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EVALUATION OF POLLUTION STATUS OF SEDIMENT FROM KAMPANI-ZURAK RIVER, PLATEAU STATE, NIGERIA

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ABSTRACT

Heavy metals are the most toxic form of contaminants that are commonly found in a mining area. The public health significance of these metals necessitates their constant monitoring to avoid acute toxicity which could lead to disease outbreak and metal poisoning. This paper assessed the pollution level of four heavy metals: Cr, Cu, Cd and Fe in sediment from Kampani-Zurak River. The sampling and analysis were carried in the months of April and October of 2012, 2013, and 2014; and standard procedures were employed in the analysis. The results obtained compared with the Consensus Based Sediment Quality Guideline (CBSQG) and average shale values revealed low levels of the metals in the sediment. The Pollution load index (PLI), contamination degree (CD) and contamination factor (CF) for Cr, Cu and Fe were < 1 in all the seasons under consideration. However, Cd showed moderate level of contamination. The results also indicate moderate to very high enrichment for Cr, Cu and Cd . The I_{geo} further revealed the unpolluted nature of the sediment. This findings suggests that the anthropogenic activity does not have much impact on the sediment quality. However, constant quality check is required to serve as a preventive measure to any form of heavy metal pollution and toxicity that might occur in the future.

Keywords: Pollution status; Heavy metal; Sediment; Kampani; Nigeria.

INTRODUCTION

The rapid growth in Nigeria population has lead to an increase in the rate of industrialization and Urbanization. These factors have direct influence on the exploration and exploitation of solid minerals. Many countries including the developed world have depended and considered mining as an economic booster. The mining of these minerals are mostly done illegally in the developing countries like Nigeria, resulting in heavy metal deposition and distribution in the aquatic environment. Owing to their toxicity, persistence and accumulative behavior (Fadiran *et al*., 2014, Atta and Zakaria, 2014; Ozturk *et al*., 2009; Prasad and Frectas, 2003), heavy metals are potential threat to the existence of man and other living organism who feed on heavy metal contaminated sediment (Olubunmi and Olorunsola, 2010). Although, many are essential, some like Pb, Cd, Cr, Cu, Hg and As are considered as priority metal pollutants that are of great health concern (Shafie *et al*., 2013).

Heavy metals are known to cause multiple organ damage like kidney, liver and brain damage even at minute concentration when transfer into water from sediment matrix (Tchounwou *et al*., 2012). Since the concentration of heavy metals in water is dynamic (Sharmin *et al*., 2010), the assessment of their level in sediment will give an insight into the possible risk involved when present in an elevated concentration.

Sediment serves as a reservoir for heavy metals (Shaari *et al*., 2015; Gupta *et al*., 2013; Idriss and Ahmed, 2013). Thus, the presence of these metals in sediment can have adverse effect on the aquatic life as well as man. This is because of the ecological dynamics of sediment which can be altered at any slight change in pH or redox potential. Studies have shown that the uppermost superficial sediment constitutes the largest reservoir for heavy metal in the aquatic environment (Ephraim and Ajayi, 2014). Furthermore, sediment is considered as an indicator of heavy metal pollution (Manoj and Padhy, 2014). This makes the assessment of its quality important to understand the metal behavior and partitioning in the sediment matrix.

It is widely believed that the contamination of aquatic system by heavy metals can be from many sources. However, anthropogenic activity such as mining remains the cofactor in increasing the concentration of these metals in the environment (Issa et al., 2011). Galena lead which has been found to be in association with Ag, Mn, Zn, Fe, Cd, Cu, Sb, Bi and Se in variable amounts, has been mined in Wase local Government Area for decades (Wikipedia, 2014). This anthropogenic activity constitutes serious health hazard and if left unchecked will lead to heavy metal poisoning and disease outbreak. Many incidences of disease outbreak due to the consumption of these toxic metals have been reported. The minamata mercury fish poisoning in Kyusho in Japan (Douglas, 2017) and the Zamfara lead poisoning in Nigeria (Lohdip, 2011) among others.

Many researchers have studied the concentration of heavy metals in sediment such as the one done by Aderinola *et al* (2017), Baran and Tarnawski (2017), Gupta *et al* (2013), Issa *et al* (2011), Ekeanyanwu *et al* (2010), Praveena *et al* (2007), Kemdirin *et al* (1989). This work aimed at assessing the concentration levels of some heavy metals in sediment in the study site to provide information that might be useful to the Government agency and other stakeholders for remediation purposes.

MATERIALS AND METHODS

Materials

All reagents used were of Analar grade and sourced from UK and Japan. AAS model varian Spectrometer 200 was accesses in Bingham University, Abuja, Nigeria.

Study area

The study area**,** Kampanin-Zurakis located between latitude 9°12´ to 9°17´N and longitude 10°32´E to10°37´E in the middle Benue sedimentary trough. It is 64 km east northeast of Wase town (Britannica, 2017) which is 216 km away from Jos, the Plateau State capital, central Nigeria. The river passes through mining belt. This river is the receiving body of mine waste, mine drainages and partially treated and untreated domestic waste.

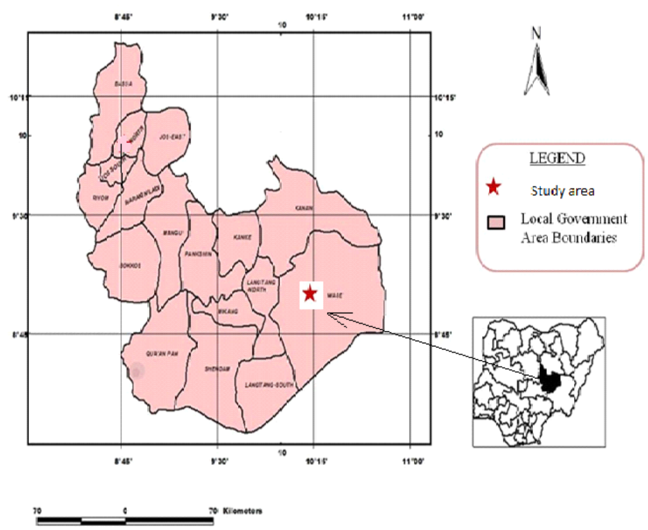

Fig 1: Map showing the study area in Plateau state

Sediment sampling

The sampling points were geo-located using Geographical Positioning System (GPS). Sediment samples were collection from five different sampling points in a particular sampling station between the debts of 0-10 cm. The samples were collected randomly at the banks and middle of the river within the sampling station and were homogenized to form stratified samples. The samples were transferred in polyethylene bags, placed in an ice chest to the laboratory. This was repeated for a period of six seasons (April 2012, October 2012; April 2013, October 2013; April 2014, October 2014).

Sediment sample preparation

Sediment samples were air dried in the laboratory for two weeks. About 500 g homogenized sample was sieved with 2 mm mesh size , out of which 10 g was ground to powder using a pulverizing machine (Manilla and Njoku, 2009; Hollingsworth, 2008). This was repeated for the remaining samples.

Extraction of the metals from five replicate sediment samples was done using mixed acid digestion method. Exactly 5 mL of HF acid and 5mL of aqua regia (HCl+ HNO_3, ratio 3:1) was added to 1 g each of the samples and digested in a water bath at 100°C for 1.5 hours. Complete decomposition of the sample was achieved after the second addition of the same volume of the acids and heating for additional 1.5 hours. This was followed by the addition of 20 mL of saturated boric acid solution after cooling at room temperature with continuous stirring. Digested samples were finally filtered using Whatman No. 41 filters and the filtrates were made up to 50 mL each with deionized water in a standard volumetric flask ready for analysis.

Analysis of sample

The concentrations of four elements in solution namely Cr, Cu, Cd and Fe were determined using Atomic Absorption Spectrometer model varian Spectr. 200 at wavelengths (nm)-Cr (357.9), Cu (324.8), Cd (228.8), Fe (248.3).

Statistical analysis

The raw data were subjected to basic statistical analysis to identify some descriptive factors using origin 2016 64bit software. Six indices were used to determine the degree of anthropogenic influences on the sediment quality. These are contamination factor (CF), contamination degree (CD), pollution load index (PLI), enrichment factor (EF) and geo-accumulation index (Igeo).

RESULTS AND DISCUSSION

The results of the total metal analysis in sediment are presented in tables 1&2. From Table 1, the selected metal concentrations in the bottom sediment varied from 0.6-10.5 mg/kg for Cr, 0.05-0.969 mg/kg for Cu, 0.03-0.45 mg/kg for Cd and 5.3-23.45 mg/kg for iron. A similar result was reported by Ekeanyanwu *et al* (2010) for Cr on Okumeshi river in Delta State, Aderinola *et al* (2017) for Cd on Afa canal, Lagos, and Issa *et al* (2011) for Cu on Orogodo, Delta State.

Table 1: Seasonal total metal concentration in sediment of Kampani River (mg/kg) for 2012, 2013, 2014.

HM	2012D	2012W	2013D	2013W	2013D	2014W
Cr	0.60 ± 0.11	2.05 ± 0.29	2.33 ± 0.15	3.75 ± 0.21	10.59 ± 0.54	5.80 ± 0.20
Cu	0.05 ± 0.01	0.48 ± 0.05	0.70 ± 0.05	0.77 ± 0.06	0.97 ± 0.02	0.97 ± 0.10
Cd	0.03 ± 0.02	0.30 ± 0.03	0.37 ± 0.02	0.42 ± 0.01	0.442 ± 0.01	0.45 ± 0.01
Fe	23.45 ± 2.18	5.68 ± 0.14	5.30 ± 0.54	6.47 ± 0.29	8.00 ± 0.19	8.53± 0.15

HM = Heavy metals; W= Wet season; D= dry season.

In Table 2, the mean seasonal concentration showed elevated levels of Cu and Cd in the wet season while the Cr and Fe were observed to be high in the dry season. The concentration of the metals depends on the activity around the sampling vicinity. Increased mining and fishing activities may be the contributing factors in the dry season while in the wet season, heavy rain, flood, erosion and agricultural activity may be the cause of the elevated levels of Cu and Cd. However, they were all below the consensus based sediment quality guidelines (CBSQG) reported in the literature (Olubunmi and Olorunsola, 2010), average shale values described by Turekian and Wedepohl (1961) and WHO values (Terhemen and Egila, 2008).

Table 2: Mean seasonal total metal content of sediment from Kampani- Zurakriver (mg/kg)

Heavy metal	Mean ± SD dry seasom	Mean ± SD wet season	WHO limit	CBSQG (mg/kg drywt)	Avr Shale value
Cr	4.51± 5.34	3.87 ±1.88	50	43	90
Cu	0.57± 0.48	0.74± 0.25	50	32	45
Cd	0.28± 0.22	0.39±0.08	5.0	0.99	0.3
Fe	12.25± 9.79	6.89±1.47	300	20,000	47200

Pollution indices

Estimation of the metal content is not enough to give a concise information about the source of the metals in the sediment. Quality indices such as CF, CD, PLI, EF and Igeo index were employed to determine the source of metals in the sediment as either anthropogenic or lithogenic (Ololade, 2014; Olubunmi and Olarunsola, 2010).

PLI, CD and CF

The pollution load index (PLI), contamination degree (CD) and contamination factor (CF) for Cr, Cu and Fe were below unity in all the seasons under consideration (Table 3) which indicates absence to low level of anthropogenic contamination. However, moderate level of contamination (CF) was observed due to the presence of cadmium.

Table 3: contamination factor (CF), pollution index (PLI) and contamination degree (CD) for sediment of Kampani -Zurak River

INDICES	Element	2012D	2012W	2013D	2013W	2014D	2014W	CLASSIFICATION
CF	Cr	0.01	0.02	0.03	0.04	0.12	0.06	CF<1 means low contamination 1<CF<3 means moderate contamination 3 ≤ CF < 6 means considerable contamination CF ≥ 6 means very high contamination
	Cu	0.00	0.01	0.02	0.02	0.02	0.02	
	Cd	0.10	1.00	1.23	1.40	1.47	1.50	
	Fe	0.00	0.00	0.00	0.00	0.00	0.00	
PLI		2.54 E-09	5.32 E-09	1.34 E-08	3.76 E-08	1.06 E-07	3.80 E-08	PLI = 0 means perfection, PLI =1 means baseline level of pollution, PLI > 1 means progressive deterioration of site,
CD		1.81 E-01	1.1 E+00	1.3 E+00	1.5 E+00	1.7 E+00	1.7 E+00	CD<6= low CD, 6≤ CD <12 ,moderate CD, 12 ≤ CD < 24 considerable CD indicating alarming anthropogenic contamination

W= Wet season, D= dry season

Enrichment factor

Enrichment factor (EF) is a convenient measure of geochemical trend and is used for making comparison between an area and overtime (Nwajei and Iwegbue, 2007). In this study, iron was chosen as a normalizer for the following reason: (i) iron is associated with fine solid surfaces (ii) has similar geochemistry to that of many other trace metals (iii) its natural concentration tends to be uniform (iv) it is the most abundant element in Nigerian soil (Krcmar *et al*., 2013). In this study, moderate to very high Cr, Cu and Cd enrichment was recorded and was in the order Cd>Cr>Cu>Fe (Table 4).

Geoaccumulation Index

The geo-accumulation index (Igeo) allows the comparison between the present sediment concentration with pre-industrial sediment concentration (Shafie et al., 2013). The Igeo index values were calculated for different metals based on Muller (1969) method. The results obtained revealed the unpolluted nature of the sediment due to the presence of these metals with Igeo values ≤ 0 (Table 5). These results explained that the anthropogenic activity does not have much impact on the sediment quality and the source could likely be natural. Therefore, their low concentration in sediment may be ascribed to the frequent flooding and erosion experienced in the research area.

Table 4: Enrichment factor (EF) for sediment of Kampani- Zurak river from 2012-2014

Element	Shale values	2012D	2012W	2013D	2013W	2014D	2014W	CLASSIFICATION
Cr	13.42	45.85	52.11	83.87	236.84	129.71	13.42	EF<2 means deficiency to mineral enrichment
Cu	2.24	21.47	31.31	34.44	43.39	43.39	2.24	EF 2-5 is moderate enrichment
Cd	201.28	2012.79	2482.44	2817.91	2952.10	3019.19	201.28	EF 5-20 is significant enrichment
Fe	1.00	0.24	0.23	0.28	0.34	0.36	1.00	EF 20-40 is very high enrichment

Table 5: Geoaccumulation index for sediment of Kampan-Zurak River

Element	Shale values	2012D	2012W	2013D	2013W	2014D	2014W	CLASSIFICATION
Cr	90	-7.81	-6.04	-5.86	-5.17	-3.67	-4.54	Igeo<0 unpolluted
Cu	45	-10.40	-7.14	-6.59	-6.45	-6.12	-6.12	0<Igeo<1 unpolluted to moderately polluted
Cd	0.3	-3.91	-0.58	-0.28	-0.10	-0.03	0.00	1<Igeo<2 moderately polluted
Fe	47200	-11.56	-13.61	-13.71	-13.42	-13.11	-13.02	2<Igeo<3 moderately to strongly polluted

CONCLUSION

The results of the investigation of sediment quality of Kampani-zurak River revealed that the concentrations of Chromium, Cadmium, Copper and Iron were all below the sediment quality guidelines for bottom sediment. The integrated index analysis approach (EF, CF, PLI, CD, Igeo) indicates that there is no risk associated due the presence of these metals in the sediment. In addition, the pollution indices evaluated revealed the background source for these metals. However, constant monitoring should be done to prevent contamination which could results in acute toxicity and poisoning of the food chain.

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CONFLICT OF INTEREST

None declared.

REFERENCES

1. Aderinola OJ, Kusemiju V and Clarke EO (2017). trace metal distribution in surface water, sediment and tissues of fresh water catfish (*Clarias gariepinus*) from Afa canal, Lagos Nigeria. *Intl J Geogr Geol* 1(1):10-22.
2. Atta ER and Zakaria KhM (2014). Evaluation of some radioactive materials and heavy metals in marine environment of Alexandria coastline, Egypt. *J Environ Prot* 5: 1618 – 1629.
3. Baran A and Tarnawski M (2015). Assessment of heavy metals mobility and toxicity in contaminated sediments by sequential extraction and a battery of bioassays. *J Ecotoxicol* 24(6):1279-1293.
4. Britannica (2017). History of mining in Zurak, Wase. Available from: http://www.britannica.bom. [Accessed On 30.06.2017]
5. Douglas A (2017). The Poisoning of Minamata, Available from: https://goapes.wikispaces.com/file/view/The+Poisoning+of+Minamata.pdf [Accessed 17.7.2017].
6. Ephraim EB, Ajayi OI (2014). Geoenvironmental assessment of heavy metals in surface sediment from some creeks of the great Kwa river, South-Eastern Nigeria. *J Environ Earth Sci* 4(21): 2224-3216.
7. Ekeanyanwu CR, Ogbuinyic A and Etienjirhevwe OF (2010). Trace metals distribution in fish tissues, bottom sediments and water from Okumeshi river in Delta State, Nigeria. *Ethiop J Environ Sci Manag* 3(3): 12-17.
8. Fadiran AO, Dlamini CI and Thwala JM (2014). Environmental assessment of acid mine drainage pollution on surface water bodies around Nyenya Mine, Swaziland. *J Environ Prot* 5: 164- 173.
9. Gupta B, Kumar R and Rani M (2013). Speciation of heavy metals in water and sediments of an urban lake system. *J*

Environ Sci Health Part A: *Toxic/Haz Subst Environ Eng*. 48 (10): 1231-1242.
10. Hollingsworth L (2008). Cramp sediment analysis. Hawaii coral reef assessment and monitoring programme. Hawaii Institute of Marine Biology, pp. 1-3.
11. Idriss AA and Ahmad AK (2013). Heavy metals, nickel and chromium in sediments in the Jum river, Penang, Malaysia. *J Environ Prot* 4: 1245-1250.
12. Issa BR, Arimoro FO, Ibrahim M, Birma GJ and Fadairo EA (2011). Assessment of sediment contamination by heavy metals in river Orogodo (Agbor, Delta State, Nigeria). *Curr World Environ* 6(1): 29-38.
13. Kemdirin EC, Ejike C and Anedu DI (1989). Seasonal Variations In The Trace Elements Contents Of Wster And Sediments Of An Upland Reservoir In A Mining District Of Plateau State, Nigeria. *J Biotech* 6: 16-18.
14. Krcmar D, Prica M, Dalmacija B, Watson M, Trickovic J, Rajic L and Tamas Z (2013).Correlation of Different Pollution Criteria in the Assessment of Metal Sediment Pollution. *J Environ Sci Health*. Part A, 48:380-393.
15. Lohdip YN (2011). Inaugural lecture on the insolvency of the universal solvent: That all may have enough to drink. UniJos Inauguaral Lecture Series 52: 24.
16. Manoj K and Padhy PK (2014). Distribution, enrichment and ecological risk assessment of six elements in bed sediments of a tropical river, Chattanapur Plateau; A spartial and temporal appraisal. *J Environ Prot* 5: 1419-1434.
17. Manilla PN and Njoku JO (2009).The chemical analysis of the water and sediment of Nwarie river in Owerri, Imo State, Nigeria. *J Chem Soc Niger* 34 (2): 95.
18. Muller G. (1969). Index of geoaccumulation in sediment of Rhine river. *Geo J* 2(3): 108-118.
19. Nwajei GE and Iwegbue CMA (2007). Heavy metals in dust particles from selected laboratories in Delta State University, Abraka, Nigeria. *J Chem Soc Niger* 32(2): 287.
20. Ololade, IA (2014). An Assessment of Heavy-Metal Contamination in Soils within Auto-Mechanic Workshops Using Enrichment and Contamination Factors with Geoaccumulation Indexes. *J Environ Prot* 5(11): 970-982. doi: 10.4236/jep.2014.511098.
21. Olubunmi FE and Olorunsola OE (2010). Evaluation of the status of heavy metal pollution of sediment of Agbabu bitumen deposit area, Nigeria. *Eu J Sci Res* 41: 373-382.
22. Ozturk M, Ozozen G and Minareci O (2009). Determination of heavy metals in fish, water and sediments of Avsar Dam Lake in Turkey. *Iran J Environ Health Sci* 6(2): 73-80.
23. Praveena PMS, Ahmed A, Radojevic M, Abdullahi MH and Aris AZ (2007). Factor-cluster analysis and enrichment study of mangrove sediments - an example from Mengkabong, Sabah. *Malays J Anal Sci* 11(2): 421-430.
24. Prasad MNV and Freitas HMO (2003). Metal Hyperaccumulation in plants-biodiversity prospecting for phytoremediation technology. *Electron J Biotechnol* 6(3): 285-321.
25. Shafie NA, Aris AZ, Zakaria MF Haris H, Yinglini W and Isa NM (2013). Application of geoaccumulation index and enrichment factors on the assessment of heavy metal pollution in sediments. *J Environ Sci Health* Part A: *Toxic/Haz Subst Environ Eng* 48(2): 182-190.
26. Shaari H, Mohammed Nazmi SNH, Sultan K, Bidai J and Mohammad Y (2015). Spartial Distribution of Selected Heavy Metals in Surface Sediment of the Eez East Cost of Peninsular Malaysia. *Intl J Oceanogr* 1-10.
27. Sharmin S, Zainr MH and Shilazono N (2010). Fractionation profile and mobility pattern of trace metals in sediment Of Nomi River, Tokyo, Japan. *J Soil Sci Environ Manag* 1(1): 1-14.
28. Tchounwou PB, Yedjou CG, Patiolla AK and Sutton DJ (2012). Heavy metal toxicity and the environment. National Institute of Health (NIH) Public Access EXS Author Manuscript. *EXS* 101: 133-164. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4144270/pdf/nihms414261.pdf [Accessed 30.06.2017]
29. Terhemen, A. And Egila, J.N (2008). Heavy metals in sediments of some inland waters adjacent to Benue Cement Company Plc, Benue State, Nigeria. *Afr J Environ Pol Health* 6(1): 1-6.
30. Turekian KK, Wedepohl KH (1961). Distribution of elements in some major units of the earth's crust. *Geol Soc Am Bull* 72: 175-192.
31. Wikipedia (2014). Galena. Available from: www.wikipedia.org. [Assessed On 16.10.14].

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Authors' contributions

Author LRA designed the study, wrote the procedure and interpreted the data. Author LYN and EJN anchored the experiments. Authors LRA managed the literature searches and produced the initial draft. All authors read and approved the final manuscript.