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Geochemical Distribution and Ecological Risk Level of Inorganic pollutant of River Ethiope Sediment

Ufuoma Ugbune[1], Jude Oghenenyore Avwenaghegha[2] , Great Iruoghene Edo[3]

[1]Department of Chemical Science,
Delta State University of Science and Technology,
Ozoro,
Nigeria

[2]Department of Physics,
Delta State University of Science and Technology,
Ozoro,
Nigeria

[3]Department of Petroleum Chemistry,
Delta State University of Science and Technology,
Ozoro,
Nigeria.

Email: ugbunueufuoma@gmail.com

Abstract
This study assessed heavy metals concentration of River Ethiope, Delta State. The sediments was geochemically partitioned and analyzed using atomic absorption spectrophotometer in order to determined the concentration level and heavy fractions in Ethiope river sediments. Geochemically fraction results proved that 50% of the assessed metals were associated with Fe-Mn oxide fraction. Environmental risk factor revealed that cu will posed a greater potential threat to aquatic organisms among the investigated metals. It is therefore, recommended that agencies of government such as federal ministry of environment should routinely monitored Ethiope river sediments in order to ensure reduction in the level of contamination by heavy metals.

Key Words: Contaminants, Sediments, Heavy metals, Geochemical phase, Mobility factor

INTRODUCTION
The process of inorganic contaminants (lead, cadmium chromium iron and zinc e.tc) is a comprehensive and natural geochemical mode that operate through chain of erosion soil and erode materials. Sediment constitutes inorganic materials, mineral particles, washed from storm water run-off from crops land, waste dump, artisans workshop. Natural and anthropogenic are the sources of inorganic contaminants in sediments with anthropogenic constituent the highest sources, this is as a result of poor or none adherence to waste management guidelines, other sources are untreated waste dump of effluents, poor management water sheds, failure of chemical offshore and onshore facilities (Sharma, 2006). Inorganic contaminants in the ecosystem do not decay in the aquatic environment, they

**Author for Correspondence*

deposits in bottom sediments after entering into surface water. Inorganic contaminants level in bottom sediment are much higher than surface water especially if the water has been attracting inorganic contaminants over a long period. Sediments are reservoirs for many pollutants including heavy metal of low degree of durability and low solubility, the contaminants conserved in sediments in a long time depending on the biogeochemical and geochemical properties of the substrata. Characterization of sediments results has been found to be in reflection in the long term quality situation of aquatic ecosystems, independent of current status of surface water (Haslam, 1990), in the fresh water environment, toxic metals are accumulated in sediment and biota, they are threat to aquatic organisms because they are poisonous in nature even in reduced concentration and subsequently transferred to man through food chain. Eroded soil material constituents is a dangerous contaminants because of the toxicity it carries, adsorbed to the particle surface. Inorganic contaminants in aquatic system are usually monitored by evaluating the concentration in sediments water bodies and biota (Saeed and Shaker, 2008., Anegbe *et al.,* 2019). Assessing sediments quantities have been reported to be good indicator of pollutants. The effects of contaminants in the aquatic life have been documented (Calamari and Naeva,1994). The current study was to assess the distribution and risk assessment of inorganic contaminant in sapele section of Ethiope River sediment, this river serve as transportation for log, water supply, source of fish and edible benthis to the inhabitant of the city. Numerous authors have adopted the use of inorganic contaminants concentration to determine the effect of of sediment on aquatic ecosystem, this suggest that that all forms of inorganic contaminants have the same effect on marine environments, which is not entirely correct (Wangboje*et al.*, 2014). In this study, inorganic contaminants sequential partitioning was adopted because it provides contaminants mobility and boiavalabilty of sediments.

Materials and Methods

Ethiope River lies between latitude 6^{o}31 and 6^{o}30N and longitude 500-600E, sediment samples were obtained from four locations in Sapele section of Ethiope river, namely Ogoro location (1), Saw mill location (2), onumaro location (3) and Uguaja location (4). Eckman graps apparatus were used to collect the sediment samples. Samples were stored in polythene bag that was previously cleansed with 5% nitric acid and washed with distilled water. In the laboratory samples were air dried before extraction and characterization.

Sediments Analysis

Soil pH was analyze using pH meter according to Ugbune *et al.,* 2021, inorganic contaminants (heavy metals) was determine by sequential extraction methods in order to asses the level of inorganic contaminants in the following operational partitions (fractions), these are exchangeable, carbonate-bound , Fe-Mn oxide, organic/ sulphide and residual fraction. The details methods has been described (Tessier *et al*., 1979., Moalla *et al*., 1998., Saenz *et al*., 2003., Lin *et al*., 2009). The concentration of various fraction were determined using atomic absorption spectrometer (Buck Scientific VGP 210 model).

Determination of Bioavailalbility/ Mobility of inorganic contaminants in Sediments

Inorganic contaminants bioavailability in sediment was determined using relative inorganic contaminant mobility factor, MF (Cezary and Bai, 2001).

$$MF=\frac{F1+F2+F4}{F1+F2+F3+F4+F5}x\frac{100}{1}$$

Where F1-F5= percentage of geochemical forms of the inorganic contaminants

Determination of Environmental Risk Factor (ERF) for Inorganic Contaminants

In order to confirm the potential threat of inorganic contaminants to marine organisms, Enviromental Risk Factor (ERF) was adopted (Saenz *et al*., 2003).

ERF =CSQV-Ci/CSQV

Where CSQV = Concentration of sediment quality value (Inorganic contaminants concentration in residual partition of sediment which is equivalent to the background/pre-industrial concentration).

Ci = Inorganic contaminant concentration in the first four partitions of sediment.

ERF < 0 = potential threat to marine organisms recorded; ERF > 0 = no potential threat to marine organisms recorded.

Determination of Contamination Factor (CF) for Sediment

The contamination factor (CF) was determined as;

CF = Inorganic contaminants concentration in sediment/ Background concentration of inorganic contaminant in sediments (Lin *et al*., 2009).

CF > 1= contaminated by inorganic contaminant, if CF < 1 = not contaminated by inorganic contaminant, 1<CF<3 = moderately contaminated by inorganic contaminant, 3 < CF < 6 considerably contaminated by contaminant, CF >6 = high contamination.

RESULTS AND DISCUSSION

The result of pH is given in Table 1, the result of pH obtained from river Ethiope

Table 1: Level of pH in sediment

Location	1	2	3	4	5
pH	6.8	6.5	6.6	6.4	6.5

Sediment is below the pH previously reported in river Nile sediment (Mostafa *et al.,* 2019). The pH in all the location are slightly acidic, this is an indication of low level of phosphate and nitrate effluent in the river. Slightly low pH of the study sediment is a pointer that metal contaminants will be moderately mobile, low pH of soil/ sediment has been reported as one of the major physiochemical properties that increase the mobility of inorganic contaminants in soil/ sediment (Ugbune and Okuo, 2011).

Total Metal concentration in Sediment

In the present study, the inorganic contaminants assessed in sediment are cadmium (Cd), nickel (Ni), manganese (Mn), lead (Pb), chromium (Cr) and iron (Fe), the inorganic contaminants follow the order: Pb<Cd<Cr<Ni<Zn<Fe. The inorganic contaminants concentration (heavy metal concentration) of sediment in this research work is lower than the earlier reports of Ikpoba sediment (Wangboje *et al.,* 2014), except in Sapele market location sediment. The higher concentration of sediment in this study area may be as a result of storm water run- off from electronic wastes dump.

Geochemical Partitioning of Inorganic Contaminants in Sediments

Geochemical partition of inorganic contaminant in sediment is depicted in Table 2, geochemical partitioning of contaminants provide predicative insight on the bioavailable and fate of inorganic contaminants associated with organic bounds, Fe-mn oxide and residual partitioning are not readily bioavailable because these partitioning are strongly bound.

Table 2: **Geochemical Partitioning of Inorganic Contaminants (Pb) in Sediments**

Fractions	Location 1	Location 2	Location 3	Location 4
F1	1.06	7.24	6.61	6.54
F2	11.20	7.28	6.20	6.61
F3	11.28	8.29	7.84	7.28
F4	9.26	6.24	6.61	6.24
F5	9.27	6.29	6.23	6.29
Metal Conc. (mg/kg)	51.63	35.34	33.7	32.96

Table 3: **Geochemical Partitioning of Inorganic Contaminants (Cd) in Sediments**

Fractions	Location 1	Location 2	Location 3	Location 4
F1	0.32	0.31	0.26	0.34
F2	0.29	0.29	0.28	0.37
F3	0.36	0.30	0.27	0.29
F4	0.34	0.32	0.29	0.40
F5	0.29	0.29	0.28	0.31
Metal Conc. (mg/kg)	1.60	1.51	1.36	1.71

Table 4: **Geochemical Partitioning of Inorganic Contaminants (Mn) in Sediments**

Fractions	Location 1	Location 2	Location 3	Location 4
F1	9.12	0.74	0.79	0.80
F2	9.28	0.79	0.85	0.82
F3	10.26	0.83	0.86	0.82
F4	9.98	0.80	0.84	0.79
F5	11.26	0.94	0.89	0.91
Metal Conc. (mg/kg)	50.04	4.10	4.23	4.12

Table 5: **Geochemical Partitioning of Inorganic Contaminants (Cr) in Sediments**

Fractions	Location 1	Location 2	Location 3	Location 4
F1	0.39	0.41	0.46	0.44
F2	0.46	0.44	0.45	0.39
F3	0.38	0.42	0.44	0.45
F4	0.47	0.39	0.42	0.42
F5	0.48	0.48	0.47	0.47
Metal Conc. (mg/kg)	2.18	2.14	2.24	2.17

Table 6: **Geochemical Partitioning of Inorganic Contaminants (Ni) in Sediments**

Fractions	Location 1	Location 2	Location 3	Location 4
F1	2.22	1.68	1.70	1.75
F2	2.20	1.71	1.69	1.81
F3	2.14	1.69	1.68	1.78
F4	2.35	1.81	1.75	1.92
F5	1.98	1.62	1.73	1.91
Metal Conc. (mg/kg)	10.87	8.51	8.55	9.17

Table 7: **Geochemical Partitioning of Inorganic Contaminants (Fe) in Sediments**

Fractions	Location 1	Location 2	Location 3	Location 4
F1	614.11	621.40	826.41	871.42
F2	632.70	631.11	821.62	868.16
F3	648.40	642.48	841.21	896.21
F4	631.00	615.21	621.71	874.15
F5	642.16	628.41	874.15	881.22
Metal Conc. (mg/kg)	3168.37	3138.61	3938.36	4391.16

Inorganic detachment into soil solution depends on depletion of mineral, decomposition as well as oxidation of organic matter (Ikhuoria *et al.,* 2010) and pH of sediment (Ugbune, 2011). In this study Cd was mostly associated with Fe-Mn oxide partition of sediment followed by organic partition (Table 3). The predominantly association of Cd in this fraction is an indication that Cd will not be readily bioavailable. Copper in the study sediment is strongly associated with organic/sulphide partition and closely rank by residual fraction.

Iron is abundant in earth crust and soluble in water especially the ferric and ferrous forms and this contribute extensively to the high concentration in soil and sediment. Sediment iron of this research is highly associated with Fe-mn oxide partition followed by residual partition, this result conformed with previous results of Wangboje *et al.,* 2014. Sources of this contaminants in sediment may be from runoff water from artisan workshop. Calamari and Naev, 1994, Wangboje *et al.,* 2014 asserted that man made sources of iron contaminants in water and sediment include iron rode, fossil fuel, refineries and paints.

In the same vein, Zinc in study sediment was also associated with Fe-Mn oxide closely rank by the residual partition, the anthropogenic sources of Zn include batteries, electric components and pesticide (Calamari and Naev, 1994).

In other hand, Cr in this sediment is associated with residual partition closely followed by carbonate partition. The association of Cr in the residual fraction is an indication of bioavailability of this contaminant in river Ethiope sediment. This will pose a serious threat to aquatic organisms.

Lead in the sediment is found in Fe-mn oxide partition, this is an indication that lead is bioavailable and therefore will not pose danger to marine organisms.

Mobility Factor

Mobilty factor (MF) of contaminants sediment explained the potential mobility of inorganic contaminants. Inorganic contaminants with high mobility factor have been said as symptom of high bioavalability in and sediments (Ugbune *et al.,* 2018., Ugbune *et al.,* 2021) The mobility factor of Pb, Cd, Mn, Cr, Ni, Fe ranges from 46.67 to 64.54, 58.48 to 60.63, 57.27 to 59.22, 56.42 to 60.26, 58.23 to 60.35, 59.81 to 63.20 respectively.

Table 8: Mobility Factor of Sediment

Locations	Pb	Cd	Mn	Cr	Ni	Fe
1	46.67	60.63	57.27	56.42	60.35	59.81
2	64.54	59.60	57.56	59.93	59.70	60.37
3	61.28	59.56	59.10	60.26	59.30	63.20
4	61.98	58.48	59.22	58.97	58.23	60.02

This an indication that some of the metal is relatively mobile in sediment and bioavailable . This is an agreement with the reports of Wangboje *et al.,* 2014 in Ikpoba sediment.

Environmental Risk Factor (ERF) for Inorganic Contaminants

Environmntal risk factor of Pb, Cd, Mn, Cr, Ni and Fe in sediment is between -3.62 to -3.24, -3.52 to -2.81, -2.53 to -2.36, -2.77 to -2.45, -3.25 to -2.80 and -3.00 to -2.76 respectively.

Table 9**: Environmental Risk Factor (ERF) for Inorganic Contaminants**

Locations	Pb	Cd	Mn	Cr	Ni	Fe
1	-3.57	-3.52	-2.44	-2.54	-3.49	-2.93
2	-3.62	-3.21	-2.36	-2.45	-3.25	-3.00
3	-3.41	-2.86	-2.75	-2.77	-2.96	-2.76
4	-3.24	-3.52	-2.53	2.62	-2.80	-2.98

Lead has the lowest value in all the sample sediments. Result of sample sediments of ERF value is a reflection of threat to marine organisms. Environmental risk factor of the sediment result is similar with earlier work of Akan *et al.,* 2010 who reported ERF value greater than zero in urban area sediment, this is an indication of high anthropogenic wastes in Ethiope river sediment arising from storm water run-off.

Contamination Factor (CF)

In the study sediment, the contamination factor (CF) is less than 6 in all the sediments samples (Table 10).

Table 10**: Contamination Factor (CF) of Sediment**

Locations	Pb	Cd	Mn	Cr	Ni	Fe
1	4.56	4.52	3.44	3.54	4.49	3.93
2	4.62	4.21	3.36	3.45	4.25	3.99
3	4.41	3.86	3.75	3.77	3.94	3.76
4	4.24	4.52	3.53	3.62	3.80	3.98

This is an evidence of considerably contaminated by inorganic contaminants in the sediment for almost all the location . Sample locations is a densely populated area with presence of artisans and sawmill, this may impact man-made waste to the aquatic system. Akan *et., al.,* 2010., Wangbojee*t al.,* 2014 reported that sediment close to urban areas is known to contained high concentration of of inorganic contaminants due to man-made activities.

CONCLUSION

Geochemical partition of Ethiope river sediments shows various degree of contamination of heavy metals. The partitioned of metals revealed that Cd, Pb, Mn were associated with Fe-Mn oxide partition while Cu, Ni were principally associated with organic fraction. Manganese and chromium was found to be associated with residual fraction. Indices of pollution used in this research suggest that the sediment is contaminated by inorganic contaminants (Pb, Cd, Mn, Cr, Ni, Fe), the contaminants exceed unity. Indices of pollution also revealed that Cd will posed potential risk to aquatic marine organisms among assessed metals. It is therefore recommended that Ministry of Environmental should routinely monitore Ethiope river sediment to ensure there is source reduction.

REFERENCES

Akan, J.C., Abdulrahman, F.I., Sodipo, A.E., Ochanya, A.E and Askira, Y.K (2010). Heavy metals in sediments from river Ngada, Maiduguri metropolis, Borno state, Nigeria. *Journal of Environmental Chemistry and Ecotoxicology*, 2 (9): 131-140.

Anegbe, B., Okuo J.M., Okieimen F.E and Ugbune U. (2019). Levels of heavy metals in soil

Calamari, D and Naeva, H. (1994). Review of pollution in the African aquatic environment. Committee for Inland fisheries of Africa technical paper No. 25, F.A.O., Rome, 188.

Cezary, K and Bai, N.S (2001). Fractionation and mobility of copper, lead and zinc in the vicinity of copper smelter. *Journal of Environmental Quality*, 30: 485-492.

Environmental Chemistry 3(1) 7- 17.

Garzanti, E., Ando, S., France-Lenard, C., Vezzoli, P.C., Galy, V., Najman, Y. (2010). Mineralogy and chemicallvarability of fluvia sediments 1. Bedload Island (gang-Brahmapula, Bangladesh), *Earth Planet Science Letter*, 299, 368-381.

Haslam, M (1990). River pollution: An ecological perspective. Belhaven press. London, 253

Ikhuoria, E.U., Urunmatsoma, S.O.P and Okieimen, F.E (2010). Preliminary investigation of chemical fractionation and heavy metal accumulation in plant maize (*Zea mays*) grown on CCA contaminated soil amended with poultry droping. *African Journal of Biotechnology.*9(18): 2675-2682.

Lin, J., Cal., M., Qi, A., and Hu, H (2009). Contamination levels and speciation of heavy metals in sediments from Yundang Lake, Xiamen, ICECS Secon international Conference on Environmental and Computer Science, 28-30 December, 48-52.

Moalla, S.M.S., Awadallah, R.M., Rashed, M.N. and Sultan.M.E. (1998). Distribution and chemical fractionation of some heavy metal in bottom sediments of Lake Nasser. *Hydrology,* 364 (1):31.40.

Mostafa, A., Salman, A.S., Seleem, E.M., Elinazer, A.A., Al-Gamal, A. G., Tacher, A.E and Mansour, H. (2019). Quality assessment of river Nile sediment between Qena and Sohag Citie, Egypt. *Journal of Environmental Science and Technology*, 12 (3): 117-124

Saenz, M.,Blasco, J and Gomez-parra, A. (2003).Speciation of heavy metals in sediments of three coastal ecosystems in the Gulf of Cadiz, southwest Iberian Peninsula.*Environmental Toxicology and Chemistry*, 22(12): 2833-39432.

sample from active automobile workshop in Benin City. *International Journal*

Tessier, A., Campbell, P.G.C and Bussan, M. (1979). Sequential extraction procedure for the separation of particulate trace metals. *Analytical Chemistry*, 517(17): 844-851.

Ugbune, U and Okuo, J.M. (2011). Sequential fractionation and distribution of heavy metals in soil from battery work sites. *Nigeria Journal of Applied Science*, 29, 132-141

Ugbune, U**.,** Kpomah, B., Idu, T.E., Emakunu, S.O (202l). Synergistic effect of poultry dropping and poultry dropping biochar on inorganic contaminants. *Fupre Journal of sciencientific and Industrial Research,5 (1):83-100.*

Ugbune, U., Okuo, J.M and Idu, T.E (2018). Impact of carbonized briquette on the fractionation of trace metals in dumpsite soils. *Chemical Science Int. Journal, 25(2):1-8*

Wangboje, O.M., Oronsaye, J.A.O., Okieimen, F.E and Oguzie., F.A (2014). Chemical fractionation of heavy metals in the sediments of the Ikboba reservoir, Benin city, Nigeria. *Nigerian Journal of Applied Science*,32, 241-254.