detrimental effect [11-14]. The accumulation and toxicity of heavy metals in the environmental samples represents a serious threat to plants, animals, and humans [15, 16], therefore posing a potential risk to human health [17], due to the transfer of these metals to aquatic media, their uptake by plants and their subsequent introduction into the food chain [18].

Analysis of river sediment is a useful method of studying environmental pollution with respect to heavy metals. Heavy metals accumulate in the sediment by means of complex physical and chemical adsorption mechanisms depending on the nature of the sediment matrix and the properties of the adsorbed compounds [19]. The occurrence of elevated concentrations of heavy metals in sediments found at the bottom of the water column can be a good indicator of man induced pollution rather than natural enrichment of the sediment by geological weathering [20].

The assessment of sediment enrichment with metals can be carried out in many ways. The most common is the use of Pollution Load Index (PLI) and Geoaccumulation Index (Igeo) [21-23]. An interesting example of calculation of pollution load indices was published [24] and represents the number of times by which the heavy metal concentrations in the sediment exceeds the background concentration, and gives a summative indication of the overall level of heavy metal toxicity in a particular sample.

This research stems from the fact that in 2011 and 2012 the worst incidence of flooding in Nigeria occurred with a lot of reported unempirical cases indicating how flood menace ravaged affected states of the country. However, some empirical reports are available on environmental samples from river Niger, Benue and after Confluence Point in Lokoja, Kogi State, Nigeria. For instance evaluation of the quality of water at the bank of River Niger in the confluence town of Lokoja used for irrigation of Sarki-Noma Fadama Farm [25]; determination of some selected heavy metals in Inland Fresh Water of lower River Niger drainage [26] and rare earth elements fingerprints: implication for provenance, tectonic and depositional settings of clastic sediments of lower Benue Trough, Southeastern Nigeria [27] and Pollution Load and Geoaccumulation indexes assessment of cadmium, lead and zinc pollution in sediments of River Niger, Benue and after Confluence point in Lokoja, Kogi State, Nigeria [28].

This article presents the data on the assessment of cobalt, chromium and copper in sediment of River Niger (RN), River Benue (RB) and after Confluence Point (CP) after the 2012 flood for a period of one year on quarterly bases using Pollution Load Index and Geoaccumulation Index.

MATERIALS AND METHODS

The Study Location

The study was conducted in Nigeria located geographically in the West African sub-region between latitude 4 ˚9'N to 13 ˚46'N and longitude 3 ˚45'E to 16 ˚54'E bordering the North Atlantic Ocean between Benin Republic and Cameroun. It covers a total area of about 923,770 km^2 and its total land mass is about 910,770 km^2 and water bodies of approximately 13,000 km^2, along the Gulf of Guinea, its coastline stretches to about 853 km. With respect to the topographical settings, Nigeria can be categorized into five major geographic regions: a low coastal zone along the gulf of guinea; hills and low plateaus north of the coastal zone; the Niger-Benue River meet at the confluence point located at located at Lokoja, the capital of Kogi State, Nigeria. This is a broad stepped plateau stretching to the northern border that has an elevation of over 1200 meters

above sea level and a mountainous zone along the eastern border (near Cameroun), which includes the country's highest point, Chappal Waddi (2,419 meters above sea level) in Taraba State (Figure 1).

Three climatic types are experienced in the country, these are: arid in the north; tropical in the center and equatorial in the south. Variations are governed by the interaction of moist southwest monsoon and dry northeast wind. Mean maximum temperature of 30˚C to 32˚C is experienced in the south and 33˚C to 35˚C is experienced in the north. High humidity is characterized from February to November in the south and from June to September in the north. Low humidity coincides with the dry season. Annual rainfall decreases northward and ranges from about 2,000 mm in the coastal zone (with an average of about 3,550 mm in the Niger Delta) to 500 to 750 mm in the north.

There are two principal water systems in Nigeria; these include the Niger-Benue basin and the Chad basin. The Niger-Benue River constitutes the major surface water that drains almost all part of Nigeria (Figure 1). It is divided into three sections-the upper Niger (in the north-west); the lower Niger (in the south) and the Benue (in the north-east). The Benue basin which originated from the Mandara mountains in Cameroun is the major tributary of the Niger River (it empties its water into the Niger at Lokoja where confluence is formed).

The major tributaries of the Benue River in Nigeria are Katsina-Ala, Donga, Taraba, Gongola and Pai. The upper Niger River originated from the Fouta Djallon Massif in Guinea at an altitude of about 800 meters and flows northeast, traversing the inland Delta in Mali down to the Niger Delta in the gulf of Guinea. At the Nigeria section of the Niger River, numerous rivers such as Zamfara, Gulbin Ka, Kaduna, Gurara, Gbaka, Kontagora and Swahi empty's their water into the Niger as it flows southward [28].

Sediment Sample Collection

Three sampling points were selected along River Niger (RN) River Benue (RB) and after Confluence Point (CP) in Lokoja, Kogi State, Nigeria. Figure 2 is the map of Lokoja showing the sampling points. A total of 9 sampling points were mapped out along each river. Using motorized boat as means of mobility on water, samples were collected along each of the studied Rivers at an interval of 500 m from each other in triplicates at the bottom of the Rivers close to the banks using hand shove. Therefore a total of 27 samples were collected and assessed on each River. The samples were stored in sterilized polythene bags and labeled. The sampling was carried out in the months of March, June, September and December, 2013, respectively

Figure 1: Study Area Showing River Niger, River Benue, and Confluence Point in Lokoja , Nigeria [28].

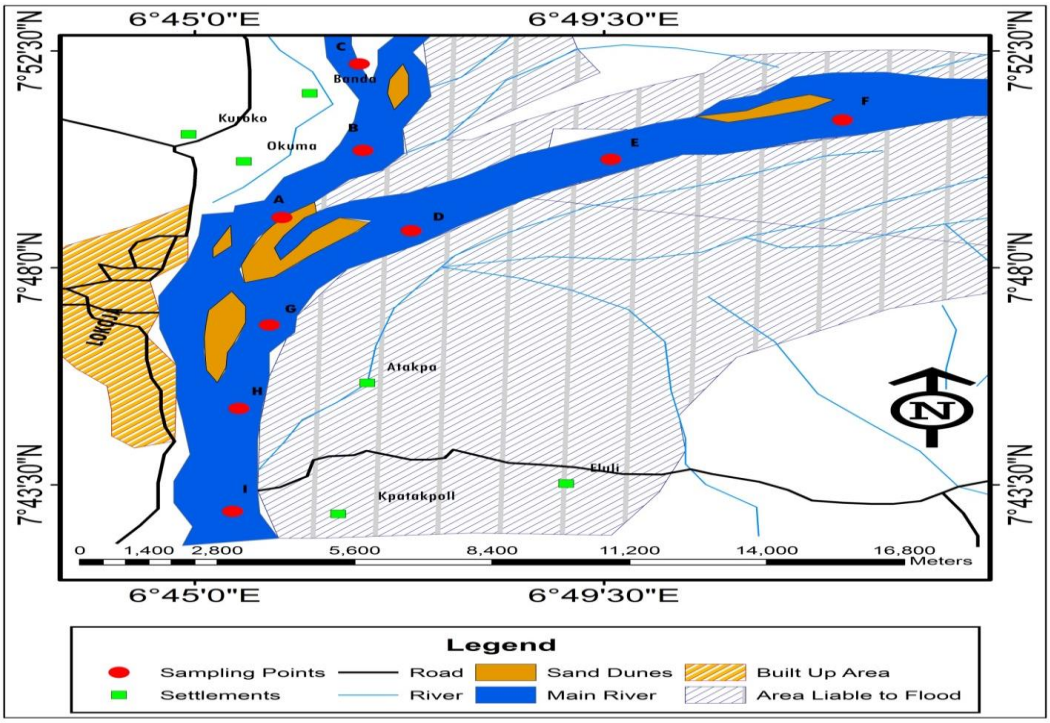

Figure 2: Map of Rivers in Lokoja Showing Sampling Points.

Reference Materials

Soil samples used as standard reference materials obtained from Institute of Agricultural Research (IAR) Ahmadu Bello University, Zaria in Nigeria, were used as quality assurance measure for the analysis of total heavy metal concentration. The recovery rate of the concentration according to the certified values of the standard reference materials was >95%.

Determination of Heavy Metals

The soil samples were air dried in the laboratory, ground manually with wooden mortar and pestle, and sieved with a 2.00 mm mesh sieve. They were then oven dried at 105°C ± 0.5°C to a constant mass and stored in plastic vials until analysis. 1.00 g of the 2.00 mm sieved, air-dried powdered sediment sample was digested in a Teflon crucible for 1 hr. on a heating mantle, using 20.00 cm^3 conc. HCl, 5.00 cm^3 conc. HNO_3 and 2.00 cm^3 conc. HF acid mixture [29]. The clear, colorless digest was set aside to cool, filtered into the 50.00 cm^3 volumetric flask and made up to volume with double distilled water. This was then stored in a polythene vial before elemental analysis.

Chemical Analysis

A stock solution of 1,000.00 μg g^{-1} Cr, Co, and Cu were prepared and stored in a polythene bottles respectively. Standard calibration curves were prepared from the stock solutions [30] by reading the absorbance of 0.20, 0.40, 0.60, 0.80, 1.00, and 1.20 μg/g standard concentrations of Co, Cr, and Cu at 324.8 nm, 228.8 nm, and 279.5 nm wavelengths, respectively, using a single element hollow cathode lamp on a VARIAN 240FS Model Atomic Absorption Spectrophotometer (AAS), equipped with automatic background correction, used to compensate for non-specific absorption and scattering of light and standard addition method was used to check matrix interference in a similar manner to a standard [31]. The values obtained were used in plotting the standard calibration curves of Co, Cr and Cu respectively from which the concentrations of Co, Cr and Cu in every test sample was calculated.

Data Analysis - Pollution Load Index

The pollution status of the sediment samples of the three Rivers was determined using Pollution Load Index [32]. One of the factors introduced to classify the quality of environmental samples is

contamination factor (CF) [33]. For its calculation, a mean concentration of a given element in at least 5 samples is divided by pre-industrial concentration of the element [34] as presented in Equation 1.

$$CF = \frac{Ci}{Cn} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where:

Ci – mean content of element in samples taken from at least 5 sampling sites

*C*n – pre-industrial concentration of element

The pre-industrial concentration (geochemical background concentration) is understood as the world average shale value equated to the Clarke value [35]. Pollution Load Index (PLI) uses the concentration factors of different elements in the same sample, and is obtained as a concentration factor (CF) of each element with respect to the background value [32] as presented in Equation 2.

$$PLI = \sqrt[n]{CF_1 \; x \; CF_2 \; x \quad \ldots\ldots\ldots CF_n} \quad \ldots\ldots\ldots\ldots \quad (2)$$

where:

CF is a quotient of the concentration of the element in the sample and its background concentration.

The background values used as reported are Cr = 17.00 mg kg^{-1}, Co = 12.00 mg kg^{-1} and Cu = 17.00 mg kg^{-1} [36]. Pollution Load Index (PLI) classification is as presented in Table 1.

Table 1: Pollution Load Index Classification.

Class	Range	Remark
1	<0 – 0	No pollution
2	0 – 1	Low degree of pollution
3	1 – 2	Moderate degree of pollution
4	2 – 4	High degree of pollution
5	4 – 8	Very high degree of pollution
6	8 – 16	Extremely high degree of pollution

Data Analysis - Geoaccumulation Index of Heavy Metal in Sediment Samples

Another geochemical approach to assess the contamination level of sediments is the Igeo (Index of Geoaccumulation) [21, 23] defined according to the Equation 3.

$$Igeo = In\left(\frac{Cn}{1.5} \times Bn\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where:

Cn= measured concentration (mg kg^{-1}),

Bn = geochemical background value (mg kg-1).

The mean values were used for this calculation while 1.5 was the factor used for lithologic variations of metals. The Geoaccumulation Index compares the measured concentration of the element in the fine-grained sample fraction (Cn) with the geochemical background value (Bn). Mean values of soil samples of the study region are considered as (Bn) values. The index of Geoaccumulation consists of seven grades as presented in Table 2.

Table 2: Geoaccumulation Index Classification.

Geoaccumulation class intensity	Sediment Igeo Contamination	Index, Igeo
0	$I_{geo} \leq 0$	Unpolluted
1	$0 < I_{geo} < 1$	low to moderately polluted
2	$1 < I_{geo} < 2$	Moderately polluted
3	$2 < I_{geo} < 3$	Moderately to highly polluted
4	$3 < I_{geo} < 4$	Highly polluted
5	$4 < I_{geo} < 5$	Highly to extremely polluted
6	$5 < I_{geo} < 6$	Extremely polluted

RESULTS AND DISCUSSION

The concentrations of heavy metals in sediments vary according to the rate of particle sedimentation, heavy metals deposition, particle size and the presence or absence of organic matter in the sediments. Descriptive statistics such as minimum, maximum, mean, and standard deviation were employed to highlight the concentrations of Chromium (Cr), Cobalt (Co) and Copper (Cu) in sediment samples of River Niger (RN) River Benue (RB) and after Confluence Point (CP).

Concentration of Chromium in Sediment Samples

Figure 3 shows the concentration of Cr in sediment samples with respect to sampling months. In RN, lead in the months of March, June, September and December range from 29.133 to 39.650 mg kg^{-1} with mean 33.391 ± 3.668 mg kg^{-1}, 20.438 to 27.508 mg kg^{-1} with mean 23.418 ± 2.610 mg kg^{-1}, 25.003 to 29.105 mg kg^{-1} with mean 27.272 ± 1.413 mg kg^{-1} and 20.559 to 28.204 mg kg^{-1} with mean 23.248 ± 2.416 mg kg^{-1}, respectively. In RB, Cr in the months of March, June, September and December range from 0.010 to 1.700 mg kg^{-1} with mean 20.929 ± 4.541 mg kg^{-1}, 10.602 to 18.349 mg kg^{-1} with mean 14.922 ± 2.816 mg kg^{-1}, 16.002 to 19.654 mg kg^{-1} with mean 17.606 ± 1.324 mg kg^{-1} and 8.0861 to 18.692 mg kg^{-1} with mean 13.1767 ± 3.317 mg kg^{-1} . respectively. Cr concentrations in CP samples in the months of March, June, September and December range from 17.881 to 29.840 mg kg^{-1} with mean 24.153 ± 4.519 mg kg^{-1}, 20.430 to 23.040 mg kg^{-1} with mean 21.911 ± 0.934 mg kg^{-1}, 19.098 to 25.657 mg kg^{-1} with mean 23.108 ± 2.117 mg kg^{-1} and 18.007 to 22.770 mg kg^{-1} with mean 20.574 ± 1.513 mg kg^{-1}, respectively.

Concentrations of Cobalt in Sediment Samples

The variation of concentrations of Co in sediment samples with respect to sampling months is as depicted in Figure 4. In RN, Co in the months of March, June, September and December range from 17.336 to 35.767 mg kg^{-1} with mean 23.3486 ± 6.0843 mg kg^{-1}, 9.575 to 24.651 mg kg^{-1} with mean 18.1988 ± 4.43406 mg kg^{-1}, 17.063 to 23.648 mg kg^{-1} with mean 20.1094 ± 2.31332 mg kg^{-1} and 5.074 to 21.678 mg kg^{-1} with mean 12.3318 ± 4.69324 mg kg^{-1}, respectively. In RB, Co in the months of March, June, September and December range from 1.005 to 5.086 mg kg^{-1} with mean 3.197 ± 1.603 mg kg^{-1}, 1.008 to 3.652 mg kg^{-1} with mean 2.443 ± 0.978 mg kg^{-1}, 1.065 to 3.100 mg kg^{-1} with mean 2.264 ± 0.644 mg kg^{-1} and 1.02 to 3.923 mg kg^{-1} with mean 2.157 ± 0.958 mg kg^{-1}, respectively. Co concentrations in CP samples in the months of March, June, September and December range from 7.001 to 9.861 mg kg^{-1} with mean 8.565 ± 0.906 mg kg^{-1}, 3.656 to 6.673 mg kg^{-1} with mean 5.381 ± 1.076 mg kg^{-1}, 2.657 to 6.08 mg kg^{-1} with mean 4.483 ± 1.271 mg kg^{-1} and 2.090 to 6.355 mg kg^{-1} with mean 4.385 ± 1.492 mg kg^{-1}, respectively.

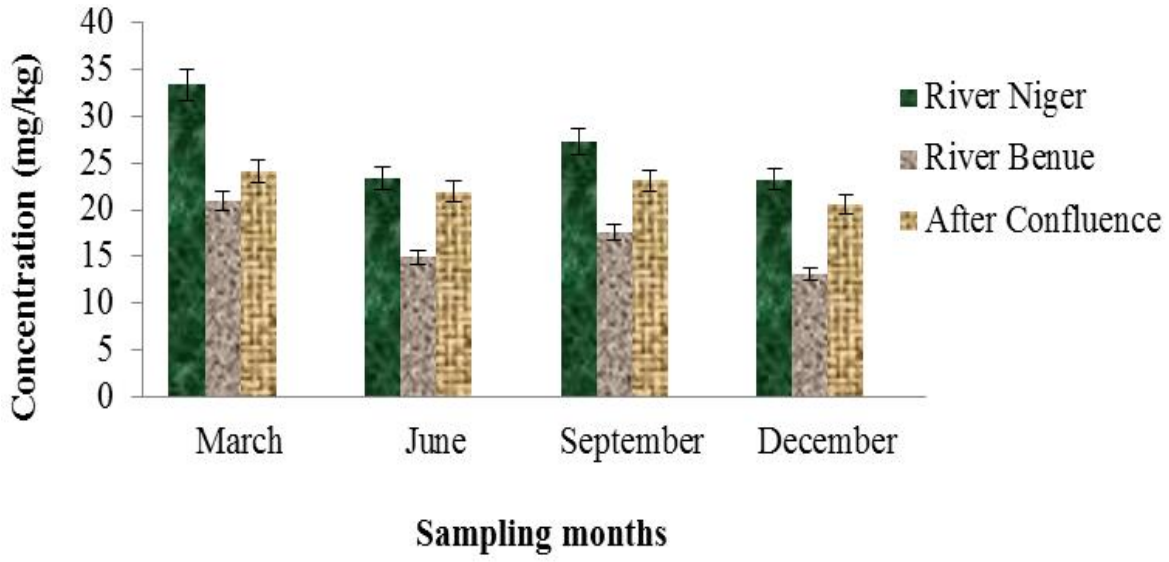

Figure 3: Concentration of Cr in Sediment Samples with Respect for Sampling Months.

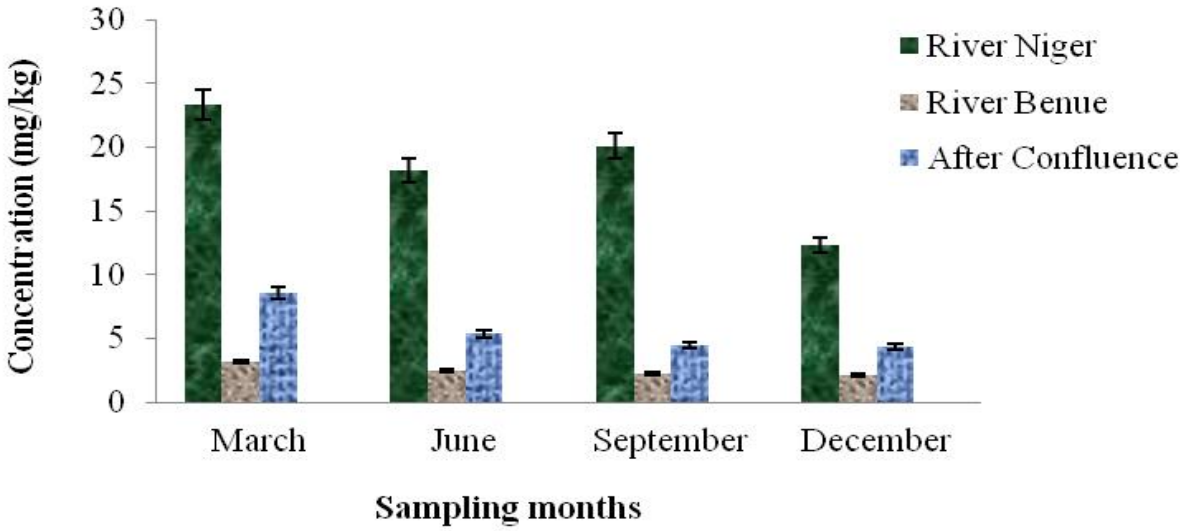

Figure 4: Concentration of Co in Sediment Samples with Respect to Sampling Months.

Concentrations of Copper in Sediment Samples

The concentration of Cu in sediment samples with respect to sampling months is as presented in Figure 5. In RN, Cu in the months of March, June, September and December range from 19.050 to 26.880 mg kg^{-1} with a mean of 23.462 ± 2.609 mg kg^{-1}, 14.990 to 18.434 mg kg^{-1} with mean 16.570 ± 1.362 mg kg^{-1}, 12.856 to 15.966 mg kg^{-1} with mean 14.405 ± 1.022 mg kg^{-1} and 8.202 to 11.290 mg kg^{-1} with mean 9.685 ± 1.119 mg kg^{-1}, respectively. In RB, Cu in the months of March, June, September and December range from 11.407 to 13.680 mg kg^{-1} with mean 12.462 ± 0.818 mg kg^{-1}, 7.023 to 10.003 mg kg^{-1} with mean 8.504 ± 1.071 mg kg^{-1}, 8.076 to 10.640 mg kg^{-1} with a mean of 9.548 ± 0.846 mg kg^{-1} and 6.021 to 8.300 mg kg^{-1} with a mean of 7.083 ± 0.752 mg kg^{-1}, respectively. Cu concentrations in CP samples in the months of March, June, September and December range from 17.043 to 19.000 mg kg^{-1} with mean 18.060 ± 0.584 mg kg^{-1}, 16.567 to 19.654 mg kg^{-1} with mean 18.308 ± 1.055 mg kg^{-1}, 10.045 to 14.966 mg kg^{-1} with mean 11.807 ± 1.529 mg kg^{-1} and 8.100 to 11.806 mg kg^{-1} with a mean value of 10.241 ± 1.317 mg kg^{-1}, respectively.

Analysis of Variance of Metal Concentrations in Samples

The analysis of variance (ANOVA) of metal concentrations with respect to sampling period is as presented in Table 3. Letters differed in vertical rows within same sampling period refer to significant differences $p \leq 0.05$, while same letter implies no significant difference within same sampling period. Therefore result shows that most of the metals have a wide range of variations of several magnitudes.

Pollution load index of heavy metal in sediment samples

Table 4 presents the PLI of RN, RB and CP in the months of March, June, September and December. The PLI of RN, in the months of March, June, September were 1.741, 1.268 and 1.316 respectively which is between 1-2 indicating moderate degree of pollution (Table 1) while in the month of December there was low degree of pollution with value 0.929 which is between 0-1.

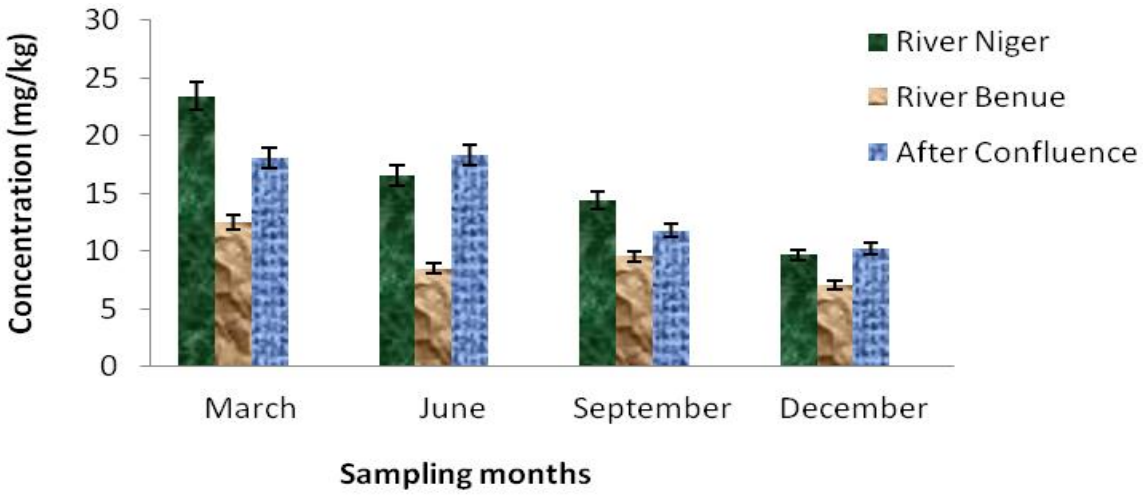

Figure 5: Concentration of Cu in Sediment Samples with Respect to Sampling Months.

Table 3: ANOVA of Metal Concentration (mg/kg) with Respect to Sampling Period.

Period	Rivers	Metals		
		Cr	Co	Cu
March	R. Niger	33.098±3.543[a]	23.349 ± 6.084 [a]	23.462 ± 2.609[a]
	R. Benue	20.930±4.541 [c]	3.197 ± 1.603 [c]	12.462 ± 0.818[c]
	Confluence	23.894±4.355 [b]	8.565 ± 0.906 [b]	18.060 ± 0.584[b]
June	R. Niger	23.166±2.5550[a]	18.199 ± 4.434 [a]	16.570 ± 1.362[b]
	R. Benue	14.922±2.816 [c]	2.443 ± 0.978[c]	8.504 ± 1.071[c]
	Confluence	21.911±0.934 [b]	5.381 ± 1.076[b]	18.308 ± 1.055[a]
September	R. Niger	27.469±1.447 [a]	20.109 ± 2.313[a]	14.405 ± 1.022[a]
	R. Benue	17.606±1.324 [c]	2.264 ± 0.644[c]	9.548 ± 0.846[c]
	Confluence	23.108±2.117 [b]	4.483 ± 1.271[b]	11.807 ± 1.529[b]
December	R. Niger	22.979±2.399 [a]	12.332 ± 4.693[a]	9.685 ± 1.119[a]
	R. Benue	13.177±3.317 [c]	2.157 ± 0.958[c]	7.083 ± 0.752[b]
	Confluence	20.574±1.513[b]	4.385 ± 1.492 [b]	10.241±1.317 [a]

RB in the months of March, June, September and December were 0.621, 0.447, 0.480 and 0.388 respectively which is between 0-1 indicating low degree of pollution while PLI in the months of June, September and December were 0.854, 0.707 and 0.643 respectively which is between 0-1 also indicating low degree of pollution while March indicated moderate degree pollution with PLI value 1.025. Values (>1) implies influence of external discrete sources like industrial activities, agricultural runoff and other anthropogenic inputs.

Geoaccumulation Index of Heavy Metals in Sediment Samples

Table 5 presents the Igeo of RN, RB, and CP in the months of March, June, September and December. Generally values obtained were ≤ 0 indicating that most samples were unpolluted. Values of Cr and Co in RN and RB in the month of March were 0.270 and 0.260 and in the month of September 0.067 and 0.111 respectively which were $0 < I_{geo} < 1$ indicating low to moderately pollution. These findings also suggest slight anthropogenic influence on the concentration of the metals studied in the sediments.

Table 4: Pollution Load Index of Heavy Metal in Sediment Sample.

Periods	Rivers	CF_{Cr}	CF_{Co}	CF_{Cu}	PLI
March	RN	1.964	1.946	1.38	1.741
	RB	1.231	0.266	0.733	0.621
	CP	1.421	0.714	1.062	1.025
June	RN	1.378	1.517	0.975	1.268
	RB	0.878	0.204	0.5	0.447
	CP	1.289	0.448	1.077	0.854
September	RN	1.604	1.676	0.847	1.316
	RB	1.036	0.189	0.562	0.48
	CP	1.359	0.374	0.695	0.707
December	RN	1.368	1.028	0.57	0.929
	RB	0.775	0.18	0.417	0.388
	CP	1.21	0.365	0.602	0.643

CF_{Cd} =Contamination factor of Cd, CF_{Pb} =Contamination factor of Pb and CF_{Zn} =Contamination factor of Zn

Table 5: Geoaccumulation Index of Heavy Metals in Sediment.

Period	Rivers	$I_{geo}Cr$	$I_{geo}Co$	$I_{geo}Cu$
March	RN	0.270	0.260	-0.083
	RB	-0.180	-1.728	-0.716
	CP	-0.054	-0.743	-0.345
June	RN	-0.085	0.011	-0.431
	RB	-0.536	-1.997	-1.098
	CP	-0.152	-1.208	-0.331
September	RN	0.067	0.111	-0.571
	RB	-0.370	-2.073	-0.982
	CP	-0.099	-1.390	-0.700
December	RN	-0.093	-0.378	-0.968
	RB	-0.660	-2.122	-1.281
	CP	-0.215	-1.412	-0.912

CONCLUSION

Cr, Co, and Cu were detected in all the samples analyzed and results show that most of the metals have a wide range of variations of several magnitudes. The PLI of all the sediment samples studied indicated low (0-1) to moderate degree of pollution (1-2) while I_{geo} study also indicated low to moderate degree of pollution ($0 < I_{geo} < 1$) of some of the samples.

These results suggest that pollutants from anthropogenic activities within the metropolis might have probably been leached into the Rivers by the flood which occurred shortly before the sample collection. However, there is a danger in continuous discharge of pollutant containing waste into these Rivers. Authors recommend control of flooding of these Rivers because if the flood is uncontrolled or unabated, there is tendency of rise in levels of pollutants which would ultimately enter the food web in this study environment and pose high risk to life since these Rivers is used for fishing, domestic and irrigation purposes.

REFERENCES

1. Sada, P.O. 1998. “Development and the Environment: A Conceptual Framework for Environmental Management”. In: Sada P.O. and Odemerho, F.O.(eds.). *Environmental Issues and Management in Nigerian Development*. 27-37.

2. Olajuyigbe, A.E., O.O. Rotowa, and E. Durojaye. 2012. “An Assessment of Flood Hazard in Nigeria: The Case of Mile 12, Lagos”. *Mediterranean Journal of Social Sciences*. 3(2):367-375.

3. Emeribeole, A.C. 2015. “Managing Flood Disasters in Nigerian Cities: Issues and Strategies towards Meeting the Challenges in the Modern World. A Case Study of Owerri Metropolis Imo State Nigeria 7587”. *The Wisdom of the Ages to the Challenges of the Modern World*. Sofia, Bulgaria. 1-16.

4. Hualou, L. 2011. “Disaster Prevention and Management: A Geographical Perspective”. *Disaster Advances*. 4(1):3-5.

5. Robertson, D.J. and K.G. Taylor. 2007. “Temporal Variability of Metal Contamination in Urban Road Deposited Sediment in Manchester, UK: Implications for Urban Pollution Monitoring”. *Water, Air, Soil Pollution*. 186:209–220.

6. Poleto, C. and G.H. Merten. 2008. “Urban Street Pollutants”. *Revista Pesquisas em Geociências*. 35:3-8.

7. Yisa, J., J.O. Jacob, and C.C. Onoyima. 2012. “Assessment of Toxic Levels of Some Heavy Metals in Road Deposited Sediments in Suleja, Nigeria”. *American Journal of Chemistry*. 2(2):34-37.

8. Poleto, C., G.H. Merten, and J.P. Minella. 2009. “The Identification of Sediment Sources in a Small Urban Watershed in Southern Brazil: An Application of Sediment Fingerprinting”. *Environmental Technology*. 30(11):1145 – 1153.

9. Davis, A.P., M. Shakouhian, and S. Ni. 2001. “Loading Estimates of Lead, Cadmium, and Zinc in Urban Runoff from Specific Sources”. *Chemisphere*. 44:997–1009.

10. San-Miguel, G., G.D. Fowler, and C.J. Sollars. 2002. “The Leaching of Inorganic Species from Activated Carbons Produced from Waste Tyre Rubber”. *Water Resources*. 36:1939 –1946.

11. Dalal, R.C. and D. Moloney. 2000. “Sustainability Indicators of Soil Health and Biodiversity”. In: *Management for Sustainable Ecosystems*. P. Hale, A. Petrie, D. Moloney, and P. Sattler (eds). Centre for Conservation Biology, University of Queensland: Brisbane, Australia. 101 –108.

12. Esakku, S., K. Palanivelu and K. Joseph. 2003. “Assessment of Heavy Metals in a Municipal Solid Waste Dumpsite”. Workshop on Sustainable Landfill Management: Chennai, India. 139-145.

13. Vaird, B., F. Pihan, S. Promeyrat, and J.C. Pihan. 2004. “Integrated Assessment of Heavy Metal (Pb, Zn and Cd) Highway Pollution: Bioaccumulation in Soil, Graminaceae and Land Snails”. *Chemosphere*. 55:1349–1359.

14. Suman, M., K. Ravindra, R. Dahiya, and A. Chandra. 2006. “Leachate Characterization And Assessment of Groundwater Pollution near Municipal Solid Waste Landfill Site”. *Environmental Monitoring and Assessment*. 118:435–456.

15. Das, P.S., S. Samantaray, and G.R. Rout. 1997. “Studies on Cd Toxicity in Plants: A Review”. *Environmental Pollution*. 98:29–36.

16. Gray, C.W., R.G. McLaren, and A.H.C. Roberts. 2003. “Atmospheric Accessions of Heavy Metals to some New Zealand Pastoral Soils”. *The Science of the Total Environment.* 305:105–115.

17. Nielen, M.W.F. and H.J.P. Marvin. 2008. “Challenges in Chemical Food Contaminants and Residue Analysis”. *Food Contaminants and Residue Analysis*.. Elsevier. 51:1–28.

18. Erika-Andrea, K., T. Frentiu, M. Ponta, and E. Cordos. 2005. “Use of Sequential Extraction to Assess Metal Fractionation in Soils from Bozanta Mare, Romania”. *Acta Universitatis Cibiniensis Seria F. Chemia*. 8(2):5-12.

19. Ankley, G.T., K. Lodge, D.J. Call, M.D. Balcer, L.T. Brooke, P.M. Cook, and J.J. McAllister. 1992. “Heavy Metal Concentrations in Surface Sediments in a Near Shore Environment, Jurujuba Sound, Southeast Brazil”. *Environmental Pollution*. 109:1-9.

20. Wakida, F.T., D.E.J. Lara-Ruiz, and P. Temores. 2008. “Heavy Metals in Sediments of the Tecate River, Mexico”. *Environmental Geology*. 54:637–642.

21. Muller, P.J. and P.J. Suess. 1979. "Productivity, Sedimentation Rate and Sedimentary Organic Matter in the Oceans. I. Organic Carbon Preservation”. *Deep Sea Res*. 26:347- 1362.

22. Singh, M., A.A. Ansari, G. Muller, and I.B. Singh. 1997. “Heavy Metals in Freshly Deposited Sediments of the Gomati River a Tributary of the Ganga River: Effects of Human Activities”. *Environmental Geology*. 29: 246-252.

23. Guilherme, M.G., L.F. Robson, A.M.G. Figueiredo, S.C.S. Paulo and D.I.T. Fávaro. 2011. "Enrichment Factor and Geoaccumulation Index Applied to Sediment Samples from the Guarapiranga Reservoir, Brazil, for Metal and Trace Element Assessment". *International Nuclear Atlantic Conference*. 1-13.

24. Galán, E., I. González, I. and J.C. Fernández-Caliani. 2002. "Residual Pollution Load of Soils Impacted by the Aznalcóllar (Spain) Mining Spill after Clean-Up Operations". *The Science of the Total Environment*. 286(1-3):167-179.

25. Enokela, S.O. and E. Salifu. 2012. "Evaluation of Groundwater Quality for Fadama Irrigation Lands in River Niger-Benue Confluence Point of Lokoja, Nigeria". *Inter. Journal of Scientific and Research Publication*. 2(9):1-4.

26. Olatunde, S.O. and O. Oladele. 2013. "Determination of some Selected Heavy Metals in Inland Fresh Water of lower River Niger Drainage in North Central Nigeria". *African Journal of African Environmental Science Technology*. 6(10):403-408.

27. Adeigbe, O.C. and A.Y. Jimoh. 2014. "Rare Earth Elements Fingerprints: Implication for Provenance, Tectonic And Depostional Settings of Clastic Sediments of Lower Benue Trough, Southeastern Nigeria". *New York Science Journal*. 7(2):11-26.

28. Nkeki, F.N., P.J. Henah and V. N. Ojeh. 2013. "Geospatial Techniques for the Assessment and Analysis of Flood Risk along the Niger-Benue Basin in Nigeria". *Journal of Geographic Information System*. 5:123-135.

29. Ekwumemgbo, P.A. 2005. "Bioaccumulation of Nickel in Soil and Plant Samples Along a Rail Route". *African Journal of Natural Sciences*. 8, 2005, 69-74.

30. AOAC. 1998. *Official Methods of Analysis of the Association of Official Analytical Chemist*. Association of Official Analytical Chemists: Alexandria, VA. 432-444.

31. APHA. 1998. *Standard Methods for the Examination of Water and Wastewater. 18th Edition.* American Public Health Association: Washington, DC. 45-60.

32. Tomlinson, D.L., J.G. Wilson, C.R. Harris, and D.W. Jeffrey. 1980. "Problems in the Assessments of Heavy Metal Levels in Estuaries and Formation of a Pollution Index". *Helgol Meeresunters*, 33:566-575.

33. Gałuszka, A. and Z. M. Migaszewski. 2011. "Geochemical Background – An Environmental Perspective". *Mineralogia.* 42(1):7-17.

34. Håkanson, L. 1980. "Ecological Risk Index for Aquatic Pollution Control: A Sedimentological Approach". *Water Research*. 14:975-1001.

35. Loska, K., D. Wiechuła, and I. Korus. 2004. "Metal Contamination of Farming Soils affected By Industry". *Environment International*. 30:159-165.

36. Bervoets, L. and R. Blust. 2003. 2003. "Metal Concentration in Water, Sediment and Gudgeon from a Pollution Gradient". *Journal of Environmental Pollution*. 126:9-10.

ABOUT THE AUTHORS

Dr. Patricia A. Ekwumemgbo, is a Lecturer/Researcher in the Department of Chemistry, Faculty of Science, Ahmadu Bello University, Zaria, Nigeria. She holds a Ph.D. degree in Analytical Chemistry with special interest in Environmental Chemistry. Her current research interests are: characteristics and mechanisms of adsorption reactions; environmental pollution, control and remediation techniques and eco-friendly herbs for detoxification. She is a member of Institute of Chartered Chemist of Nigeria (ICCON); a Fellow of the African Institute for Leadership & Good Governance (AILGG), recipient of the Grand Achievers in Public Service Award for Excellence by AfricanAGE International; a Fellow of Chemical Society of Nigeria (CSN) and a distinguish recipient of the Woman of Merit Gold Award (WMGA).

Dr. Israel K. Omoniyi, is a Lecturer/Researcher in the Department of Chemistry, Faculty of Science, Ahmadu Bello University, Zaria, Nigeria. He holds a Ph.D. degree in Analytical Chemistry; a member of Institute of Chartered Chemist of Nigeria (ICCON) and a member of Chemical Society of Nigeria (CSN).

B. Isuwa is a Postgraduate Analytical Chemistry student of the Department of Chemistry, Faculty of Science, Ahmadu Bello University, Zaria, Nigeria and a staff of the Department of Crop Protection, Ahmadu Bello University, Zaria, Nigeria and holds a Postgraduate Diploma Degree (PGD) in Chemistry.

SUGGESTED CITATION

Ekwumemgbo, P.A., I.K. Omoniyi, and B. Isuwa. 2016. "Geochemical Assessment of Anthropogenic Influence on Pollution Status of Cobalt, Chromium, and Copper in Sediments of some Rivers in Lokoja, Kogi State, Nigeria". *Pacific Journal of Science and Technology*. 17(1):352-363.