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An Assessment of the Impact of Industrial Effluents on Sediment Quality of Woji River

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Abstract: A study on the sediment quality of Woji river as affected by industrial effluents has been carried out at five sampling stations along the river. Sediment samples were analyzed for pH, total hydrocarbon (THC), oil and grease, mercury (Hg), chromium (Cr), lead (Pb), nickel (Ni), iron (Fe), copper (Cu), cadmium (Cd) and zinc (Zn). The result showed pH sediment quality that is acidic (5.84±0.99), while THC (33.8±4.85 mg/kg), oil and grease (1346±182 mg/kg), also exceeded permissible level. High values of Pb(22.4±10.5 mg/kg), Ni (16.6±5.6 mg/kg), Cd (2.44±0.74 mg/kg), Cr (21.2±7.6 mg/kg), Cu (9.3±4.3 mg/kg), Fe(10510±4689 mg/kg) and Zn (74.4±29.8 mg/kg) were also obtained. The results suggested sediment pollution of Woji river. Hence, there is the need to develop management plan to ensure that pollution of the river is prevented especially on the possibility of bioaccumulation of heavy metal on marine organisms that could magnify along food chain.

Key words: Sediment quality ? Woji river ? Hydrocarbons

INTRODUCTION

A substantial increase in agricultural and industrial development has been witnessed in the Niger Delta with attendant population growth in the past decades. These activities generate wastewater which may contain organic matter, radioactivity, heat, toxic chemicals, pathogenic organisms and plant nutrients [1]. Environmental pollution can also occur from spills of toxic chemicals, gasoline tanks and other hydrocarbons [2]. These pollutants may find there way to receiving water bodies and finally settle at the sediment which acts as sinks of contaminants in aquatic systems [3].

The determination of heavy metal and hydrocarbon concentration in sediment is a useful tool in monitoring and ensuring good sediment quality of contaminants from marine resources by humans. Studies on sediment quality include those of [4-8]. Similar studies that focused on heavy metal concentration on aquatic species and sediment samples include those of [9-14]. Generally, these studies identified high metal concentration on sediment and aquatic species. Consequently, the accumulation of heavy metals and hydrocarbons in sediments can affect not only the productivity and reproductive capabilities of the organism that can be contaminated through direct contacts or ingestion of these contaminants, but its effect on humans who depend on these organisms as their major source of protein [12].

Luoma *et al.* [15] emphasized that heavy metal concentration on sediments can be influenced by variation in sediment texture, composition, reduction/oxidation reactions, adsorption/desorption and physical transport as well as anthropogenic metal input. Consequently, fluctuation of metal concentrations of sediments occurs in time and space with changes in bioavailability from sediment. Even within an apparent homogeneous habitat, sediments heavy metal concentrations fluctuate from place to place as the chemical behaviour and quantities of trace metals are highly dependent on the physiochemical conditions [16, 17].

Chindah *et al.* [14] reported high concentration of THC and heavy metals distribution in the wet seasons than in the dry season in sediments along Bonny/New Calabar river estuary. Their results are summarized in Table 1. It was observed that sediments THC levels on all the stations in the 3 ecological zones studied were higher than permissible limits, indicating the anthropogenic contribution of hydrocarbon to the system.

In the capital city of Port Harcourt, the Woji river runs through an industrial site; the Trams-Amadi Industrial layout. The effluents from some industries are discharged into this river and inhabitants who live by it engage in fishing practice. Surprisingly, documented information on sediment quality is not readily available for authorities concern to take proper action in preventing pollution of the environment and

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Table 1: Heavy metal/THC concentration in sediment (Chindah *et al*, 2004)

Metal	Range (wet season) ppm	Range (dry season) ppm
Chromium (Cr)	0.01-0.83	0.002
Cadmium (Cd)	0.5-0.034	-
Vanadium	0.02-0.13	<0.04
Lead (Pb)	0.003-0.027	0.01 (Uniform)
Zinc (Zn)	0.063-0.277	1.03-2.04
Cupper (Cu)	0.007-0.057	0.001-0.20
THC	0-798.2	246.92-571.63

health of the population. The objective of this study was to assess the sediment quality of the receiving river as affected by industrial effluents discharged therein.

MATERIALS AND METHODS

Study area: The study area is the portion of the Woji river that stretched from Abuloma to Azuabie town in Trans-Amadi Industrial layout, in Port Harcourt, Rivers State. The area lies between longitude $7^0$00’E and $7^0$5’E and latitude $4^0$45’N and $4^0$50’N (Fig. 1). This river is tidal and traverses across communities namely Woji, Azuabie, Okujagu, Abuloma, Kalio-Ama and Adjoining with other tributaries passes through Okrika into the ocean.

Woji river receives industrial, domestic and agricultural waste from the numerous companies that drain their waste into it. Some of these companies located by this river include Halliburton, Schlumb erger, Nigerian bottling company, Michelin company Ltd, two boats construction companies-SNG Nigeria ltd and sea truck companies and the slaughter house. The inhabitants, who have settled along the river bank, build toilets on the shoreline and discharge faeces and domestic waste into the river.

Samples were collected from five sampling stations designated STN 1 to 5 along the study zone representing Oginiba, Woji, Azuabie, Okujagu and Abuloma stations respectively (Fig. 2). Sediment samples for total hydrocarbon and heavy metal were randomly collected at each station. Three replicates sediment samples were collected at surface layer (0-15 cm) depth using bottom grab sampler. The three replicate samples were composed and placed in an aluminum foil for pH, oil and grease, hydrocarbon analysis and another set of replica for heavy metal analysis were placed in cellophane bags. The samples

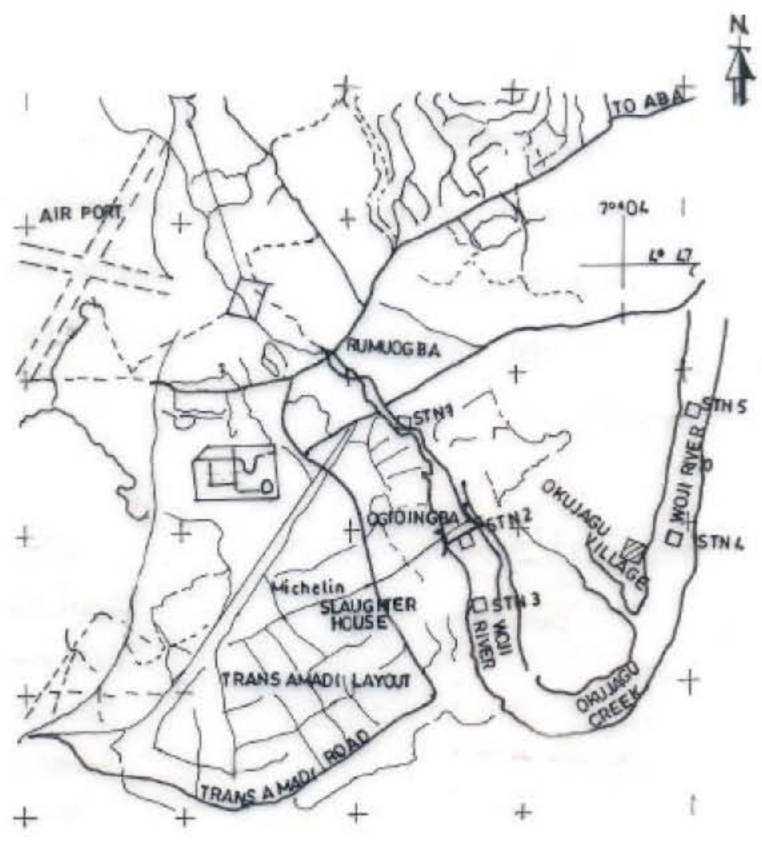

Fig. 1: Location of sampling station

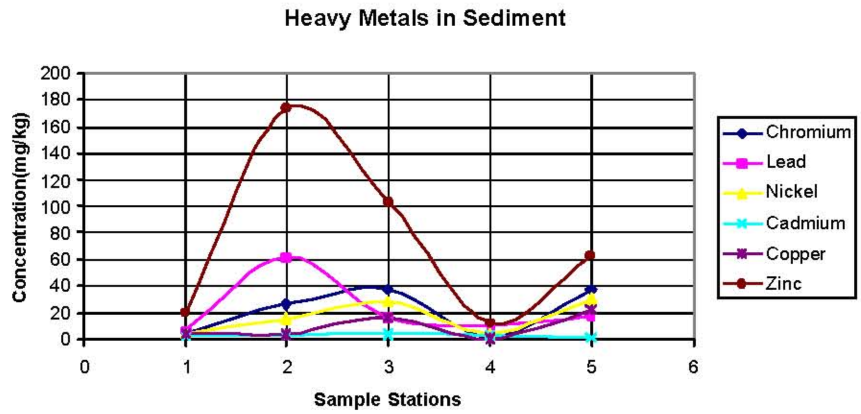

Fig. 2: Concentration of Heavy Metal on Sediment

were immediately stored in an iced-cooled box and transported to the laboratory for analysis.

Heavy metals in sediment (Hg, Cr, Pb, Ni, Cd, Cu, Fe, Zn) were analyzed using four grammas of finely ground soil samples that were weighed into a platinum crucible and 50 ml of de-ionized water added. A 10 ml of concentrated Hydrochloric (HCl) acid and 1ml of Nitric acid (HNO_3) were added in succession. The mixture was heated in a steam bath to a thick yellow liquid. The crucible was allowed to cool down and its contents filtered and made up to 100 ml with de-ionized water. The extracts were stored in plastic bottles and analyzed using Buck scientific Atomic Absorption /Emission spectrophotometer 205 nm.

RESULTS

The results of heavy metal, pH, THC and oil and grease concentration on sediment of Woji river at the five stations are presented in Table 2 and 3. Their graphical representation are depicted in Fig. 2- 5.

Mercury (Hg) concentration in sediment at the five stations along Woji river was less than 0.10 mg/kg dry weight while that of chromium (Cr) in sediment ranged from 1.45 to 36.77 mg/kg at stations 1 to 5 with a mean value of 21.2±7.6 mg/kg. The maximum (36.77 mg/kg) and minimum (1.45 mg/kg) concentration of chromium were obtained at station 5 and 4 respectively. Generally, very high concentration levels were obtained except at station 4. Lead (P_b) concentration in sediment ranged from 6.66 to 62.22 mg/kg, with minimum concentration level observed at station 1 and a value of 37.25 mg/kg was obtained at station 3. It has a mean value of 22.4±10.1 mg/kg. No definite distribution trend was obtained for the sites.

Nickel concentration ranged from 4.08 to 30.46 mg/kg at stations 1 to 5 with a mean value of 16±5.6 mg/kg. An increase in concentration level was observed downstream, except at station 4, where a drop in concentration level was obtained. A maximum (30.46 mg/kg) concentration was obtained at station 5, while a minimum (4.08 mg/kg) concentration was obtained at station 1. The distribution of cadmium in sediment ranged from 1.36 to 3.7 mg/kg with a mean value of 2.4±0.7 mg/kg at the studied stations. A reduction in concentration was observed downstream from station 3 to station 5. At stations 1 and 2, concentration levels were very close (2.31 and 2.40 mg/kg, respectively).

Copper concentration level in sediment along Woji river varied from less than 0.10 to 22.24 mg/kg at stations 4 and 5 respectively. The mean copper concentration was 9.3±4.3 mg/kg. The concentration level of iron along the study area ranged from 3941 to 25894 mg/kg with a mean value of 10510±4689 mg/kg. Very high values that increased downstream from station 1 to station 5 were observed except at station 4, where a drop in the increasing trend was obtained. A minimum (4704 mg/kg) and maximum (25894 mg/kg) concentration levels were obtained at stations 4 and 5 respectively. Variation in zinc concentration at the five stations ranged from 12.15 mg/kg at station 4 to 174.27 mg/kg at station 2. It has a mean value 74.4±29.8 mg/kg. No definite trend in variation of zinc concentration emerged along the stations.

The pH values on sediment at the five stations ranged from 2.43 to 7.05 and a mean value of 5.84±0.99. The minimum (2.43) value was obtained at station 1, located by the slaughterhouse, while the maximum (7.05) value was recorded at station 3. No definite trend in pH variation was observed, but sediment quality indicated acidic characteristics. Oil and grease concentration in sediment ranged from 810 to 1695 mg/kg and a mean value of 1346±182 mg/kg at

Table 2: Concentration of heavy metal in sediment (mg/kg)

Station	Location	Hg	Cr	Pb	Ni	Cd	Cu	Fe	Zn
STN_1	Oginiba	<0.10	4.83	6.66	4.08	2.31	4.49	3,941	19.38
STN_2	Woji	<0.10	26.12	62.22	15.53	2.40	2.99	15,994	174.27
STN3	Azuabie	<0.10	37.25	16.11	28.62	3.70	16.74	20,319	103.07
STN4	Okujagu	<0.10	1.45	9.44	4.70	2.43	<0.10	4,704	12.15
STN5	Abuloma	<0.10	36.77	17.77	30.46	1.36	22.24	25,894	63.03

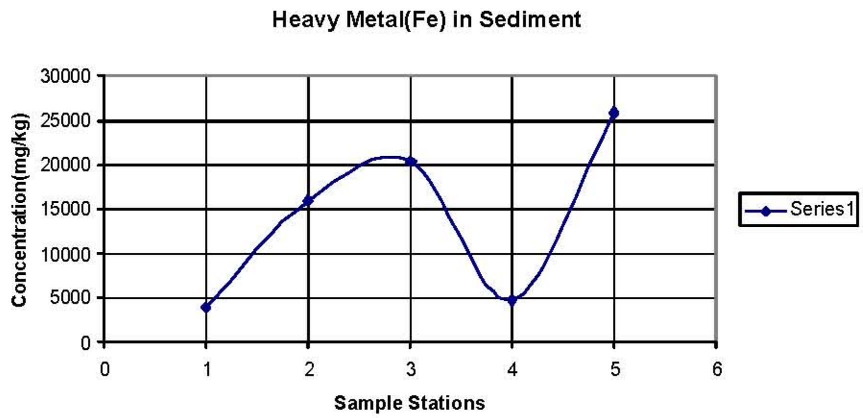

Fig. 3: Concentration of iron on sediment

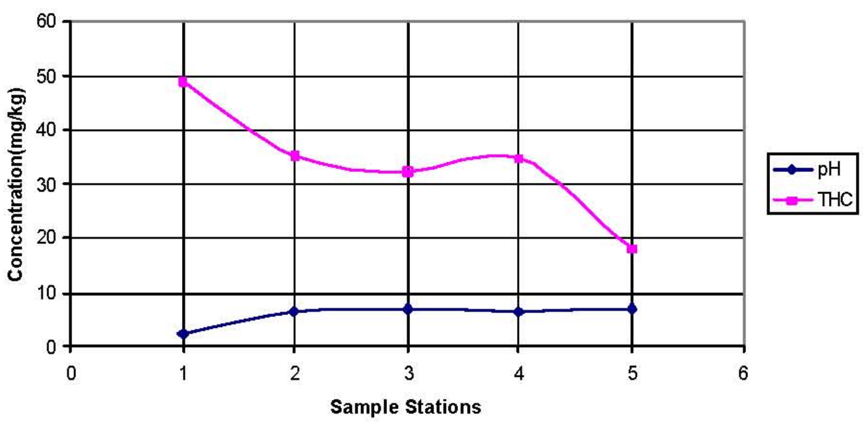

Fig. 4: Concentration of pH and THC on sediment

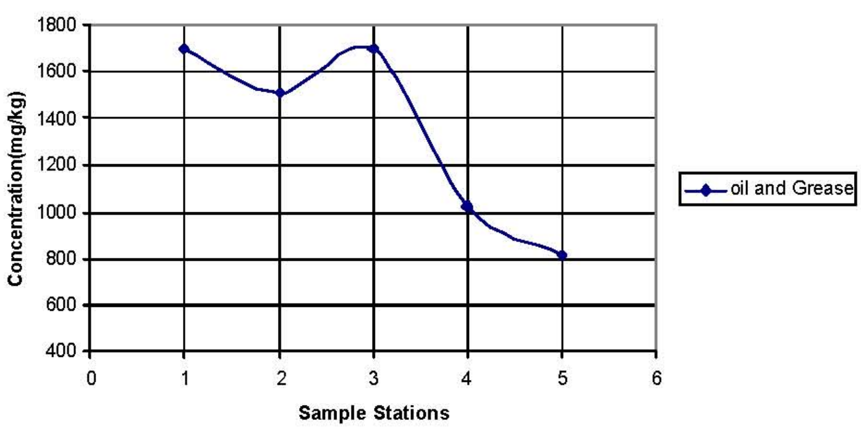

Fig. 5: Concentration of oil and grease on sediment

Table 3: pH, THC and oil and grease

Station	Location	pH	Oil and grease (mg/kg)	THC (mg/kg)
STN_1	Oginiba	2.43	1695	48.82
STN_2	Woji	6.51	1510	35.21
STN_3	Azuabie	7.05	1695	32.35
STN_4	Okujagu	6.34	1020	34.71
STN_5	Abuloma	6.89	810	18.24

the five stations. Maximum concentration values (1695 mg/kg) occurred at stations 1 and 3, but minimum (810 mg/kg) concentration occurred at station 5. Sediment Total Hydrocarbon (THC) concentration ranged from 18.24 to 48.8 mg/kg at the five stations with a mean value of 33.8±4.8 mg/kg. The maximum value of 48.8 mg/kg was recorded at station 1, while the minimum (18.24 mg/kg) concentration was recorded at station 5.

DISCUSSION

The result of heavy metals generally suggests polluted sediments. Mercury concentration exceeded permissible level implying sediment pollution by mercury. Discharge of mercury to the environment could come from indiscriminate disposal of motor batteries, pharmaceutical wastes and transformers in the environment. It is well known for its devastating effects on health; brain; nervous system and chromosome damage. Chromium concentration generally increased downstream except at station 4 where a significant reduction in concentration was recorded. This may be a result of high level of mixing and flushing by a tributary within the station. Generally, the values exceeded permissible level. A major source of chromium discharge is from industrial activities in metal alloys, pigments for paints, ceramics and plastic related processes in the study area. The result of lead concentration had no definite trend, but exceeded permissible level. The lowest value also occurred at station 4, which reflect the hydrodynamic nature by that station rather than from anthropogenic input. A major source of lead discharge could emanate from the numerous metal fabrication activities by the shore line. The variation of nickel concentration generally increased downstream, except at station 4 again. Permissible limit is exceeded.

Cadmium concentration in sediment increased downstream to station and then reduced downstream to station 5. Sources of cadmium compounds are through fungicides, selenium rectifiers, pigments used in ceramic glasses.The West African glass industry in Trans-Amadi, could contribute to cadmium in sediment. Very high values of iron concentration increased downstream except at station 4 again. Permissible level is exceeded. Input in to the river could also come from the numerous metal fabrication and construction along the river. No definite trend on concentration of zinc occurred at the five stations. But concentration levels are significantly higher than permissible level. Anthropogenic inputs could come from the process of welding, fabrication and building by boat construction companies in the study area.

Values of pH on sediment were acidic and generally agree with Swingle [18] who reported that organic waste reduces the pH of water to acidic level. The slaughter house discharge in to the river could also contribute to the low pH values. Oil and grease levels at all the stations exceeded permissible level. The source of discharge could be traced to the activities of oil prospecting companies, marine vessels and land base runoff in to the river.

The THC levels on sediment at the stations were observed to be higher than permissible limits, indicating anthropogenic contribution of hydrocarbon into the river. This could be explained by improper discharge of wastes from various human activities in the study area, especially from the industrial oil sector and municipal discharges [19].

A comparison of heavy metal concentration levels in this study area with those values reported by Chinda *et al.* [13, 14] along the Bonny/New Calabar river has shown consistently higher levels on sediment of Woji river. The reason for the lower values on sediments of the main Bonny/New Calabar river may be associated with the high energy of current and the volume of water which not only dilute but ensure proper flushing. Besides, a possible reason for higher values on sediments of Woji river may also be attributed to the rapid changing environment around the river resulting from increasing urbanization and industrial activities. However, lower THC values were obtained in this study when compared with those of Bonny/ New Calabar river. The high THC values may be associated with the high oil exploration and exploitation activities carried around the Bonny/New Calabar studied zone.

The sediment quality of this river with those sited might be difficult to compare as heavy metal concentration on sediment vary from place to place [20]. Origin and composition of sediment, particle size distribution, feasible post depositional reactions, physical transport as well as anthropogenic input play an important role in determining metal concentrations. The hydrodynamic and chemical complexity of each particular river with singular behavior of each metal, make it difficult to compare the results from one river to another.

CONCLUSION

Based on the results of sediment quality parameters of Woji river, it is evident that the river is polluted. Pollution by heavy metal is dangerous because of their tendency to bioaccumulate over time in a biological organism and could magnify along food chain. Their effect on human life may include carcinogenic, mutagenic and tetratogenic in nature. Consequently, there is the need for sediment quality monitoring scheme for Woji river. This is to guide against the consequences of bioaccumulation and biomagnification of these metals on the environment and health.

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