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CONCENTRATION OF HEAVY METALS IN A NIGER DELTA MANGROVE CREEK, NIGERIA

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ABSTRACT

The concentration of some heavy metals, Ca, Mg, Fe, Zn, Pb, Cd, Cr, Ni, Hg, and total hydrocarbon content (THC) were assessed in the surface waters of a Niger Delta mangrove creek (Buguma Creek). Samples were collected between November 2004 and October 2006 from five stations. The minimum and maximum concentrations of these heavy metals in the creek were 7.21-228.5 mg/l for Ca, 51.18-428.3 mg/l for Mg, 0.01-6.78 mg/l for Fe, 0.010-0.43 mg/l for Zn, 0.01-0.61 for Pb, 0.01-0.11 for Cd, 0.01-1.49 mg/l for Cr, 0.01-2.73 mg/l for Ni, while Hg and the total hydrocarbon content was approximately 0.01 mg/l throughout the study period.
The rank profile of metals according to their mean values was Mg > Ca > Fe > Zn > Ni > Cr > Pb > Cd > Hg in the study stations. There was no statistically significant difference (P > 0.05) in the concentration of heavy metals at the study stations. The EDTA hardness depicts hard water condition. The extremely low levels of the toxic heavy metals, Ni, Cr, Pb, Cd, and Hg, and total hydrocarbon content (THC) of <1 mg/l indicate that the water was not polluted.

INTRODUCTION

Heavy metals are high priority pollutants because of their relatively high toxic and persistent nature in the environment. Therefore, a knowledge of the changing concentration and distribution of heavy metals and their compounds in various compartments of the environment is a priority for good environmental management programmes all over the world (Don-Pedro *et al*., 2004).

Several workers have investigated the concentration of heavy metals in the coastal rivers with Atlantic tidal effect in Nigeria. Egborge (1991) related the heavy metal pollution of the Warri River to industrialization of Warri Town. Edema (1993) investigated the heavy metal contents of the shellfishes of the Warri River catchments. Ndiokwere (1984) investigated the heavy metal content of the sediments, algae and the Nigerian coastal waters. Ntekim *et al,* (1993) reported on the distribution of trace metals in the sediments of the Calabar River, while Oluwande *et al.* (1983) reported generally on the pollution levels in some Nigerian rivers.

Low heavy metal concentration have been reported in Nigerian water bodies by earlier workers, notable among which are Obire *et al.* (2003) on Elechi Creek, Chindah and Braide (2004) on lower Bonny River, Omoigberale and Ogbeibu (2005) on Osse River, Southern Nigeria.

The use of fish and invertebrates as bioindicators of water quality has been advocated by several workers (Ogbeibu and Victor, 1989; Yamazaki *et al.* (1996). This is because they produce evidence of relatively stable concentration compared with water analysis that indicates only short term conditions. A considerable amount of studies have been carried out on the effects of pollution in Nigerian water bodies. Victor and Tetteh (1988) reported a reduction in fish diversity associated with discharge of municipal wastes and industrial pollutants into the Ikpoba River, while Fufeyin (1998) investigated heavy metal concentration in some dominant fish in the river and found that the fish species showed higher mean levels, with variable contamination factor and bioaccumulation quotient among stations.

Don-Pedro *et al.* (2004) investigated the

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trend of heavy metal concentrations in Lagos Lagoon ecosystem, Nigeria, and found that the concentration of the metals detected in the lagoon sediments, water and animal samples collected from zones of the lagoon that received most of the industrial effluents, generally had higher concentration than samples collected from zones which received fewer or no industrial effluents.

Davies *et al.* (2006) in the studies on bioaccumulation of heavy metals in water, sediment and periwinkle (*Tympanotonus fuscatus* var. *radula*) from Elechi Creek, Niger Delta, reported that the sediment concentrated more heavy metals than the water, while periwinkles accumulated more of these metals than the sediment.

The Buguma Creek, which is seldom polluted by oil has not been given any scientific attention, except for its use in experimental aquaculture by Nigerian Institute for Oceanography and Marine Research, and for the work of Dublin-Green (1986), and Dublin-Green and Ojanuga (1988) on the acid sulphate soil. This paper investigates the current state of heavy metals and total hydrocarbon content of the creek.

DESCRIPTION OF THE STUDY AREA

The Buguma Creek is located Southeast of the Niger Delta between longitude 6^0 47^1E and 6^0 59^1E, and latitude 4^0 36^1N and 4^0 59^1N (Fig.1) in Asari-Toru Local Government Area of Rivers State. The Buguma Creek system consists of the main creek channel and associated interconnecting creeks, which interconnect and surround Buguma and Ido communities. The Buguma Creek serves as a source of tidal water for Nigerian Institute for Oceanography and Marine Research/Buguma Brackish Water Experimental Fish Farm, which was constructed between 1963 and 1966 under the auspices of the FAO. The New Calabar River brings the salty ocean water as tidal flows diurnally to the fish ponds (Dublin-Green and Ojanuga, 1988).

Based on the peculiarities and features observed around the study area, three sampling zones were selected for the study. Two of the stations (1 and 2) were chosen in two extremes of the Nigerian Institute for Oceanography and Marine Research (NIOMR) Buguma Experimental Fish Farm, one station (3) around Marywood pedestrian bridge, and two stations (4 and 5) from the main channel of the Creek.

The scope of the field work and selection of sampling stations were governed primarily by accessibility and tidal regimes. The descriptions of the stations are as follows:

Stations 1 and 2 are 0.77km apart and located in the least disturbed portion of the creek, but in an adjoining creek to the main channel. Station 1 is located north of the NIOMR/Buguma brackish water fish farm, where the creek branches to Ido, while station 2 is located south of the fish farm at the main sluice gate, a portion of the creek called Jordan Creek by Buguma indigenes. Activities associated with these two stations are aquaculture activities in the pond area by NIOMR staff, picking of periwinkles from intertidal portions of the creek by Buguma and Ido indigenes, setting of trap nets for *Tilapia* spp., *Periopthalmus* spp. and crabs by artisanal fishers.

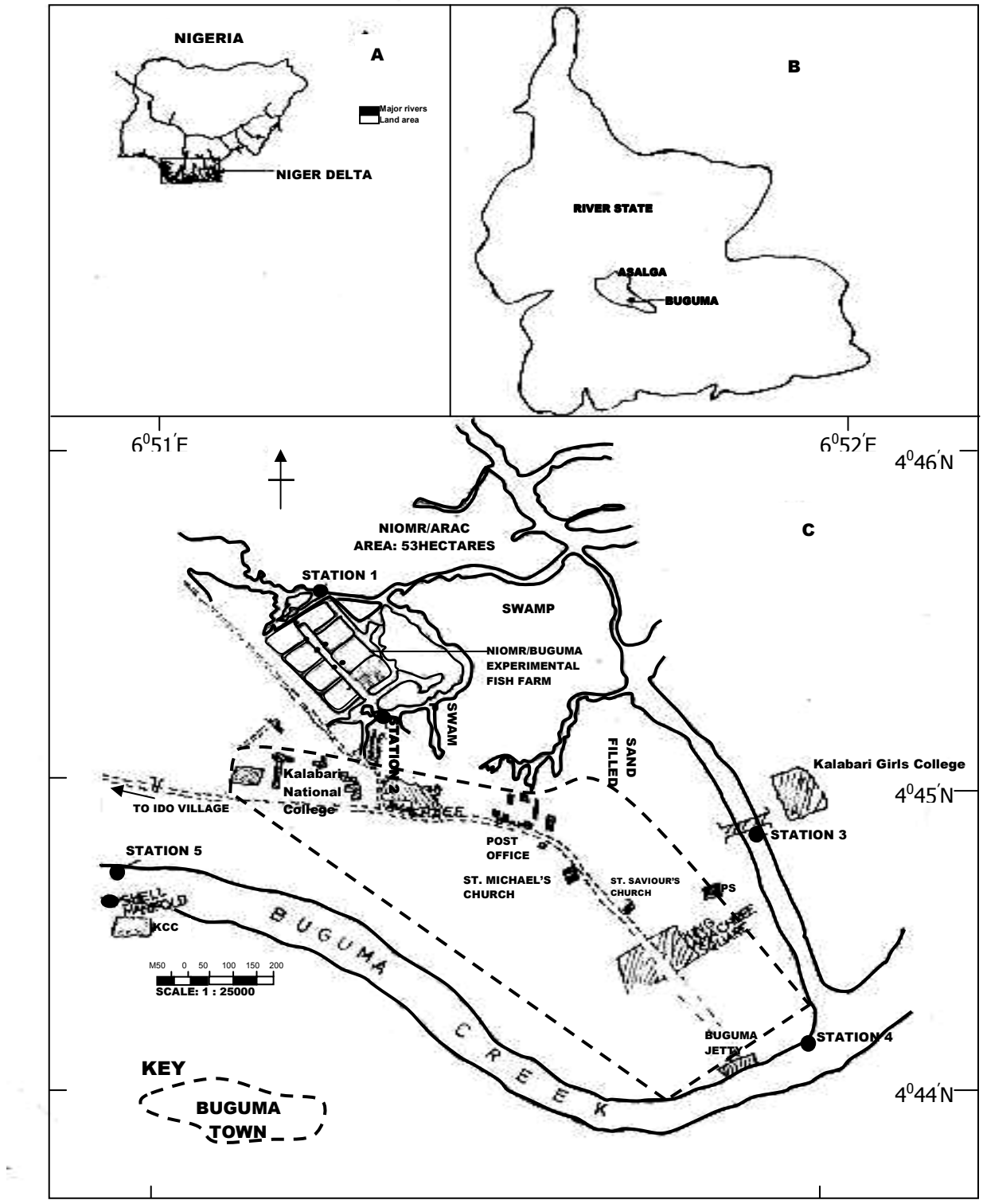

Figure 1: Map of the Study Area: **A -** Nigeria showing Niger Delta, **B –** Rivers State showing Buguma, **C.** The study Creek showing study stations.

Station 3 is 1.78km upstream of station 2, located northeast of Buguma, where a 96.5m long pedestrian bridge is sited. Associated with this bridge is dumping and burning of domestic wastes, cum continuous cutting of mangrove. Canoe landing is also a common practice in this station.

Stations 4 and 5 are located on the main creek. Station 4 is 0.63 km from station 3 and located upstream of the main creek. Its southwestern portion has been sandfilled from the main channel to Buguma town for human settlement. An over- water toilet has been built in this station, where human excrement is passed directly into the water. This station serves as a fish landing and sale site for fishers. The sandfilled intertidal zone is used by children for bathing and swimming practice.

Station 5 is 1.81km downstream of station 4. In the southern portion is Shell manifold and Kalabari Community College. The northern portion has been sandfilled for human settlement and part of the southern portion has been sandfilled for the school site. Transport of humans with speed boat is a common practice in the main channel of the Buguma Creek. Indigenes pick periwinkles at this station.

METHODOLOGY

Water sampling at high tide was conducted monthly between 0800 and 1700h each sampling day, from November 2004 to October 2006. Water samples were collected in pre-washed and dried one litre polyethylene bottles, acidified with nitric acid and taken to the laboratory for analysis. Analysis of the water samples was based on APHA *et al*. (1985). Samples for Fe, Zn, Ni, Pb, Cr and Cd, were analyzed by Atomic Absorption Spectrophotometer using Buck Scientific Atomic Absorption Spectrophotometer. EDTA hardness, calcium and magnesium were determined by the EDTA titrimetric method, while total hydrocarbon content (THC) was determined by the approximate method. All laboratory equipment and sample bottles were thoroughly cleaned with nitric acid according to the method of Martin *et al.* (1992). All analytical quality control requirements were strictly adhered to.

All measures of central tendency to characterize the stations, and test of significance using the Parametric One Way Analysis of Variance (ANOVA), were computed using the SPSS 11.0 statistical package. The Microsoft Excel was used for the graphical presentation.

RESULTS

The minimum, maximum and mean concentrations of heavy waters in the study stations are summarized in Table 1.

Table 1: Summary of the heavy metals concentrations in the study stations

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	Statistical Significance
	$\overline{X}\pm SE$ (min - max)	$\overline{X}\pm SE$ (min – max)	$\overline{X}\pm SE$ (min – max)	$\overline{X}\pm SE$ (min – max)	$\overline{X}\pm SE$ (min – max)	
THC (mg/l)	0.010 ± 0.000 (0.01 – 0.01)	0.010 ± 0.000 (0.01 – 0.01)	0.010 ± 0.000 (0.01 – 0.01)	0.010 ± 0.000 (0.01 – 0.01)	0.010 ± 0.000 (0.01 – 0.01)	P>0.05
EDTA Hardness (mg/l $CaCO_3$)	209.4 ± 21.62 (64 – 528)	211.8 ± 19.25 (100 – 456)	204.5 ± 17.74 (112 – 456)	206.09 ± 16.04 (124 – 436)	203.61 ± 20.79 (64 – 552)	P>0.05
Calcium (mg/l)	37.084±8.934 (8.82 – 200.4)	36.420 ± 7.804 (12.02 ± 202.8)	37.554 ± 8.339 (12.83 – 216.4)	35.547 ± 8.697 (14.43 – 222.8)	37.084 ± 8.935 (7.21 – 228.5)	P>0.05
Magnesium (mg/l)	171.74±17.611 (55.18 – 428.3)	171.76± 15.895 (87.98–415.92)	166.98± 13.132 (89.55–352.72)	171.65 ± 11.73 (98.35–304.73)	166.53±14.229 (56.79– 323.54)	P>0.05
Iron (mg/l)	0.703 ± 0.299 (0.01 – 6.02)	0.712 ± 0.301 (0.01 – 6.08)	0.727 ± 0.306 (0.01 – 6.12)	0.771 ± 0.336 (0.01 – 6.78)	0.714 ± 0.303 (0.01 – 6.10)	P>0.05
Zinc (mg/l)	0.087 ± 0.021 (0.01 – 0.42)	0.087 ± 0.022 (0.01 – 0.43)	0.102 ± 0.024 (0.01 – 0.44)	0.092 ± 0.024 (0.01 – 0.41)	0.074 ± 0.019 (0.01 – 0.43)	P>0.05
Lead (mg/l)	0.090 ± 0.025 (0.01 – 0.53)	0.107 ± 0.0266 (0.01 – 0.52)	0.115 ± 0.027 (0.01 – 0.51)	0.155 ± 0.034 (0.01 – 0.61)	0.145 ± 0.032 (0.01 – 0.52)	P>0.05
Cadmium (mg/l)	0.036 ± 0.0058 (0.01 – 0.10)	0.037 ± 0.0057 (0.01 – 0.10)	0.040 ± 0.0064 (0.01 – 0.10)	0.050 ± 0.0082 (0.01 – 0.11)	0.041 ± 0.0067 (0.01 – 0.11)	P>0.05
Chromium (mg/l)	0.120 ± 0.066 (0.01 – 1.49)	0.149 ± 0.063 (0.01 – 1.42)	0.153 ± 0.0657 (0.01 – 1.37)	0.150 ± 0.0633 (0.01 – 1.27)	0.165 ± 0.0640 (0.01 – 1.34)	P>0.05
Nickel (mg/l)	0.2922±0.1225	0.2552± 0.1175	0.3204± 0.1267	0.2243± 0.0742	0.3126± 0.1251	P>0.05

	(0.01 – 2.71)	(0.01 – 2.72)	(0.01 – 2.73)	(0.01 – 1.50)	(0.01 – 2.72)	
Mercury (mg/l)	0.010 ± 0.00	0.010 ± 0.00	0.010 ± 0.00	0.010 ± 0.00	0.010 ± 0.00	P>0.05
	(0.01 – 0.10)	(0.01 – 0.10)	(0.01 – 0.10)	(0.01 – 0.10)	(0.01 – 0.10)	

* P>0.05 = Not Significant

The total hydrocarbon content (THC) was approximately 0.01 mg/l (Fig.2) throughout the study period. EDTA hardness ranged from 64 mg/l $CaC0_3$ to 552 mg/l $CaCO_3$ (Fig.3). Calcium ranged from 7.21 mg/l to 228.5 mg/l (Fig.4). Magnesium ranged from 55.18 mg/l to 428.3 mg/l (Fig.5). There was no consistent seasonal trend in EDTA hardness, Calcium and magnesium. Fe ranged from 0.01mg/l to 6.78 mg/l (Fig.6). Zinc ranged from 0.10 mg/l to 0.43 mg/l (Fig.7). Lead ranged from 0.01 mg/l to 0.61 mg/l (Fig. 8). Cadmium ranged from 0.01 mg/l to 0.11 mg/l (Fig. 9). Chromium ranged from 0.01 mg/l to 1.49 mg/l (Fig. 10). Nickel ranged from 0.01 mg/l to 2.73 mg/l (Fig. 11), while mercury was approximately 0.01 mg/l throughout the study period (Fig. 12).

The statistical analysis using ANOVA showed that there was no significant difference (P > 0.05) in the concentrations of heavy metals at the study stations (Table 1).

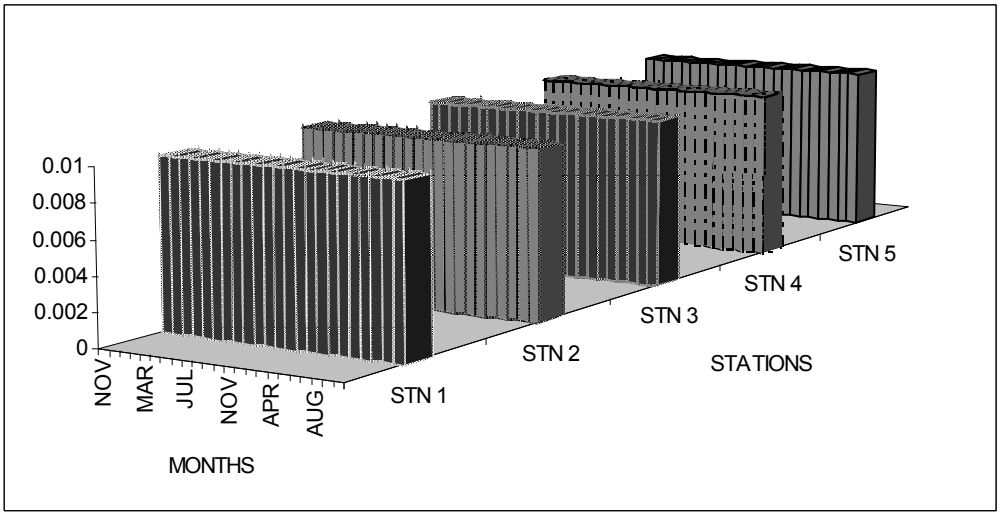

Fig. 2: Spatial and Temporal Variations in Total Hydrocarbon Content (THC) at the Study Stations, Nov. 2004 – Oct. 2006.

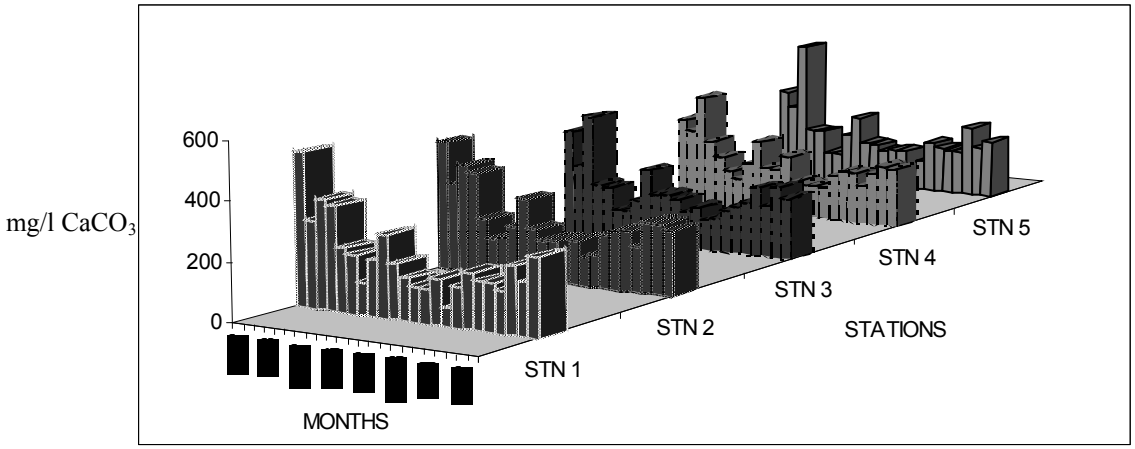

Fig. 3: Spatial and Temporal Variations in EDTA Hardness at the Study Stations, Nov. 2004 – Oct. 2006.

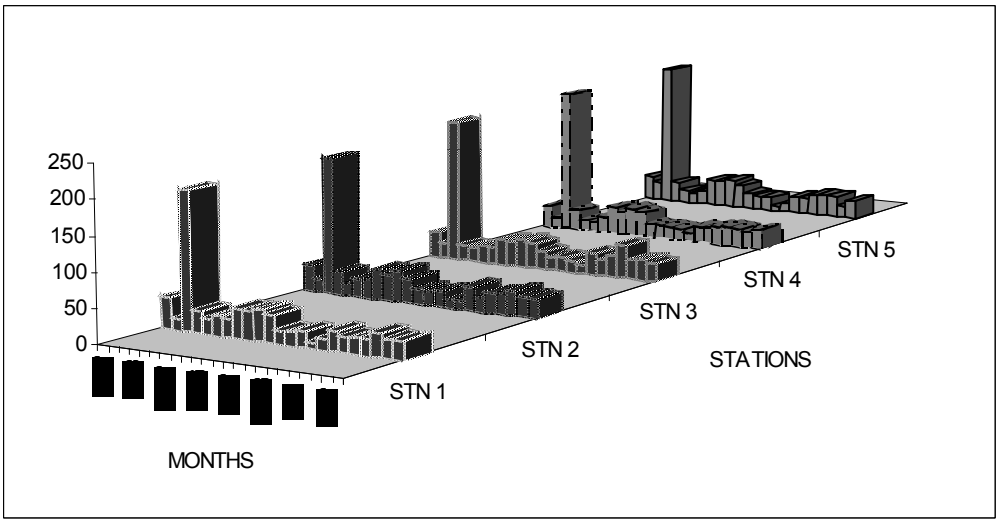

Fig. 4: Spatial and Temporal Variations in the concentration of Calcium at the Study Stations, Nov.2004 – Oct. 2006.

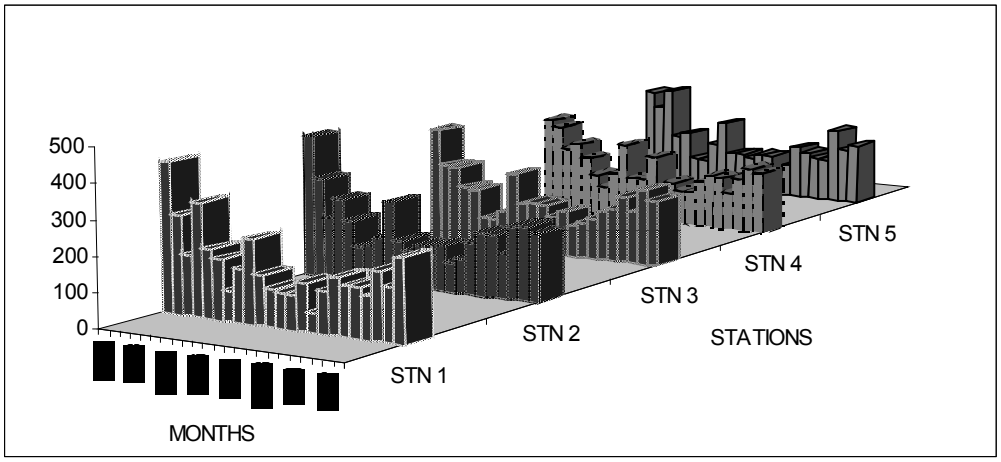

Fig. 5: Spatial and Temporal Variations in the concentration of Magnesium at the Study Stations, Nov. 2004 – Oct. 2006.

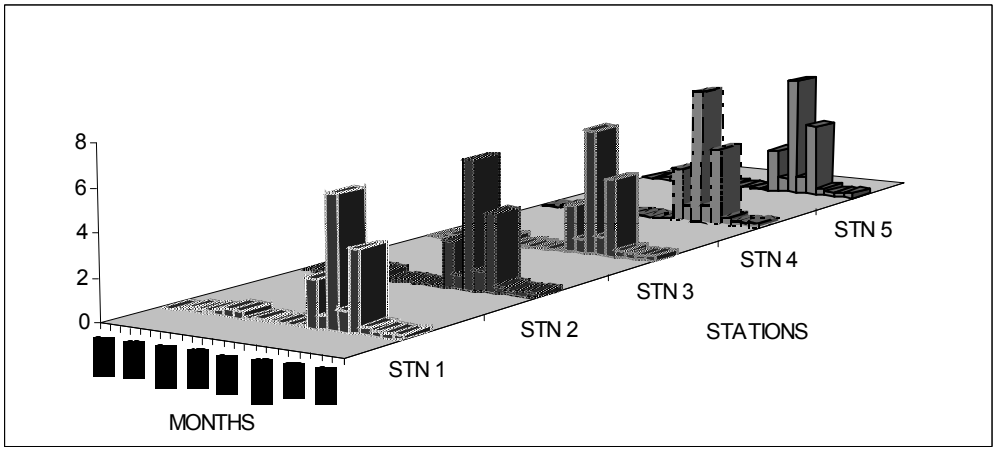

Fig. 6: Spatial and Temporal Variations in the concentration of Iron at the Study Stations, Nov. 2004 – Oct. 2006.

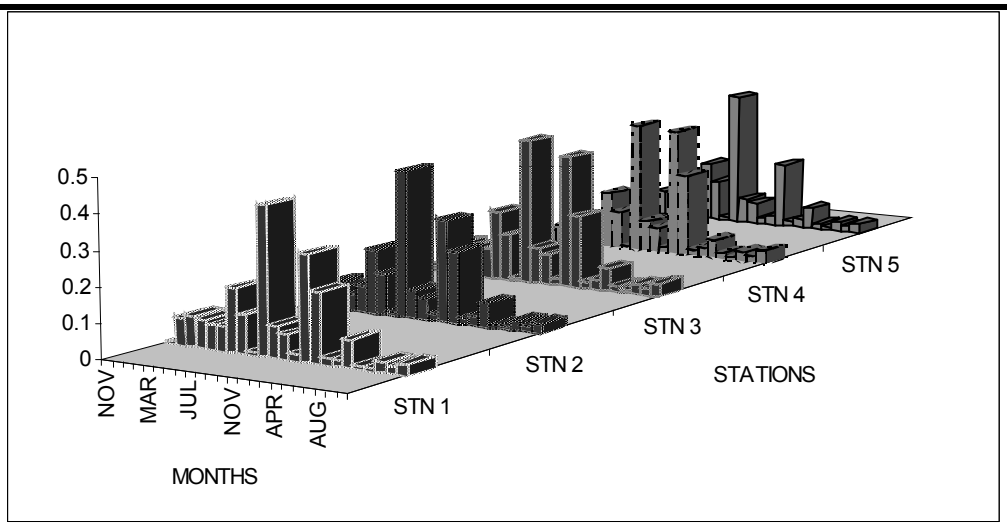

Fig. 7: Spatial and Temporal Variations in the concentration of Zinc at the Study Stations, Nov. 2004 – Oct. 2006.

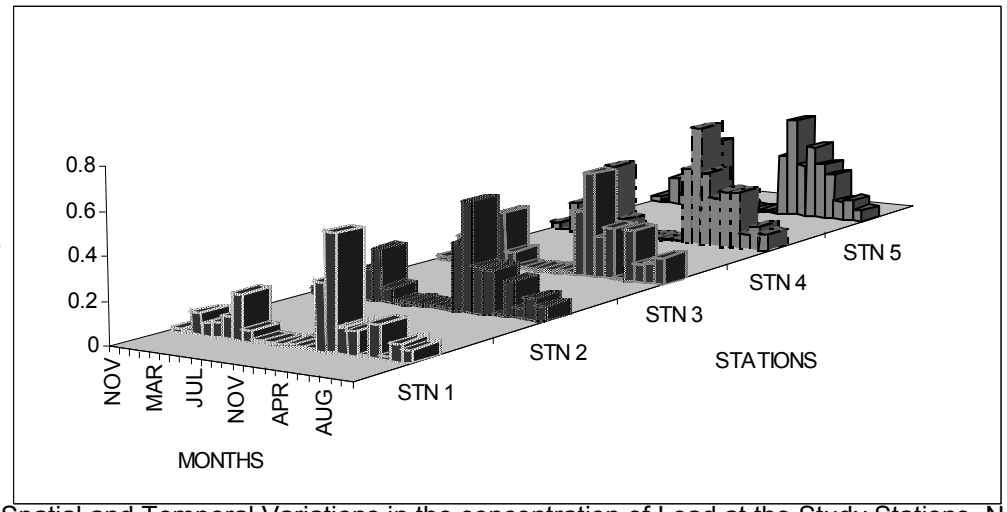

Fig. 8: Spatial and Temporal Variations in the concentration of Lead at the Study Stations, Nov. 2004 – Oct. 2006.

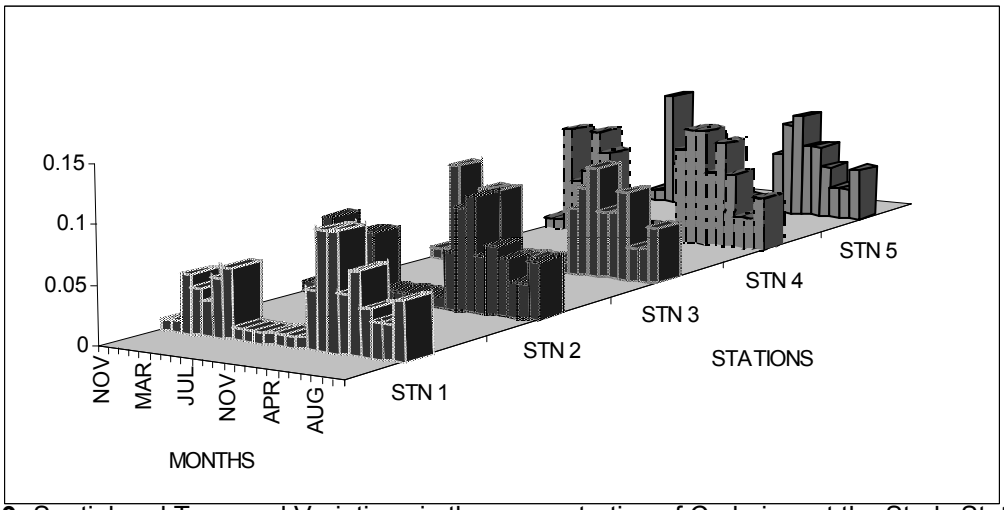

Fig. 9: Spatial and Temporal Variations in the concentration of Cadmium at the Study Stations, Nov. 2004 – Oct. 2006.

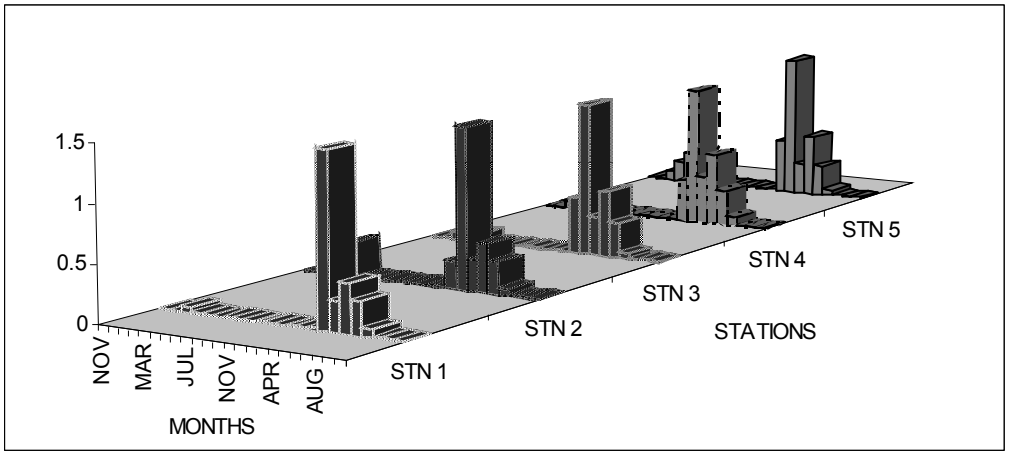

Fig. 10: Spatial and Temporal Variations in the concentration of Chromium at the Study Stations, Nov. 2004 – Oct. 2006.

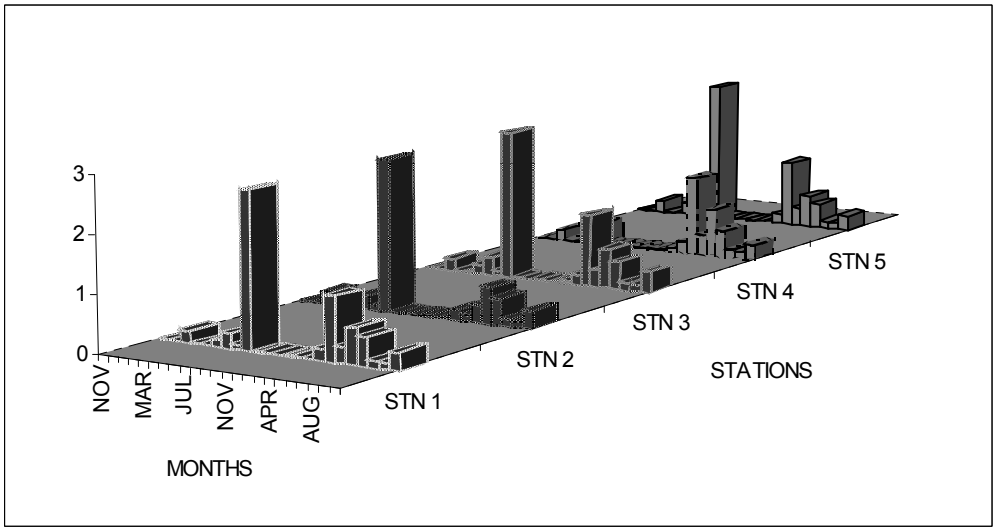

Fig. 11: Spatial and Temporal Variations in the concentration of Nickel at the Study Stations, Nov. 2004 – Oct. 2006.

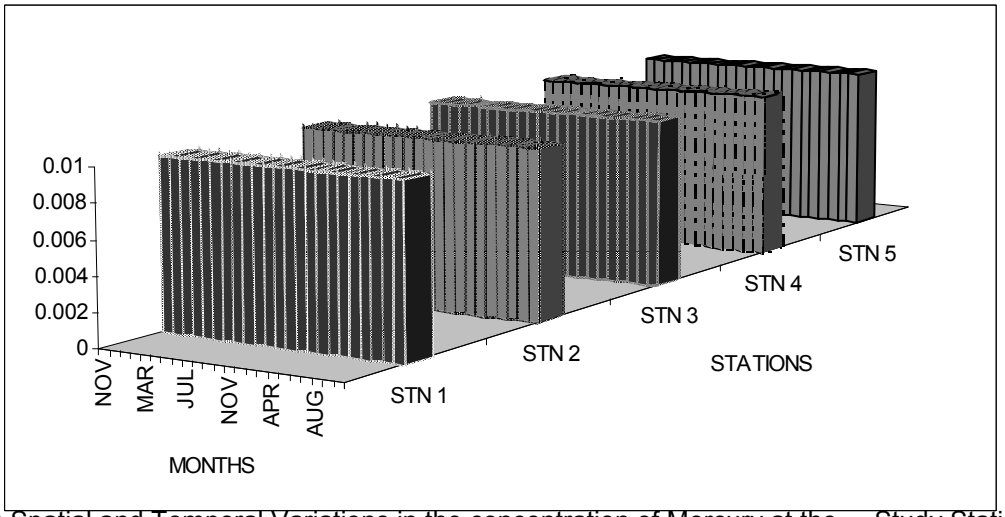

Fig. 12: Spatial and Temporal Variations in the concentration of Mercury at the Study Stations, Nov. 2004 – Oct. 2006.

DISCUSSION

The total hydrocabon content (THC) was very low (0.01 mg/l). This could be due to very low input of pollutants. Minimal values (0.09 to 1.22ppm) of oil and grease were considered not surprising for Elechi Creek, due to absence of oil related activities (Obire *et al.,* 2003). Shell Petroleum Development Company has a mainfold in station 5 of the study stretch, but spillage rarely occurs.

The EDTA hardness of 64-552mg/l $CaCO_3$ recorded in this study is within the range of 1- 1872 mg/l $CaCO_3$ recorded for New Calabar River (Ekeh and Sikoki, 2003). This record depicts hard water condition. The high level of EDTA hardness is due to the high concentrations of calcium and magnesium. The dry season maximum for these parameters could be due to evaporation and concentration of solids. Other cations, iron and zinc, had higher values than those reported for New Calabar River (Ekeh and Sikoki, 2003). The cation concentrations of Mg > Ca > Fe > Zn do not totally conform with the observation of Chindah and Braide (2004) of Mg > Ca > K > Zn > Fe for lower Bonny River.

The toxic heavy metals concentrations were in the order of Ni > Cr > Pb > Cd > Hg. Mercury concentration was extremely low (0.01 mg/l) throughout the study period. The higher records of metals during the dry season could be attributed to low influx of fresh water and evaporation resulting in concentration of material in the creek. The intermittent high values of nickel in wet months could be due to influence of run-off from rain water and human introduction.

Heavy metals have been used as indices of pollution because of their high toxicity to human and aquatic life (Omoigberale and Ogbeibu, 2005). Mombeshora *et al.* (1981), Atuma and Egborge (1986) and Edema (1993) associated the high concentrations of heavy metals in the aquatic ecosystems with effluents from industries, refuse and sewage. Buguma Creek is generally low in heavy metals compared to other waters in the Niger Delta such as the Warri and Ikpoba Rivers (Atuma and Egborge 1986; Fufeyin and Egborge 1998). The extremly low levels of the toxic heavy metals and total hydrocarbon content (THC) of < 1 mg/l indicate that the water was not polluted. This report on the concentration of heavy metals in the surface water of Buguma Creek should contribute to the baseline for monitoring of the water which is currently used in experimental brackish water aquaculture.

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