Contamination Risk Assessment of Physico-chemical and Heavy Metal Distribution in Water and Sediments of the Choba Section of the New Calabar River, Nigeria

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Abstract
This study is aimed at assessing geo-environmental risk of physico-chemical and heavy metal distribution in water and sediments of New Calabar River, Eastern Niger Delta. Seven (7) river sediments and twelve (12) surface water samples were collected for the study. Heavy metals (Mn, Pb, Zn, Fe, Mg, Cd, Cr, and Cu) were tested for in both river sediment and surface water. Heavy metals were analysed in river sediments, so as to determine their Contamination Factor (CF), Pollution Load Index (PLI) and Geo-accumulation Index (I_{GEO}) within the study area. W.H.O. limits were also used in evaluating Pollution Index (P_I) of heavy metals in surface water. The Pollution Load Index (PLI) level of river sediments ranged from 5.12-33.26. PLI values <1 was considered unpolluted; all samples analysed showed high pollution levels. Of all the heavy metals, Cu, Mg, Cr and Mn had moderate to considerable CF levels, while the others were of low levels. I_{GEO} levels were all <1, indicating low levels. For surface water, Pb and Zn had the worst Pollution Index values, with Pb having P_I values ranging 10-211. There was considerable contribution of pollutants from human activities into the river. Discharge from municipal storm water into the river, and the continued corrosion of sea vessels abandoned along the river flow path have been established. It is recommended that regulatory bodies responsible for protecting the environment pay adequate attention to this stretch of the river.
Keywords: Risk assessment, Contamination, Heavy metal, Pollution index, New Calabar River, Eastern Niger Delta, Nigeria

Introduction

Heavy metal pollution is prevalent in the environment and it usually results from numerous activities and sources such as discharge of untreated effluent from industries, foundry waste, paints, auto-mobile fumes, mining cuttings, and rock weathering (Don-Pedro *et al.*, 2004, Amadi *et al.*, 2015). The major concern with regards heavy metals is their hazardous acute toxicity and ability to bio-accumulate in the human tissue (Otitoloju and Don-Pedro, 2002). Heavy metals are considered to be the most common environmental pollutants, and their occurrence in waters and biota indicate the presence of natural or anthropogenic sources (Mohiuddin *et al.*, 2015, Amadi *et al.*, 2016). Solid wastes can contribute to forms of pollution that are hazardous to human health. Leachate generated from within the waste heap is a source of inorganic and organic hazardous substances that can migrate with the flow of storm water to contaminate both surface and groundwater (Leton, 2013). Akaninwor *et al.*, (2006) dwelt on pollution by microbial agents, which were most likely caused by the discharge of industrial effluent by Indo-Food Company (Dufil Prima Foods). The study was centred around five (5) sampling stations for surface water of the New Calabar River. Onuoha and Ifeanacho (2015) went further by studying the effect of effluent from

Indomie Food Comapany (Dufil Prima Foods) on the biochemical parameters of Tilapia fish from the New Calabar River in which Potassium ion (K^+), Chloride ion (Cl^-), Sodium ion (Na^+), Urea and Creatinine concentrations were measured in the blood, liver, gills and muscles of fishes.

Theodore and Chikwuogwo (2014) studied human and ecological threats to water and sediment of the New Calabar River, using the Chrysicthys Nigrodigitus species fish as a biomarker for the quality of the environment. Uzukwu *et al.,* (2014) investigated the physical characteristics and physico-chemical qualities of the Upper Reach of the New Calabar River, around Aluu. The highest recorded depth at the middle of the river was 9.20m, while its width during the spring high and low tide were 174 and 110m, respectively. The measured cross-sectional area and average flow velocity of the river were 797.13 m^2 and 0.374 m sec^{-1}, respectively. The physico-chemical parameters analysed showed that the river water had an acidic pH value (5.12-7.43). Mmom and Chukwu-Okeah (2011) assessed the impact of sand dredging activity on channel morphology, and the broader implications on biological resource conservation along parts of New Calabar River. Abu and Egenonu (2008) investigated the incidence of environmental pollutants on bacterial strains isolated from the New Calabar River and ascertained the possible effects of those suspected pollutants on antibiotic resistance and patterns.

The New Calabar River and its tributaries are all located in Rivers State. It is a low lying deltaic river which rises at approximately latitude 5°10'N and longitudes 6°50'E near Elele-Alimini and flows Southward for roughly 150km before its discharge into the Atlantic Ocean at about latitude 4°20'N and longitudes 7°00'E (Francis and Elenwo, 2012). It occupies a low relief region, ranging from 0-50m above sea level at the low zone, to 50-100 above sea level at its source. The soil of the river basin consists of clays, silt and sand, with high organic matter (Theodore and Chikwuogwo, 2014). The river is unidirectional in the upper reach and tidal in the lower reach. Its upstream reach is fresh water with tropical lowland, dense rainforest through secondary forest/farmland vegetation. The downstream reach is however brackish and consist of Mangrove swamp forest. As human population increases geometrically, so also does the need for development that meets the needs of the populace increases. Development in the form of urbanisation and industrialisation, if not checked, has the potential of negatively altering the quality of the environment. In order to maintain the delicate relationship between human development and the quality of the environment, there is need for constant monitoring and evaluation of human activities that have the potential of altering the quality of the environment within which such activities occur. This study therefore is aimed at assessing contamination risk of physico-chemical and heavy metal distribution in water and sediments of the Choba section of the New Calabar River, Eastern Niger Delta.

Study Area

This study was carried out in Obio-Akpor Local Government Area of Rivers State (Fig. 1), between the months of February and April 2016. Obio-Akpor alongside the Port Harcourt Local Government Area forms the Port Harcourt Urban Area (the metropolis). Rivers State is located in the South-South geopolitical zone of Nigeria and the eastern sector of the oil-rich Niger Delta region of the country. Port Harcourt doubles as the Capital City of Rivers State, and also the largest city in the State. The Port Harcourt urban area has a total population figure of 1, 382, 592 (2006 Census). Obio-Akpor Local Government Area is one of the eight (8) Local Government Areas that forms the Greater Port Harcourt urban area, namely: Port Harcourt, Okrika, Obio-Akpor, Ikwerre, Oyigbo-Bolo, Tai and Eleme Local Government Areas respectively. As at 2012, the Greater Port Harcourt urban area had an estimated total population of 1,947,000 (Nigerian Administrative Division: City Population). This made it the 5th largest urban area in Nigeria; only after Lagos, Kano, Ibadan and Abuja. Port Harcourt has a tropical monsoon climate; having a lengthy and mostly heavy rainy seasons and very short dry seasons. December and January are the only months that truly qualify as dry season months, with December averaging 20mm of rain (Chinda, 1998). The city's heaviest precipitation is usually recorded in the month of September (averaging 367m of rain). The average annual temperature value in the city is typically between 25°C-28°C (Nwankwoala and Ogbonna, 2017). The most dominant economic activity in the study area is centred on the Petroleum Industry. Many Multi-National companies that are into Production and Servicing operations in the Petroleum Industry operate in the State. Rivers State does not only host Multi-National Oil Companies, it also hosts two (2) oil refining facilities. Due to its strategic location, Rivers State is among the richest states in Nigeria; in terms of Gross Domestic Product and revenue derived from Foreign Exchange earnings of the Oil Industry. The State has crude oil as its principal export earner. The major cash crops cultivated are rubber, oil palm products, raffia, coconut and jute. Others that cultivated for food are melon, vegetable, pineapple, banana, mango and plantain (Rivers State Government: People and Culture). The locals however in engage in fishing, hunting, lumbering and petty trading.

Geology of the Study Area

Port Harcourt is located within the oil-rich Niger Delta sedimentary basin. Generally, the basin consists primarily of regressive sediments which are of Tertiary age. The detailed geology of the lithostratigraphic subdivision of the Niger Delta basin was given by Short and Stauble (1967). The Niger Delta basin is one of the most prolific hydrocarbon systems in the world. The delta was formed at the site of a rift triple junction that is related to the opening of the Southern Atlantic; starting in the late Jurassic, continuing into the Cretaceous. The coastal sedimentary basins of Nigeria have witnessed three depositional cycles. The first depositional cycle began with a marine incursion in the middle Cretaceous, which was terminated by a mild folding phase in the Santonian. The second cycle is identified by events leading to the growth of a Proto-Niger Delta during the late Cretaceous, ending in a major marine transgression in the Paleocene. The third cycle stretched from Eocene to Recent, marking the continuous growth of the main Niger Delta. A threefold subdivision is established for the lithostratigraphic units of the Niger Delta subsurface. These units occur throughout the Niger Delta basin; with ages ranging from early Tertiary to Recent. They are related to the present outcrops and environment of deposition (Short and Stauble, 1967). The Benin flank is regarded as the northern boundary of the Niger Delta; which is an east-north-east trending hinge line which lies south of the West African basement massif. The basin's north-eastern boundary is defined by outcrops of the Cretaceous on the Abakaliki High and also further east-south-east by the Calabar Flank (a hinge line bordering the adjacent Precambrian).The Tertiary portion of the basin is subdivided into three distinct formations, representing a prograding (regressive) depositional facies which are distinguished by their sand-shale ratio.

1. The Akata Formation: This formation lies at the base of the basin, which is of marine origin; composed of low density, high pressure shallow marine to deep water thick shale sequence (Short and Stauble, 1967). Beginning in the Paleocene and through to the Recent, the Akata Formation formed during lowstands, when terrestrial organic matter and clays were transported to deep water areas that are characterized by low energy conditions and anoxic settings. The formation underlies the entire stretch of the delta and it's typically over-pressured. During the development of the delta, the deep sea sands of the upper Akata were most likely deposited by turbidity currents.

2. The Agbada Formation: This consists of paralicsiliciclastics over 3700 meters thick and represents the actual deltaic portion of the sequence. The formation is entirely an alternating sequence of deltaic (fluvial, coastal, fluvio-marine) sands and marine shale. In the lower Agbada Formation, shale and sandstone beds were deposited in equal proportion. However, the upper coastal portion is mostly sand with minor shale interbeds (USGS, 2009).

3. The Benin Formation: This formation consists of freshwater continental (fluviatile) deposits, comprising of alluvial and upper coastal sands and gravel with occasional clay layers. The formation has a thickness of 2100 meters at the basin center (Weber and Daukaru, 1975).

Methods of Study

Standard field sampling techniques were adopted for the sample collection exercise. The sampling exercise for the work was carried out on two different trips, which were two weeks apart. The first sampling trip was aimed at obtaining sample from the effluent fallout point along the New Calabar River. The second sampling trip involved sampling both surface water and river sediment also along the New Calabar River. Due to the riverine nature of the sampling locations, transportation from one location to the next was achieved by the use of a paddling boat.

Effluent Fall-out Area Sampling

At the fallout point, sample was collected in the capped, transparent, sterilized polyethylene container; which was already labelled prior to sampling. The sample container was sealed-off in an air-tight way, immediately after sampling. The sealing of the sample container was done so as to avoid aerobic reaction or contamination by atmospheric agents (which could be biotic or abiotic).

Surface Water and River Sediment Sampling

The sampling exercise for surface water and river sediment started off with sampling for river sediments first. This approach to sampling was adopted due to a time sensitive phenomena typical of that part of the New Calabar River. The New Calabar River, around the Choba bridge axis of the East-west road is usually in a regressive position at its banks in the early hours of the day. Towards noon, the level of water at the bank of the river starts rising, thereby flooding portions of its banks that were earlier exposed in the morning hours. As such, river sediment sampling at those sites were only possible in the early hours of the morning. The sediments collected were a mixture of sandy, muddy and clayey sediments. Table 1 shows the coordinates and elevation of sampling locations while Fig. 1 is the map of study area showing sampling points.The flow direction of the river influenced the decision to start sampling for surface water at the farthest location of sampling river sediment. The sampling of surface water from the farthest location, then moving up towards the take-off point ensures adherence to the best sampling technique for surface water. This choice ensured the movement of the boat while sampling was to guide against the flow direction of the river. This made sampling of surface water from an undisturbed flow, possible.

Table 1: GPS Coordinates and Elevation of sampling locations

		RIVER SEDIMENT	
S/N	Sample ID	GPS Coordinates	Elevation
1	SD L_1	N 04.89621" E 006.90061"	1m
2	SD L_2	N 04.88980" E 006.89907"	2m
3	SD L_3	N 04.88925" E 006.89564"	4m
4	SD L_4	N 04.88671" E 006. 89471"	0m
5	SD L_5	N 04.88392" E 006.89209"	4m
6	SD L_6	N 04° 52' 50.6" E 006° 53' 49.8"	2m
7	SD L_7	N 04.86988" E 006.90355"	3m
		SURFACE WATER	
S/N	Sample ID	GPS Coordinates	Elevation
1	SW L_1	N 04.86821" E 006.90381"	3m
2	SW L_2	N 04.87057" E 006.90191"	3m
3	SW L_3	N 04.87315" E 006.90018"	3m
4	SW L_4	N 04° 52' 34.3" E 006° 53' 55.45"	2m
5	SW L_5	N 04° 52' 43.7" E 006° 53' 50.7"	3m
6	SW L_6	N 04° 52' 51.0" E 006° 53' 45.1"	2m
7	SW L_7	N 04° 52' 57.9" E 006° 53' 40.4	2m
8	SW L_8	N 04° 53' 2.62" E 006° 53' 33.1"	3m
9	SW L_9	N 04° 53' 11.6" E 006° 53' 34.9"	3m
10	SW L_{10}	N 04° 53' 17.6" E 006° 53' 40.9"	2m
11	SW L_{11}	N 04° 53' 20.6" E 006° 53' 49.0"	3m
12	SW L_{12}	N 04° 52' 28.7" E 006° 53' 55.0"	3m
		EFFLUENT FALL-OUT AREA	
S/N	Sample ID	GPS Coordinates	Elevation
1	EF	Latitude: 04^0 53' 18.2" Longitude: 006^0 53' 48.8"	3m

Note: RS= River Sediment, SW= Surface Water, EF= Effluent Fall-out area, L= Sampling Location.

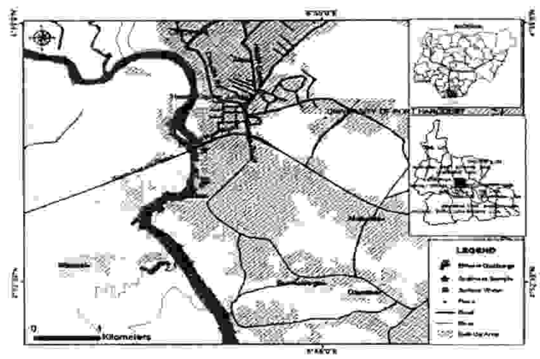

Fig. 1: Map of study area showing sampling points

Results and Discussion

Results from analysis of samples of river sediment and surface water portray a trend of concentration of certain chemical elements which suggests the possibility site specific pollution. As seen from several graphical plots below, the variation of concentrations of parameters across sampling locations were random and only showed a progressively increasing trend between locations 3, 4 and 5 of river sediments. Of particular interest were the levels of Oil and Grease in river sediments from those three locations. In all the heavy metals tested in the sediments, the highest concentrations were all detected between those locations. The river sediments were acidic, with pH values ranging 5.4 - 6.4. Table 2 shows the analytical results of river sediments while Table 3 indicates the analytical results of surface water of New Calabar River.

Table 2: Analytical Results of River Sediments in mg/Kg

Sample ID	Mn	Fe	Pb	Zn	Cr	Cd	Cu	PO_4	NO_3	SO_4	Mg	TOC (%)	pH	Oil and Grease
SD. L1	10.30	975.0	8.01	25.20	1.71	4.11	23.00	2.32	1.72	1.04	1.17	0.78	5.7	1.43
SD. L2	7.88	218.0	7.42	21.40	1.93	7.50	14.10	1.06	2.11	1.21	1.18	1.76	6.4	1.60
SD. L3	12.60	800.0	15.00	17.20	2.70	5.01	25.10	1.91	3.75	1.76	3.11	5.27	5.8	18.4
SD. L4	8.10	873.0	6.04	27.10	1.83	5.01	21.30	1.52	2.57	0.89	1.21	0.39	5.4	24.5
SD. L5	5.65	477.0	16.50	33.20	2.31	7.82	19.00	1.04	2.34	0.98	2.31	1.37	6.3	23.7
SD. L6	7.38	564.0	14.50	31.10	2.12	4.91	15.30	1.13	1.32	0.56	1.31	0.04	5.7	1.04
SD. L7	6.73	645.0	10.30	25.60	1.87	5.22	13.60	1.43	1.28	0.34	1.02	0.35	5.4	1.02
Minimum	5.65	218.0	6.04	17.20	1.71	4.11	13.60	1.04	1.28	0.34	1.02	0.04	5.4	1.02
Maximum	12.60	975.0	16.50	33.20	2.70	7.82	25.10	2.32	3.75	1.76	3.11	5.27	6.4	24.5
Mean	8.37	650.3	11.11	25.82	2.06	5.65	18.77	1.48	2.15	0.96	1.61	1.42	5.8	10.24
DPR Standard (2002)	_	_	35	_	20	100	0.3	_	_	_	_	_	_	_

DPR = Department of Petroleum Resources

Table 3: Analytical Results of Surface Water of New Calabar River in mg/L

Sample ID	Mn	Cr	Pb	Cd	Fe	Zn	DO	BOD	COD	PO_4	SO_4	NO_3	TDS	EC (µS/cm)	pH	Oil and Grease
SW. L1	1.24	0.21	0.10	<0.001	2.54	1.08	1.14	2.30	5.01	0.56	0.82	0.09	23.00	5.02	5.7	0.02
SW. L2	1.55	0.01	1.09	0.01	3.60	2.53	2.15	2.98	4.02	0.87	0.73	0.27	28.00	6.74	5.6	0.01
SW. L3	2.38	0.001	0.45	0.01	1.30	0.58	1.57	2.50	4.82	0.82	0.56	0.07	33.40	2.38	6.2	<0.01
SW. L4	2.01	0.05	1.87	<0.001	4.16	1.10	2.38	3.22	3.56	0.96	0.89	0.08	25.60	8.87	5.9	0.02
SW. L5	2.16	<0.001	0.20	0.01	0.97	1.51	1.37	4.10	5.09	0.72	0.67	0.04	37.30	7.07	6.3	0.01
SW. L6	1.85	0.65	2.00	0.03	2.43	1.24	3.13	4.01	4.22	0.55	1.01	0.06	25.20	8.97	5.7	0.01
SW. L7	1.72	0.44	0.10	<0.001	0.27	1.76	2.09	2.89	5.10	0.87	1.03	0.11	33.40	5.02	6.2	<0.01
SW. L8	1.53	0.03	1.30	0.08	0.90	1.80	3.28	4.29	4.77	0.98	0.92	0.24	23.20	8.66	5.8	0.01
SW. L9	2.52	0.10	0.46	<0.001	2.17	0.90	1.49	2.78	3.22	0.59	0.87	0.61	35.30	3.07	5.9	0.02
SW. L10	1.36	0.07	1.55	<0.001	3.40	1.21	1.45	2.36	3.58	0.90	0.76	0.52	24.40	6.88	5.8	0.03
SW. L11	1.38	<0.001	2.11	<0.001	1.25	1.31	1.49	2.15	2.32	0.53	0.64	0.11	27.80	4.12	5.9	<0.01
SW. L12	1.20	<0.001	1.12	<0.001	1.01	1.26	1.18	2.64	3.01	0.61	0.72	0.08	21.20	4.31	6.0	0.01
Minimum	1.20	<0.001	0.10	<0.001	0.27	0.58	1.14	2.15	2.32	0.53	0.56	0.04	21.20	2.38	5.6	<0.01
Maximum	2.52	0.65	2.11	0.08	3.60	2.53	3.28	4.29	5.10	0.98	1.03	0.61	37.30	8.97	6.3	0.03
Mean	1.74	0.13	1.03	0.01	2.00	1.35	1.89	3.02	4.06	0.75	0.80	0.19	28.15	5.93	5.9	0.01
WHO Limits (2011)	0.4	0.05	0.01	0.003	3.00	3.00	N/A	N/A	N/A	N/A	N/A	50	N/A	N/A	N/A	N/A

The surface water showed the most random set of concentrations of the two, which could be attributed to the mobile state of the medium of sampling. The Dissolved Oxygen (DO) range from 1.14 mg/l – 3.28 mg/l with a mean of 1.89 mg/l while the BOD range from 2.15 mg/l to 4.29 mg/l with a mean of 3.02 mg/l. The Chemical

Oxygen Demand (COD) range from 2.32 mg/l – 5.10 mg/l with a mean of 4.06. The amount of Dissolved Oxygen (DO) in the samples, as compared to Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) shows a slight pollution of the river water, which would require some time to achieve self-purification. Heavy metal concentrations in the surface water sample were objectionable when compared to the W.H.O. permissible limits for drinking water. Those heavy metals are a great concern for the quality of fish consumed from the river. The pH reading for all the surface water samples were also found to be acidic like those of the river sediments; having pH values ranging from 5.6 - 6.2.

Because the quality of the surface water only gives the momentary quality of the environment, the quality of the river sediment which gives a more definite detail of the quality of the environment is of more importance in interpreting changes in the quality of the environment. Results from sampling and analysis of the river sediment and surface water shows that the chemistry of the two varies distinctly from one location to the other and that certain locations could have been sites of localised pollution (Table 4). Table 5 shows the Pollution Index (P_I) values of sampled surface water while Table 6 shows the contamination factor values for river sediments.

Table 4: Water quality according to pollution index value. (Chinese Quality Standard Code for Groundwater - GB/T 14848-1993)

Water Quality	Very good	Good	Moderate	Bad	Worst
Pollution Index	<0.80	0.80-2.50	2.50-4.25	4.25-7.20	>7.20

(Modified After Tamasi and Cini, 2004; Amadi, 2012)

Table 5: Pollution Index (P_I) values of sampled surface water

Sample Locations	Mn	Cr	Pb	Cd	Fe	Zn
SW. L1	3.10	4.20	10.00	0.00	0.84	21.60
SW. L2	3.80	0.20	109.00	3.30	1.20	50.60
SW. L3	5.90	0.00	45.00	3.30	0.43	11.60
SW. L4	5.00	1.00	187.00	0.00	1.30	22.00
SW. L5	5.40	0.00	20.00	3.30	0.32	30.20
SW. L6	4.60	13.00	200.00	10.00	0.81	24.80
SW. L7	4.30	8.80	10.00	0.00	0.09	35.20
SW. L8	3.80	0.00	130.00	26.60	0.30	36.00
SW. L9	6.30	2.00	46.00	0.00	0.72	18.00
SW. L10	3.40	1.40	155.00	0.00	1.10	24.20
SW. L11	3.40	0.00	211.00	0.00	0.41	26.20
SW. L12	3.00	0.00	112.00	0.00	0.33	25.20

Table 6: Contamination factor values for river sediments

Sample Locations	Mn	Fe	Pb	Zn	Cr	Cd	Cu
SD. L1	1.53	1.51	0.77	0.98	0.91	0.78	1.69
SD. L2	1.17	0.33	0.72	0.83	1.03	1.43	1.04
SD. L3	1.87	1.24	1.45	0.67	1.44	0.95	1.84
SD. L4	1.20	1.35	0.58	1.05	0.97	0.95	1.56
SD. L5	0.84	0.74	1.60	1.29	1.23	1.49	1.39
SD. L6	1.09	0.87	1.40	1.21	1.13	0.94	1.12
SD. L7	1.00	1.00	1.10	1.00	1.00	1.00	1.00

Pollution index values for heavy metals in surface water were of significant proportion in most of the locations (Table 4). Manganese (Mn) had pollution index value ranging 3.0 to 5.9, which when compared to the standards, had moderate to bad levels of pollution. Chromium (Cr) pollution levels were slightly insignificant in most of the sampling locations, except for locations 6 and 7 which had pollution index values of 13 and 8.8 respectively. Of all the heavy metals, Lead (Pb) recorded the most chronic levels of pollution across all the sampling locations; having pollution index values ranging from 10 – 211. Next to Lead (Pb) is Zinc (Zn) which also recorded the chronic levels of pollution; ranging 11.6 – 50.6. On the other hand, Iron (Fe) recorded the least levels of pollution of all the other heavy metals, across all the sampling locations; recording 1.3 as its highest pollution index value. Cadmium (Cd) pollution index levels were insignificant in almost all the sampling locations; with locations 6 and 8 recording pollution index levels 10 and 26.6 respectively.

Majority of metals were however of moderate contamination factor levels. Based on the Pollution Load Index, all the sampled locations were found to be polluted; with locations 3 and 5 being the most polluted. Fig. 2 is the plot of pH levels in river sediments while Fig. 3 is the plot of pH levels in surface water. Fig. 4 shows pollution load index and Fig. 5 shows heavy metal concentration.

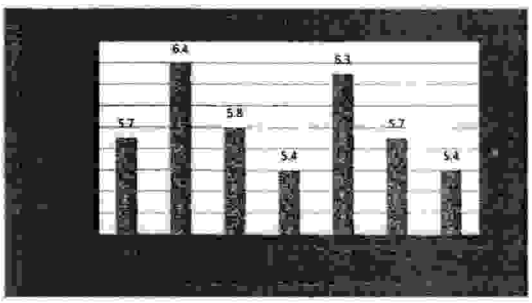

Fig. 2: Plot of pH levels in river sediments

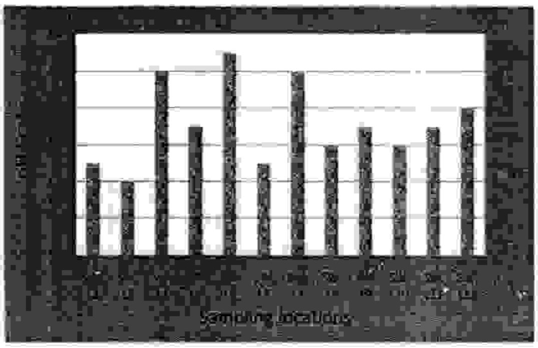

Fig.3: Plot of pH levels in surface water.

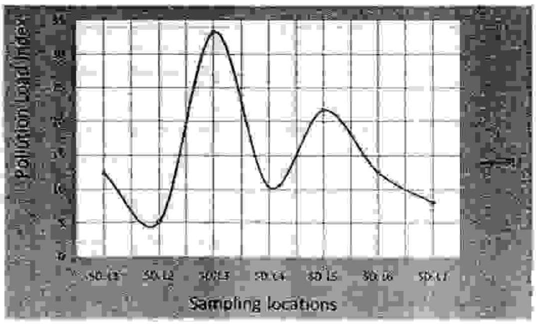

Fig. 4: Plot of pollution load index across all sampling locations

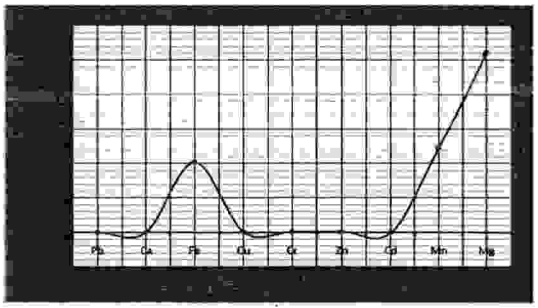

Fig. 5: Plot of Heavy metals concentration

Conclusions

The outcome of the analysis of the sampled surface water shows slight pollution of the samples based on some pollution indicator parameters. All the samples tested were found to be acidic; having pH values ranging 5.6 - 6.2. Aside from chromium and cadmium, all the heavy metals had significant concentrations in all the twelve samples analysed.The Pollution Load Index (PLI) level of river sediments ranged from 5.12 - 33.26; considering the fact that only PLI values <1 was considered unpolluted; all samples analysed showed high pollution levels. Of all the heavy metals, Cu, Mg, Cr and Mn had moderate to considerable CF levels, while the others were of low levels. I_{GEO} levels were all <1, indicating low levels. For surface water, Pb and Zn had the worst Pollution Index values, with Pb having P_I values ranging 10 - 211. There was considerable contribution of pollutants from human activities into the river.It is recommended that authorities responsible for maintenance of environmental quality within Rivers State take seriously the findings of this study, so as to mitigate the potential short and long term effects of the on-going activities on the New Calabar River.

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