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Assessment of Pre-Dregding levels of Heavy Metal Pollution in Sediments of Otamiri River, IMO State of Nigeria

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Abstract

The distribution, controlling geochemical factors and contamination status of heavy metals in sediments of Otamiri River in Owerri, Imo State of Nigeria, were investigated. Two groups of bed sediments samples were collected from three sites during February 2008 and June 2008. The samples were analyzed to determine their heavy metals (Cd, Pb, Ni, Zn, Cu, Fe and Cr), pH and Total organic carbon (TOC %) content. The results showed that the heavy metal concentrations were slightly higher in February than those sampled in June. The results also showed that metal content are directly correlated to TOC%. Environmental assessment of sediments pollution by heavy metal was carried out using geo-accumulation index (I_{geo}) and comparison with Canadian, Dutch and German targets for sediment quality Guidelines. The results indicated that natural processes such as weathering and erosion of bedrock are the main supply sources of heavy metals in sediments of Otamiri Rivers near Owerri, as the sediments were noted to be in unpolluted or excellent state.

Keywords: Heavy metal, sediment, contamination status, geoaccumulation index, otamiri river.

Introduction

Heavy metals are among the most common environmental pollutants and their occurrence in waters and biota indicate the presence of natural or anthropogenic sources. The existence of trace metals in aquatic environments has led to serious concerns about their influence on plant and animal life[1, 2].

Study on the geochemistry of the River sediments in the present study area has not been undertaken by previous workers so far. However, the surface water chemistry of the river has received wide attention in the recent past. Commendable work in the line was done in 1998[3]. River borne sediments, especially the suspended matter, act as a major carrier and source of heavy metals in the aquatic system. Geochemical study of sediments to evaluate the concentration of heavy metals is necessary as it helps to assess the ecotoxic potential of the river sediments.

Material and Methods

Study Area: The study was conducted within the stretch of Otamiri River, (7^{o}2E, 5^{o}27N) which originated from Egbu in Owerri North and flows through (Nekede, Ihiagwa, FUTO) in Imo State of Nigeria. This River meandered its way to Ozuzu in Etche town of Rivers State of Nigeria where it finally joins the Atlantic Ocean.

Sample Collection: For the purpose of this study, three sample stations 1, 2 and 3 were established on the river. Station 1 was established at reservoir base. Station 2 after Aba Road about 2km downstream of station 1, where there is massive solid waste dump and also after the confluence point a tributary river (Nworie). Station 3 at Nekede, about 3km downstream of station 2 and receives effluents 4m a tributary river (Nworie). The sampling campaign was carried out in February 2008 and June 2008. Surface sediment samples were collected with Eckman grab into plastic bags previously cleaned and preserved with 5 ml of dilute Hydrochloric acid. The samples were wrapped in aluminium foils, stored in an ice chest before being taken to the laboratory for analysis.

Treatment and Sample Analysis: Sediment sample were dried at about 105^{o}C in an oven to constant weight and ground to powder and then sieved through 0.5mm sieve to remove coarse materials. Digestions of all powdered sediment were according to[4,5]. One gram of each sample were digested using 1.5.1 mixture of perchloric acid, conc. HNO_3 and conc. H_2SO_4 in a fume chamber at 80^{o}C until a colourless liquid was obtained. Each digested sediment was analyzed for the listed heavy metals (Cd, Pb, Ni, Zn, Cu, Fe and Cr) at their respective resonance line using atomic absorption spectrophotometer. The sediment pH was determined by mixing dry sediment with distilled water[6]. Total organic carbon (TOC %) was determined by Walkey and Black method[7]. Statistical Analysis using student's t-test were applied to study the seasoned variation and the metal contents and their correlation in the bed sediments Ms-Excel 2007 and Data analysis soft wares. I_{geo} for the sediment was also done in order to classify the pollution intensity of the sediment.

Geoaccumcation Index (I_{geo}): Geoaccumcation index was also used to assess metal pollution in sediments besides enrichments factor[8]. Geoaccumulation index is expressed below

$I_{geo} = \log_2 (Cn/1.5Bn)$

Where Cn = measured concentration of heavy metals in sediments, Bn = Geochemical background values in average shale, of element, and 1.5 is the background matrix correction, a factor due to lithogenic effects[9].

Table-1, shows the geoaccumulation index which includes seven grades.

It includes various degrees of enrichment above the background value ranging from unpolluted to very polluted sediment quality. The high grade (Class six) reflects 100 folds enrichment above the background values[10].

Results and Discussion

The results show very low concentration of Cd, Cu and Cr accross the sample stations and values are below the detection limit of the machine and background values of the upper earth crust.

The concentration of Pb and Fe were highest at station 2, above the mean values of 0.47mg/kg and 234.38 mg/kg respectfully for all the stations in February and almost similar trend was also observed in October. The concentration of Nickel (Ni) was highest at station 1 above the mean values of 2.35mg/kg for all the stations in February and almost similar trend was also observed in October. The concentration of Zn was highest at stations 2 during February but its value was highest at station 3 during October. This shows that the heavy metal's concentration in the sediment follows almost similar pattern in the two seasons. The results also shows that the heavy metal concentration in the sediment across the three stations is in the order SS2 > SS1 > SS3. Station 2 is just located after the confluence point downstream of station 3, hence, the combined influx of accumulated sediment from dumpsite and Nworie, and land use system must have led to the highest values for station 2 and further dispersion downstream to station 3.

The relatively high concentration of Fe over other metals is due to the reported high level of Fe in the upper earth crust of Southern Nigeria.

General assessment was conducted by comparing the average total heavy metals concentration with the permissible values of different sediment quality objectives (table 2). The results of this simple comparison revealed that, the Otamiri bed sediment concentrations of heavy metals are within the permissible limits of standards during February and October. However, this comparison with the sediments quality objectives might not be sufficient for assessment of pollution levels in bottom sediments of the area under study. Therefore, another assessment method was applied using certain indices to access the environmental impacts on sediments. This index is the Geoaccumulation index (I_{geo}).

The average I_{geo} of sediments across the sample stations show that the River sediments are in unpolluted and excellent condition, for both seasons.

From the results of the one-way ANOVA across the ROW, since the F value (calculated) is less than the F value (critical) there is no significant difference in the variance of all the metals at each of the sample stations. From the results of the one-way ANOVA across the COLUMN, since the F value (calculated) is greater than the F value (critical) there is significant difference in the variance of each the metals accross of the sample stations.

Table-1
Geoaccumulation Index of Heavy Metal concentration in sediment

I_{geo}	Class	Pollution Intensity
≤ 0	0	Background concentration
0-1	1	unpolluted
1-2	2	moderately to unpolluted
2-4	3	moderately polluted
3-4	4	moderately, to highly polluted
4-5	5	Highly polluted
>5	6	very highly polluted

Source[10].

Table-2
Comparison between the heavy metals in the bottom sediment of the Otamiri River and quality objectives (mg/kg)

Quality Objective	Cd	Zn	Cr	Cu	Ni	Pb
Canadian target [11]	0.6	123	37	36		35
Dutch target [11]	0.8	140	100	36	35	85
German target [12]	1.2	200	100	60	50	100
Otamiri river bed sediment	<0.001	10.47-11.30	<0.001	<0.001	2.15-2.35	0.37-0.47

Source[11, 12.]

Table-3
Pre-Dredging Data for Some Heavy Metals in Sediments Dry Session in mg/kg

	Cd	Pb	Ni	Zn	Cu	Fe	Cr	TOC%	pH
SS1	<0.001	0.52	2.79	7.51	<0.001	261.17	<0.001	2.87	6.31
SS2	<0.001	0.83	2.17	13.4	<0.001	284.64	<0.001	2.01	6.4
SS3	<0.001	0.07	2.1	12.89	<0.001	157.32	<0.001	2.11	6.6

Table-4
Pre-Dredging Data for Some Heavy Metals in Sediments Rainy Session in mg/kg

	Cd	Pb	Ni	Zn	Cu	Fe	Cr	TOC%	pH
SS1	<0.001	0.42	2.66	6.3	<0.001	251.52	<0.001	2.81	6.4
SS2	<0.001	0.63	1.83	12.01	<0.001	268.3	<0.001	1.96	6.3
SS3	<0.001	0.05	1.95	13.1	<0.001	143.81	<0.001	1.97	6.5

Table-5
Geoaccumulation Index for Pre-Dredging Sediment (Dry)

	Cd	Pb	Ni	Zn	Cu	Cr	Fe	Average
SS1	-8.82	-5.18	-5.2	-3.41	-16.04	-17.04	5.33	-7.19429
SS2	-8.82	-5.85	-5.19	-4.25	-16.04	-17.04	5.2	-7.42714
SS3	-8.82	-8.74	-5.6	-3.47	-16.04	-17.04	4.47	-7.89143

Table-6
Geoaccumulation Index for Pre-Dredging Sediment (Rain)

	Cd	Pb	Ni	Zn	Cu	Cr	Fe	Average
SS1	-8.82	-5.57347	-5.79586	-3.57347	-15.3466	-17.04	5.24489	-7.2721
SS2	-8.82	-6.15843	-5.26534	-4.50635	-16.02	-17.04	5.15097	-7.5227
SS3	-8.82	-9.22594	-5.71786	-3.44222	-16.02	-17.04	4.34412	-7.9888

Conclusion

From the values obtained using student's t-test, there is no significant difference in the mean concentration of the heavy metals in the dry and rainy seassion.

TOC%, pH, and flow condition are the main determinants for distribution/redistribution of heavy metals in Otamiri river bed sediment.

The results indicated that natural processes such as weathering and erosion of bedrock are the main supply sources of heavy metals in sediments of Otamiri Rivers near Owerri, as the sediments were noted to be in unpolluted or excellent state.

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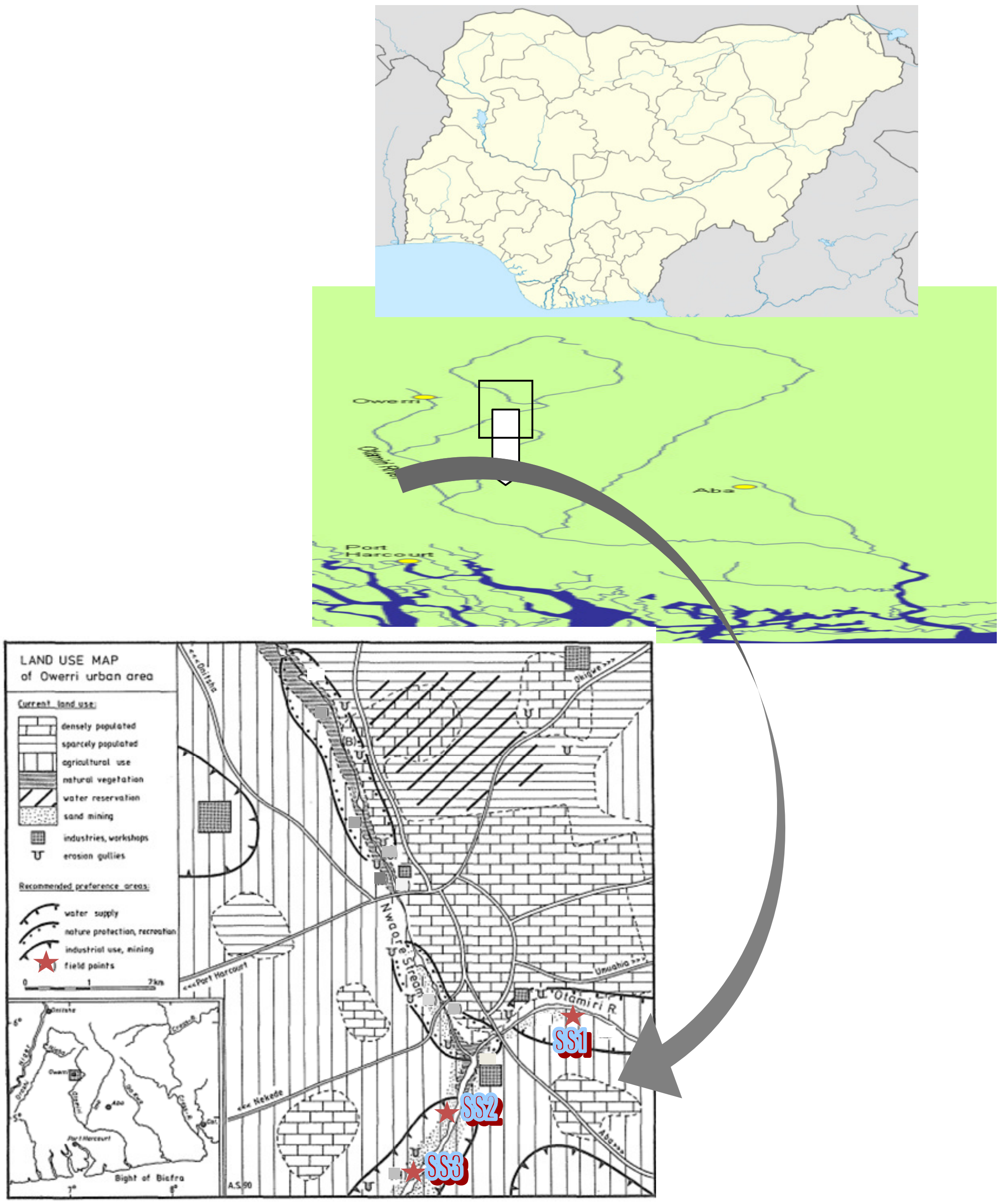

Figure-1

Map of Owerri and land usage. From Wikipedia, the free encyclopaedia

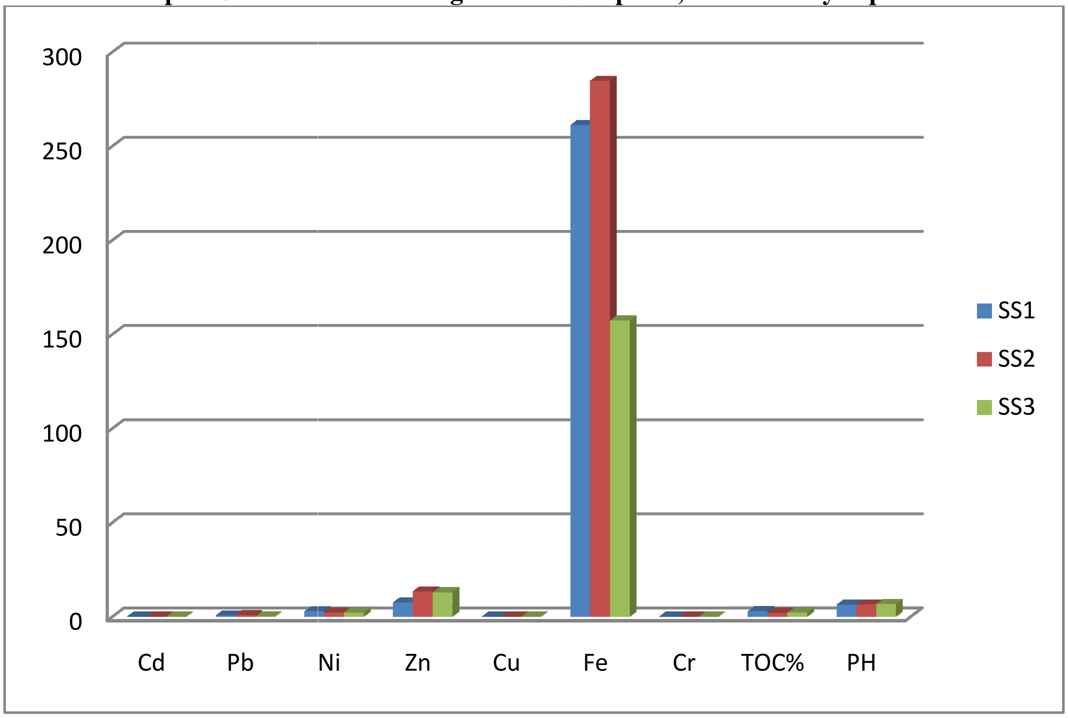

Figure-2
Graph of heavy metal in mg/kg, pH and TOC% at various sample stations

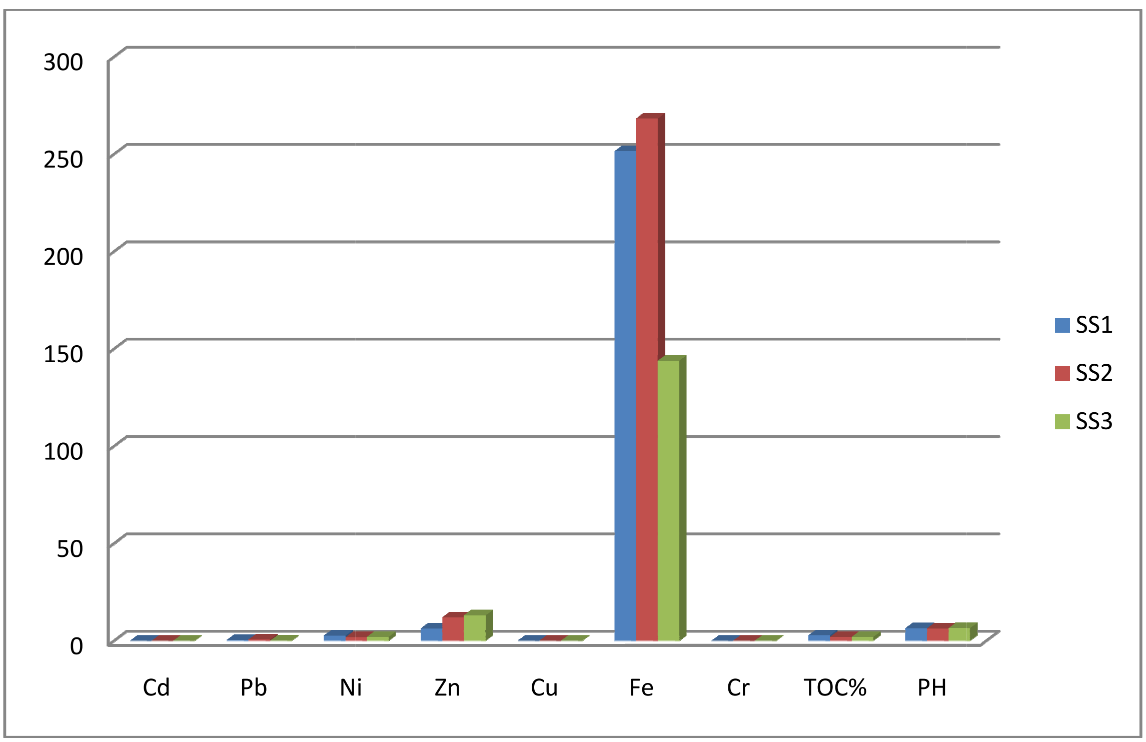

Figure-3
Graph of heavy metal in mg/kg, pH and TOC% at various sample stations

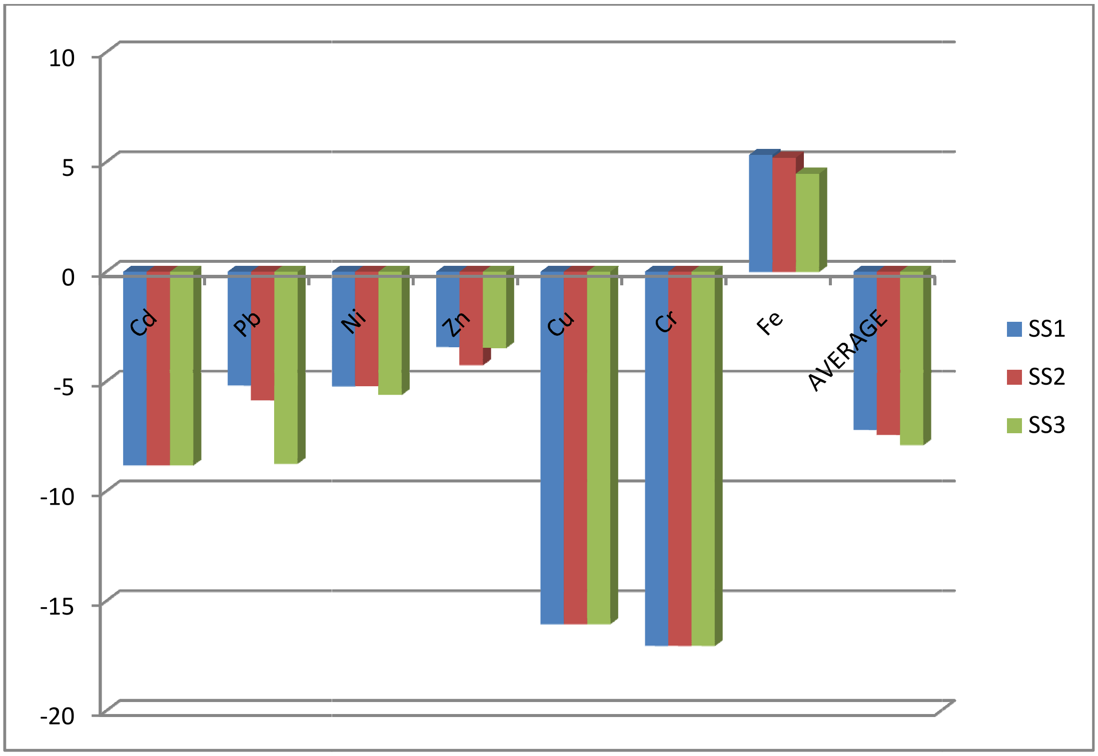

Figure-4
Geoaccumulation index for pre-dredging sediment (dry)

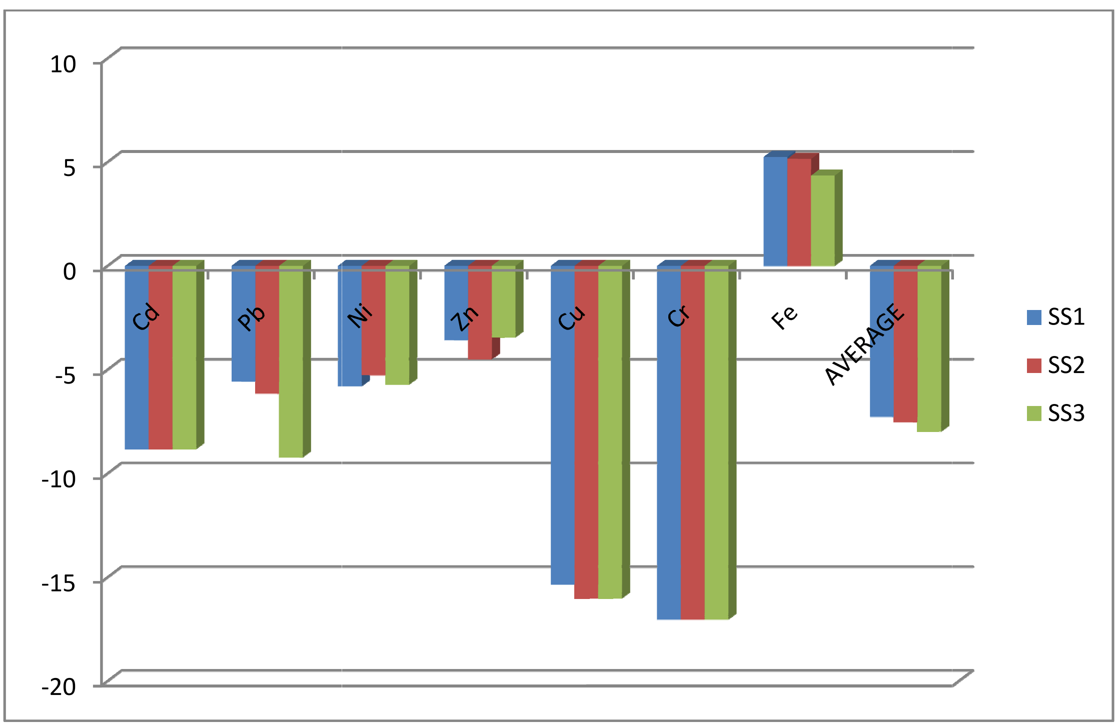

Figure-5
Geoaccumulation Index for Pre-Dredging Sediment (rain)