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Full Length Research Paper

Spatial Distribution of Heavy Metals in Sediments from Imo River Owerrinta Environs Imo State Nigeria.

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Abstract
Concentrations of five (5) parameters (pH, Pb, Cd, Fe and Zn) in surface sediments from Imo river were determined for April and July at three (3) sampling locations to evaluate their presence and spatial distributions. Imo river receives effluent discharges from paper mill industry. The range of the measured concentrations in the sediments is as follows:7.62-7.76mg/l for pH, 0.78-1.14mg/l Pb,1.60-2.02mg/l Cd, 1.01-1.20mg/l for Fe and 1.87-2.85mg/l for Zn. Most of the parameters had no significant correlation expect for Fe and Pb, Zn and Fe(r=0.05) while geo accumulation index for Fe and Zn were considered moderately to strongly polluted at (1.60 $I_{geo.}$ <2.02) and (1.92 I_{geo} <2.85) for April and July respectively. These parameters were higher than FEPA standard when compared. If future occurrences are not checked, the carrying capacity of the river could be exceeded and this would eventually pose serious human and ecological risk to local residents.

Keywords: *Contamination, Effluent, Geoaccumulation, Heavy Metals, Sediments*

Introduction

Heavy metal is a general collective term which applies to the group of metals and metalloids with atomic density greater than 4g/cm^3 (Daffus, 2002). They are natural components in soils (Lasat,2000). Some of these metals are micronutrients necessary for plant growth such as Zn, Cu, Mn, Ni and Co while others have unknown biological functions such as Cd, Pb and Hg (Gaur etal, 2004). Consequently, heavy metals are emitted to the environment from variety of anthropogenic sources to supplement natural background geochemical sources. The amounts of most heavy metals deposited to the surface of the earth are many times greater than the depositions from natural background sources. Metals that are naturally introduced into the river come primarily from such sources as rock weathering, soil erosion, or the dissolution of water-soluble salts. Natural occurring metals move through aquatic environments independently of human activities, usually without any detrimental effects. However, the metals introduced by human activities have affected water and sediment quality of most rivers. As such, heavy metal contamination in aquatic environment is of critical concern due to toxicity of metals and there accumulation in aquatic habitats. Heavy metals being non-biodegradable can be concentrated along the food chain, producing their toxic effects at points far from the source of pollution (Tilzer and khondker, 1993). Although, Some of these metals are essential for proper metabolism in all living organisms yet toxic at high concentration; other metals such as Cd, Hg, As and Pb are non-essential and therefore have toxic effects on living organisms (Burger, 2002). Metal pollution has harmful effects on biological systems and does not undergo biodegradation. Toxic heavy metals such as Pb, Co, Cd can be differentiated from other pollutants since they cannot be biodegraded but can be accumulated in living organisms, thus causing various diseases and disorders even in relatively lower concentrations (Pehlivan, 2009).

Contaminated sediments are of great concern to humans and wildlife that live within the ambits of Imo river basin. No doubt, years of industrial and municipal discharges and agricultural non-point source runoff have contributed to the creation of vast amount of highly polluted sediments that pose serious human and ecological health risk. Sediments near urban areas commonly contain high levels of contaminants (Cook and Well, 1996; Lamberson et al, 1992) which constitute a major environmental problem faced by many human induced aquatic environments (Magalhaes et al, 2007).

Sediments are loose unconsolidated particles that make up sediment quality and may originate in soil worn away by physical and chemical erosion, or they may come from the decomposition of shells or wood chips. It is interesting to note that in areas of slow moving water, sediments sink and accumulate on the bottom of lakes and rivers.

Sediments are ecologically important components of the aquatic habitat which play a significant role in maintaining the trophic status of any water body (Singh et al,1997). Sediments represent significant sources of heavy metal pollution in aquatic environment as a result of size of the source and adsorption, the physico-chemical characteristics of the environment (e.g, pH, water hardness and redox potential) and the concentration of other metals and complex chemicals present in the soil water, river or sediment. Sediment is the major depository of metals, in some cases holding more than 99 percent of total amount of a metal present in the aquatic system (Odiete, 1999). Overwhelming evidence supports the theory that toxics trapped in sediment can adversely impact humans and the environment. By a process known as biomagnifications, the toxics contained in bottom sediments can increase exponentially in concentration at every level of the food chain, starting with the sediment dwelling benthos, continuing to fish and eventually reaching birds of prey, mammals and even humans. This bioaccumulation of sediment pollutants in fish is one way for humans to become affected by the contaminants. Heavy metals being recalcitrant can persist in the environment and may become concentrated up to food chain (Eja et al.,2003) leading to enhanced levels in liver and mussel tissues of fish (Eja et al., 2003).

Considering the massive use of the river by communities of Owerrinta, Umuocheala ,Umuika and Umuolo for drinking, fishing, domestic and recreational activities, it became imperative to assess and measure the concentration of heavy metals in surface sediments and the pollution status of Imo river.

Materials and Methods

Study area

The study area Owerrinta is located in the Niger Delta basin of Nigeria .The modern Niger Delta started its growth after the Paleocene transgression which was followed by a cycle of deposition in Eocene and confirmed till the present day (Hosper, 1965). The local geological setting of Owerrinta indicates that it falls within the Benin formation which consists of friable sands with interrelations of shale/clay lenses and some isolated units of gravels, conglomerates and very coarse sandstones (Ananaba et al., 1993). It is Pliocene to Micone in age and has a mean thickness of about 800m around the study area (Avbovbo, 1978). The surface geology of Owerrinta area is characterized by ferruginised sands that are occasionally pebbly and massively bedded.

Owerrinta is drained by the Imo River which is a major fresh water centric system in southern Nigeria. The geological setting and activities (industrial input, fishing and farming) around and within the Imo River are major factors that modify the chemistry of the Imo River ecosystem. The modification of the river chemistry is capable of altering its resource status and usefulness. This calls for constant assessment of the bio-chemical and physical characteristics of the river.

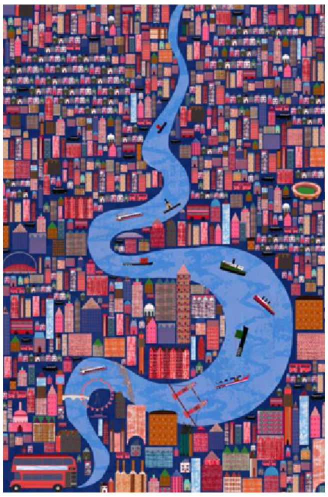

Figure 1: Picture showing the direction of river

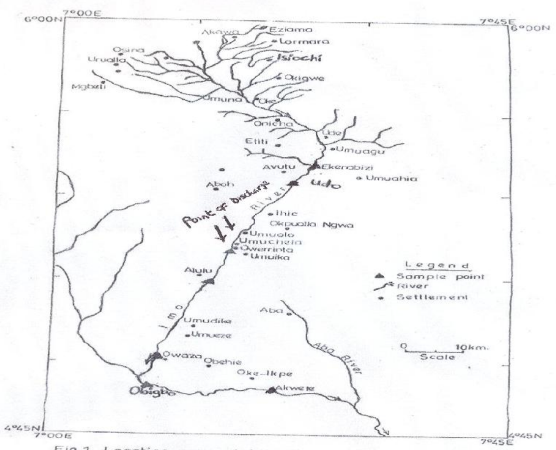

Fig.1 Location map of Imo River showing the sampling points.

Three sampling points were established to cover possible pristine and impacted areas along the river course. The sampling points are: upstream, 700m from point of discharge of the paper mill effluent, point two(2) located 10m from the point of discharge while point three(3) located downstream about 1010m from point of discharge.

River sediments samples were collected at various sampling point and analyzed for Cadmium (Cd), Lead (Pb), Zinc(Zn) and Iron(Fe). Sediments were gathered with Ekman grab sampler. The contents of the sampler were emptied into a clean glass tray and homogenized with a plastic spatula prior to placing into containers.

Sample Preparation

Sediment samples were air-dried, crushed, sieved and 5g of samples were digested with 1.1 HNO_3 and H_2SO_4. Solution was filtered and the filtrate made up of 100ml.

The solution was then used for the heavy metal analysis. Spectrophotometric methods were used for the various metals according to standard methods (APHA, 1971) using the SPECTRUMLAB-22PC and the following procedures and at the following wavelengths:

Metal	Reagent	Wavelength
Cadmium	Dithizone	518nm
Lead	Dithizone	520nm
Zinc	Dithizone	535nm
Iron	Phenanthroline	510nm

Statistical Analysis

SPSS version 17 was utilized for this analysis. To statistically evaluate the data, correlation analysis and one-way analysis of variance (ANOVA) ($P<0.05$) was employed to understand the relationship between heavy metals in sediments and other parameters.

Results and Discussion

Table 1. : Variation of sediment quality parameters at sampling points (April)

Sampling point	pH	Pb	Fe	Cd	Zn
A	7.62	**1.10**	**1.60**	**1.20**	**2.85**
B	**7.76**	**1.05**	**1.85**	**1.10**	**2.72**
C	**7.69**	**2.02**	**1.08**	**1.92**	**1.92**
FEPA Limit	**6-6.9**	**< 1.0**	**2.0**	**<1.0**	**<1.0**

Table 2.: Variation of sediment quality parameters at sampling points (July)

Sampling point	pH	Pb	Fe	Cd	Zn
A	7.61	1.14	1.42	1.07	2.04
B	7.72	1.08	1.67	1.08	2.57
C	7.67	0.82	2.01	1.01	1.87
FEPA Limit	6-6.9	< 1.0	2.0	<1.0	<1.0

Table 3: Descriptive statistics of parameters

Parameter	Mean	Max	Min	Range	SD
pH	7.69	7.72	7.62	0.14	0.17
Pb	1.39	2.02	1.60	0.42	0.30
Fe	1.51	1.20	1.08	0.12	0.10
Cd	1.40	2.85	1.92	0.93	0.42
Zn	2.50	2.85	1.92	0.93	0.32

The result of the analysis of Imo river sediment samples collected from the sampling stations in the study area for the periods of April and July, 2011 are presented in the tables 1.0 and 1.1 above.

In April, prior to receiving effluents, the sediment quality at point A, had pH of 7.62 and with the following concentrations of heavy metals is as follow: 2.85mg/l for Zn, 1.05mg/l for Pb, 1.85mg/l for Fe and 1.10mg/l for Cd. Upon receiving effluents, the sediment quality parameter significantly varied. Having pH increased to 7.76 with the values 2.72 for Zn, 1.05 for Pb, 1.85 for Fe and 1.10 for Cd

At point C, downstream the (about 1010m from the point of effluent discharge) the values exponentially dropped as sediment quality gradually assumed its original status of the upstream point(fig1). The mean content for pH was 7.69 while arranging the metals from higher to lower mean content was Zn>Fe>Cd>Pb.

In July, which was the peak of rains, a similar trend was observed at different points(fig2) Values were lower at the upstream (point A): 1.14mg/l for Pb,1.42mg/l for Fe,1.07 for Cd and 2.04 for Zn. High immediately after the point of discharge (point B): 1.08mg/l for Pb,1.67mg/l for Fe, 1.08mg/l for Cd and 2.57mg/l for Zn then exponentially decreased again at point C: 0.82mg/l for Pb,2.01mg/l for Fe,1.01mg/l for Cd and 1.87mg/l for Zn. Also, the mean content for pH was 7.67 while arranging the metals from higher to lower mean content was Zn>Fe>Cd>Pb. However, it was observed that higher values of heavy metals were recorded in July than in April.

The Pearson's correlation coefficient matrix amongst the heavy metal under investigation is presented in Table 1.2 below. Significant correlation between Fe and Pb (r= 0.012) and Zn and Fe(r=0.470) were observed. However, eight (80) percent of the contaminants were without correlation.

Table 4: Correlation matrix between pH and heavy metals in sediment samples from the Imo river.

Parameter	pH	Pb	Fe	Cd	Zn
Pb	0.700				
Fe	0.273	0.012*			
Cd	0.662	0.299	0.400		
Zn	0.644	0.149	470*	0.066	

** Correlation is significant at the 0.05 level (2-tailed).*

Using Muller's classification for the geo accumulation Index(Muller, 1981) in Table 1.4 presented below, it could be observed that Pb can be considered as being unpolluted to moderately polluted at the three(3) location under investigation(0.78 I_{geo}<2) while Cd is considered moderately polluted(1.08 *I*geo<1.2). Fe and Zn are considered as being moderately to strongly polluted at (1.60 I_{geo}<2.02) and(1.92 I_{geo}<2.85) respectively.

Table 5: Muller's classification for the geo accumulation Index (Muller, 1981)

Value I_{geo}	Class	Quality of sediment
< 0	0	Unpolluted
0-1	1	From unpolluted to moderately polluted
1-2	2	Moderately polluted
2-3	3	From moderately to strongly polluted
3-4	4	Strongly polluted
4-5	5	From strong to extremely polluted
> 6	6	Extremely polluted

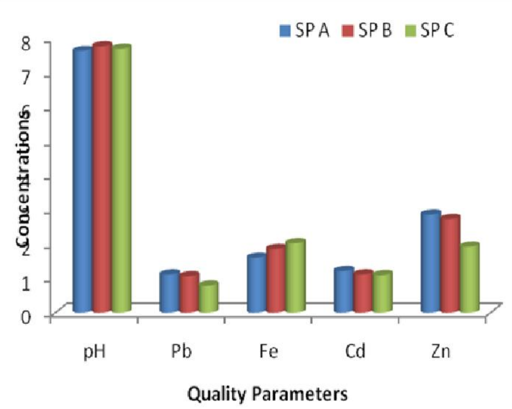

Fig. 1. Spatial variation in concentrations of sediment parameters in April

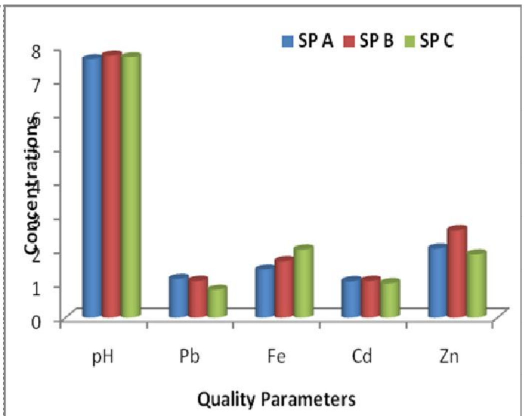

Fig. 2. Spatial variation in concentrations of sediment parameters in July

Discussion

From the results of the study shown in tables 1.0 and 2.0, it would be observed that the average concentrations of heavy metals before effluent discharge was lower than the average concentration of effluent after discharge for the two months under investigation(April and July). This invariably implied that elevated concentration was mostly originated from the paper mill industrial discharge into the river. Although, runoff due to rainfall and natural input also have contributing impact to heavy metal contamination. However, self purification was observed from point C when the values of Pb and Cd reduced exponentially for both months owing to the potential ability of the river to recover from the impact. Although Fe and Zn were said to be partially elevated even after recovery. This phenomenon could be attributed to geochemical input originating from natural background rather than anthropogenic source. This is further substantiated by significant correlation between Zn and Fe at P<0.05(table 4.0).
Also, on the basis of Muller's classification values of $I_{geo,}$ Fe and Zn are considered moderately to strongly polluted at (1.60 $I_{geo,}$<2.02) and (1.92 I_{geo} <2.85) for April and July respectively. This phenomenon is said to constitute a major environmental problem faced by many human induced aquatic environment (Magalhaes et al, 2007)

The standard deviation (SD) of the study has also shown that the concentration of the metals at different sampling locations is relatively uniform in spatial distribution (tables 3).

Conclusion

The result of this study shows that the concentration of heavy metals is higher than the guidelines set by Federal Environmental Protection Agency (FEPA). However, the river has some good measures of potential ability to recover from previous impact. If future occurrences are not checked, the carrying capacity of the river could be exceeded and this would eventually pose serious human and ecological risk to local residents.

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