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Original article

Spatial and seasonal variability in sediment parameters of Amadi-Ama Ckeek, port Harcourt, Nigeria

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ABSTRACT

The spatial and seasonal variability in sediment parameters of Amadi-Ama creek were investigated for 2years (January2009 and December 2010). Sediment samples collected were analyzed following the standard limnological methods of APHA and values subjected to statistical analysis($p<0.05$).The study revealed that only temperature did not exhibit spatial significant difference while other parameters such as pH, conductivity, nitrate, sulphate, phosphate and chlorophyll 'a' all differed significantly in both years. By the exception of nitrate and phosphate, all other parameters/nutrients exhibited significant difference seasonally. The parameters and nutrients such as pH, sulphate and chlorophyll 'a' recorded higher values in the dry season than the wet season while conductivity was higher in the wet season than the dry season. Temperature, nitrate and phosphate values fluctuate during the period of study. The recorded chlorophyll 'a' values placed Amadi-Ama creek between mesotrophic and euthrophic status.

1. Introduction

According to Grundling (1971), sediments are known to absorb, store and release nutrient as they are needed by epipelic algae. The composition and density of epipelic algae depend to a great extent on the nature of sediment, availability of nutrient and other ecological factors. United State Environmental Protection [USEPA], 2002] described sediment as the loose sand, silt and other particles that settle at the bottom of a body of water which could come from soil erosion or from decomposition of plant and animal materials. The activities of denitrifiers in a sediment vary with the nature of sediment and its depth. Also, phosphorus dynamics, sorption and desorption depends on sediments characteristics(Guy, 1992).The presence of organic matters on the sediment in polluted or non polluted form determines the characteristics of the water as well as its productivity.

In the determination of water quality of any aquatic ecosystem, physicochemical parameters or water chemistry have been in use for years (USEPA, 2002, Adamus, 1996). The knowledge of the state of water quality of a water body in rivers and creeks due to changes produced by human activities is usually the first step in establishing an efficient water management system which is essential for the preservation of the ecosystem (Douterelo *et al;* 2004). Investigation by Guy (1992) revealed that the abundance and distribution of aquatic organisms precisely plankton and others is a function of the physicochemical variables or parameters of such a water body or aquatic ecosystem.

Chindah(2004) opined that seasonal variation in either water or sediment parameters is attributed to so many factors such as rainfall, evaporation, precipitation, surface run-off and the nature of the anthropogenic wastes deposited in the water which cause high level of microbial degradation in the aquatic ecosystem thus releasing its contents into the sediment and the water. According to Nwankwo(1988), the major factors in water quality affected by pollutants are the dissolved oxygen and pH and that depletion of dissolved oxygen arises from bacterial degradation of the organic constituents utilizing oxygen.

There is paucity in the number of published works on the sediment parameters of Amadi-Ama creek despite the various anthropogenic wastes deposited into the creek hence the need for the present study. This study therefore intends to evaluate the seasonal and spatial variability in sediment parameters and chlorophyll'a' for future use.

2. Materials and methods

2.1. Study area

Amadi-Ama Creek is located in Port Harcourt Local Government Area of Rivers State and lies between longitude 5^0 60'E-6^0 60'E and latitude 6^0 06'N-6 07'(Fig.1). The creek is one of the tributories of the upper Bonny Estuary, brackish and tidal in nature with fresh waters intrusion from the surrounding inland waters and flood during the wet season. The Bonny River Estuary lies on the South-Easthern edge of the Niger Delta between longitudes 6^o58'and 7^o14'East and latitudes $4^0$19' and $4^0$34'North with an estimated area of 206km^2 and extends 7km offshore to a depth of about 7.5metres (Scott, 1966).

2.2. Sampling stations

The six sampling stations chosen along the creek course include the following: Station 1:(Amadi),Station 2 (Nkpogu), Station 3(Oginigba),Station 4(Woji),Station 5(Azubie),Station 6(Abuloma Jetty)(Fig.1).

2.3. Sample collection and analysis

Sediment samples were collected on monthly basis from January 2009-December 2010(24 months).Sediment samples were collected from the creek bed at low tide and the collected samples were then transferred to already labeled water proof bags and taken to the laboratory where they were air dried under a room temperature and kept for further analysis. Temperature readings were taken using mercury thermometers(o^c),pH and conductivity were measured using a Hannan Instrument(portable pH/EC) model No.H1991300 while nitrate-nitrogen and phosphate–phosphorus were determined using a HACH DR/2000 Direct Reading spectrophoto-

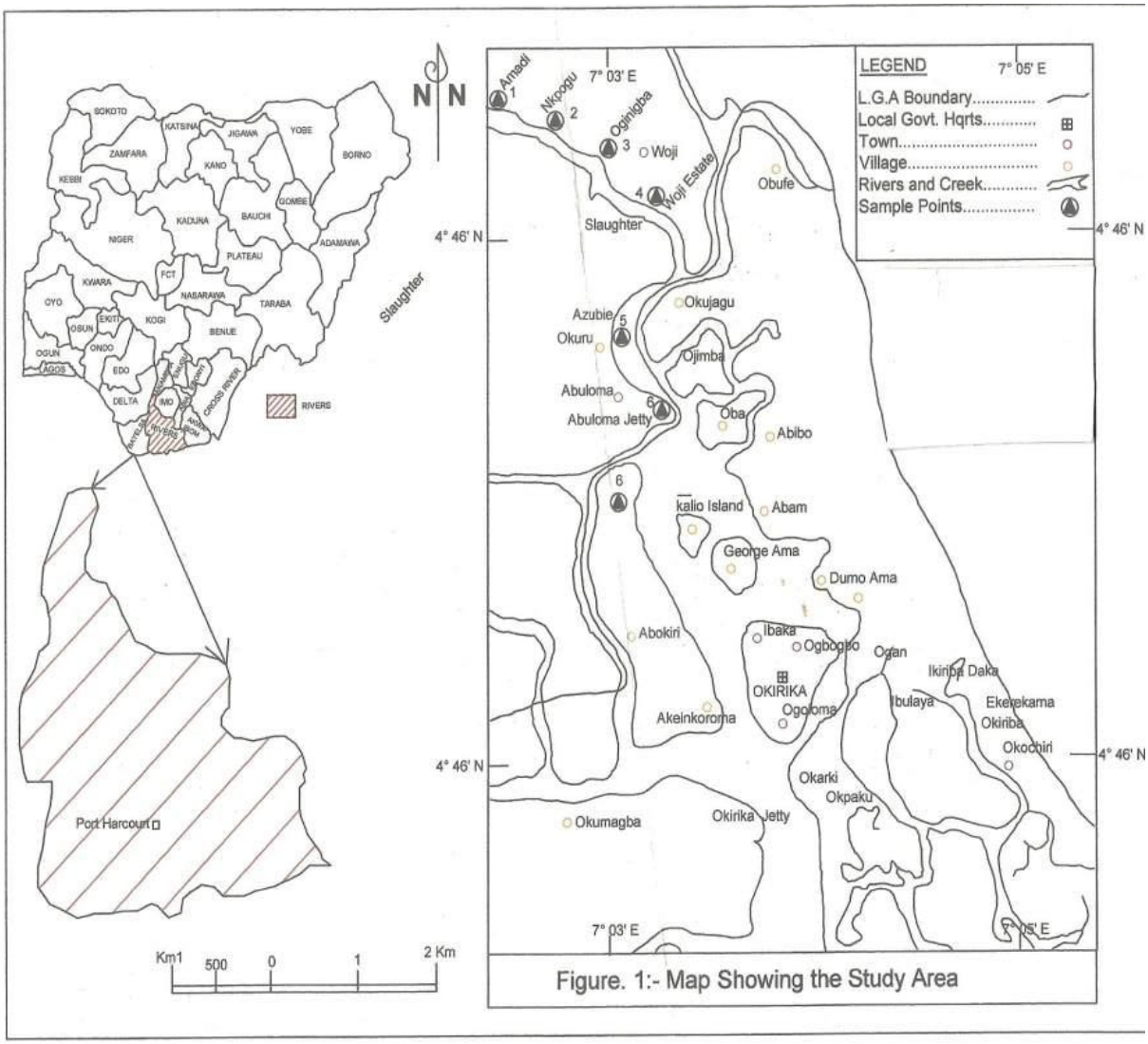

Figure. 1:- Map Showing the Study Area

Fig. 1. Map showing the study area

meter. Sulphate- sulphur was measured using Nephelometer after precipitation in a hydrochloric acid medium and Barium chloride. Chlorophyll'a' was measured fluorometrically and spectrophotometrically.

2.4. Statistical analysis

The data obtained from the laboratory were analyzed using SAS(2003) and Microsoft Excel (2003) statistical packages for Duncan Multiple Range(DMR) and analysis of variance (ANOVA).

3. Results

Tables1 shows the overall mean sediment parameters while table 2 -3 show the spatial and seasonal sediment parameters of the creek. The water temperature recorded in the study area ranged from 27.20-30.5^{o}C with an overall mean of 29.18±0.97^{o}C in the first year (2009) while the second year (2010) values ranged from 26.0-31.1^{o}C with an overall mean of 28.87±1.52(Table 1). Spatially, temperature shows fluctuation between

stations with the highest mean value (29.45±0.73^{o}C) recorded in Station 6 in the first year while in the second year, the lowest (28.73) and highest (29.00) mean temperature were observed in Stations 5 and 3 respectively(Table 2a). Generally, sediment temperature fluctuates seasonally with significant difference in 2010 but without difference in 2009(Table 2b).

The P^{H} values ranged between 2.6 and 6.4 NTU with an overall mean of 3.95±0.76NTU in the first year while the second year ranged from 2.1-6.0NTU with the mean value of 3.88±0.89NTU(Table1). Spatially, pH values fluctuate but maintain acidic range in both years(Table 2). The sediment seasonal pH showed higher values in the dry season than wet season throughout the period(Table3).pH value showed significant difference seasonally in the second year but non seasonal in the first year($p<0.05$) (2009).

Conductivity value ranged from 1000 and 7,500µS/cm with an overall mean of 4678.47±1521.67µS/cm in the first year while the second year values ranged between 1000-8400US/cm with a mean of 5040.69±1672.61µS/cm(Table 1). Spatially, conductivity exhibited significant difference only in the first year with the highest means in stations 4(2009) and 3(2010) respectively(Table 3). The conductivity values were highest in wet seasons than the dry seasons in both years with significant difference ($P<0.05$)(Table 3).

The nitrate values recorded ranged from 0.5-2.8mg/l with a mean of 1.10±0.44 mg/l in the first year while the second year(2010) values ranged from 0.3-3.5mg/l with a mean value of 0.97±0.47mg/l(Table2). Spatially, significant differences were observed with station 1 having the highest values in both years(Table2). The sediment seasonal nitrate concentration in the dry and wet seasons exhibited non seasonality(Table3).

The sulphate-sulphur values observed ranged from 30.0-920mg/l with a mean of 268.25±149.93mg/l in the first year(2009) while the second year(2010) value ranged between 79.2-950mg/l with a mean of 268.25±149.93mg/l)(Table 1). Spatial fluctuation and significant difference were observed with the highest mean values (310.33±36.66mg/l and 297.9±141.2) recorded in Station 3 during the period of study(Table 2). Sulphate values were observed to be highest during the dry season than the wet seasons during the period(Table 3). Sulphate showed significant difference between seasons and stations ($P<0.05$) for the two years of study.

The phosphate value ranged from 0.9-1.95mg/l with a mean of 1.56±0.21mg/l in the first year and 1.1-2.1mg/l with a mean of 1.59±0.19mg/l in the second year(Table 1). Spatially, values exhibited slight variation with the highest values observed in stations 3 and 6 in 2009 and 2010 respectively. The phosphate values for dry and wet seasons exhibited non seasonality throughout the period.

The chlorophyll'a'(chl'a') values in sediment recorded during the study ranged between 0.00 and 4.1mg/l with the mean value 2.20±1.14mg/l in 2009 where as the second year values ranged between 2.90 and 6.50 mg/l with a mean of 5.09±0.79mg/l(Table 1). Spatial values varied significantly with the highest values observed in station 3 while the lowest mean values were recorded in Station 6 throughout the period ($p<0.05$)(Table 2).Seasonality and non seasonality were observed during the second and first year respectively. Chlorophyll'a'values were higher during the dry season than the wet seasons for the two years of study(Table 3).Generally, chlorophyll 'a' increased with increase in nutrients especially phosphate.

Table1

Sediment physicochemistry of amadi-ama creek (Jan.2009-Dec. 2010

Parameters Jan.-Dec.2009	**Jan-Dec 2009 Overall Mean**	**Range**	**Jan-Dec 2010 Overall Mean**	**Range**
Temperature(oc)	29.18±0.97	27.20-30.50	28.87±1.52	26.00-31.10
pH	3.95±0.76	2.60-6.40	3.88±0.89	2.10-6.00
Conductivity(µs/cm)	4678.47	1000-7500	5040.69±1672.60	1000-8400
Nitrate(NO^{-2}_{3})(mg/l)	1.10±0.44	0.50-2.80	0.97±0.47	0.30-3.50
Sulphate(SO^{-2}_{4})(mg/l)	271.57±147.76	30.00-920.00	268.25±149.93	79.20-950
Phosphate($P0^{-2}_{4}$)(mg/l)	1.56±0.21	0.90-1.90	1.59±0.19	1.10-2.10
Chlorophyll 'a'(mg/l)	2.20±1.14	0.00-4.10	5.09±0.79	2.90-6.50

Table2a
Spatial values of sediment parameters in amadi-ama creek (Jan-Dec 2009)

PARAM/STN	1	2	3	4	5	6
Temperature	29.35±0.81a	29.23±1.02a	29.12±1.09a	28.87±1.18a	29.07±0.98a	29.45±0.45a
	28.00-30.20	27.80-30.50	27.20-30.20	27.24-30.30	27.60-30.10	28.44-30.40
PH	2.81±0.41c	3.78±0.47ab	4.22±0.87ab	3.99±0.55ab	4.43±1.09a	3.36±0.49c
	2.00-3.30	3.10-4.30	3.10-6.10	3.10-5.00	3.20-6.40	2.60-4.20
Conduct	4116.67±1780c	4416.67±1674b	4516.7±17ab	5424±1144a	4708.3±16ab	4887.5±12ab
	1000-7200	1200-7500	1500-6900	3700-7000	2000-7000	3250-6900
Nitrate	1.63±0.66a	1.17±0.38b	0.90±0.27b	0.99±0.26B	0.87±0.30b	0.99±0.17b
	0.90-2.80	0.80-1.80	0.50-1.60	0.80-1.70	0.60-1.66	0.80-1.40
Sulphate	245.17±227.33b	280.92±145a	310.3±137a	236.7±65b	267.92±15b	288.37±14a
	78.0-920	96.0-700	180.5-720	180-400	30.0-600	190.0-619
Phosphate	1.65±0.19a	1.56±0.29ab	1.68±0.25a	1.43±0.26b	1.44±0.12b	1.65±0.12a
PO_4^{2-}	1.30-1.95	1.20-1.80	1.3-1.95	0.90-1.80	1.20-1.60	1.40-1.80
CHL'a'	2.22±1.26b	1.87±1.22b	3.50±0.49a	1.97±1.14b	1.93±0.85b	1.68±0.76b
	0.00-3.26	0.00-3.90	2.5-4.10	0.00-3.40	0.0-3.00	0.0-2.80

Mean with the same letter in the same row are not significantly different

Table2b
Spatial mean values of sediment parameters in amadi-ama creek (Jan-Dec2010).

PARAM./STN.	1	2	3	4	5	6
Temperature	28.75±1.67a	28.90±1.56a	29.0±1.43a	28.91±1.56a	28.73±1.37a	28.93±1.81a
	26.0-30.10	26.40-30.30	26.90-30.10	26.40-30.40	26.60-30.10	26.0-31.10
PH	4.27±1.13a	4.01±0.83b	3.78±0.84ab	3.96±0.66a	4.03±1.04b	3.24±0.51a
	2.60-6.00	3.10-5.33	2.60-5,00	2.50-4.90	2.10-5.30	2.10-4.20
Conduct	4716.7±2067b	5275±1553a	5460.8±1199a	5020.8±1619a	5175±1799a	4595.8±187b
	3000-8200	3400-8000	3900-7000	3100-7200	3200-8200	1000-8400
Nitrate	1.48±0.60a	1.01±0.40b	0.79±0.26b	0.83±0.29b	0.73±0.17b	1.00±0.57b
	0.70-2.20	0.60-1.90	0.30-1.30	0.50-1.50	0.50-1.00	0.40-2.50
Sulphate	225.41±238c	270.88±14b	297.9±141.2a	238.05±77.36c	290.96±122a	286.3±15b
	79.20-950	90.0-680	195-730	160.5-430	201-580	150-600.1
Phosphate	1.64±0.21ab	1.54±0.10b	1.60±0.21ab	1.50±0.21b	1.49±0.17b	1.74±0.14a
	1.30-1.90	1.40-1.70	1.40-2.10	1.10-1.85	1.20-1.80	1.45-1.94
CHL'a'	5.25±0.57b	5.24±0.52b	6.15±0.24a	4.93±0.61bc	4.74±0.49c	4.23±0.73d
	3.90-6.10	4.0-6.00	5.90-6.50	4.00-5.90	3.90-5.40	2.90-5.20

Mean with similar letter in the same row are not significantly different

Table3

Seasonal mean values (Dry and Wet) of the sediment parameters in amadi-ama creek (2009).

PARAMETERS	MEAN (DRY SEASON) NOV-APRIL. 2009	RANGE	MEAN (WET SEASON) MAY-OCT. 2009	RANGE
Water temperature(oc)	28.77±0.77[a]	27.24-30.40	29.59±0.79[a]	27.20-30.50
pH	4.03±0.85a	2.60-6.40	3.87±0.66a	3.0-5.60
Conductivity(µs/cm)	3684.72±1035.16b	1000-5400	5672.22±1262.56a	3000-7500
Nitrate(NO^{-2}_3)(mg/l)	1.54±0.23a	0.50-2.80	1.58±0.19a	0.80-2.00
Sulphate(SO^{-2}_4) (mg/l)	315.89±191.11[a]	78.00-920	227.25±0.64b	30.00-310.00
Phosphate($P0^{-2}_4$) (mg/l)	1.06±0.50a	0.90-1.95	1.14±0.37a	1.05-1.90
Chlorophyll 'a' (mg/l)	2.59±0.91a	1.00-4.10	1.79±1.21a	0.00-3.60
PARAMETERS	MEAN(DRY SEASON) NOV-APRIL.2010	RANGE	MEAN(WET SEASON) MAY-OCT.2010	RANGE
Water temperature(oc)	30.01±0.36[a]	29.10-31.10	27.73±1.38b	26.00-30.20
pH	4.19±0.95a	2.50-5.50	3.57±0.71b	2.10-6.00
Conductivity(µs/cm)	3911.94±966.30[b]	1000-6000	6169.44±1456.18[a]	3000-8400
Nitrate(NO^{-2}_3)(mg/l)	1.05±0.41a	0.60-2.20	0.90±0.52a	0.30-2.50
Sulphate(SO^{-2}_4)(mg/l)	316.73±195.19a	79.20-950	219.78±51.64b	80.00-300
Phosphate($P0^{-2}_4$)(mg/l)	1.61±0.18a	1.30-2.10	1.56±0.21a	1.10-1.90
Chlorophyll 'a'(mg/l)	5.33±0.69a	4.00-6.50	4.86±0.82b	2.90-6.20

Mean with similar letter on the same row are not significantly different

4. Discussion

The sediment temperature range of 26-31.1^{0}c observed in this study is in agreement with the 26-30^{0}c observed by Davies(2008) in Okpoka creek but contrary to that of Tisser et al.,(2008) in Samaru stream Zaria which could be attributed to environmental difference. The study area with this range of temperature is typical of African water bodies. The non significant difference in temperature observed across the stations in this study could be ascribed to non variability in environmental factors such as climate and among others. The seasonality and non seasonality observed in temperature values in this study is in agreement with Deekae(2008) observation in Nun river which could be as a result of environmental factors such as difference in rainfall and insolation and dredging activities within the periods. The pH range of 2.6 and 6.4 observed in this study showed that the sediment is acidic. This is similar to pH 4.27-4.88 of Okrika Creek sediment reported by Ebere(2002) and Davies (2008) which was attributed to the presence of sulphur compounds that characterizes brackish water system of Niger Delta. This observation is contrary to the low acidity to neutral pH level (6.8-7.28) reported by Izuoafuo et al.,(2004) in the middle reach landing jetties of Bonny Estuary but similar to the level(4.6-6.2) reported by Anderson(1966) in Okrika river in Rivers state. Conductivity range of 1000-8400 (µs/cm) observed in this study showed that the creek water falls within class (111) of the classification of African waters by Talling and Talling(1965). The seasonal variation with the higher values in the wet season than the dry season in both year is contrary to those of Obunwo (2004) which was attributed to high rate of evaporation caused by high temperature in the dry season. The observed high conductivity in the wet season could also be ascribed to high influence of the sea on the creek.

The Nitrate value ranged from 0.5 – 3.50mg/l and the variations between stations were considered low. This confirms the observation of Harbel (2007) in the Earth Terrestrial ecosystem that nitrogen is one of the major nutrients required by phytoplankton which is usually needed in small amount. The observed low concentration has also been observed by Chindah et al (1998) in the New Calabar River, Chindah and Onyebuchi (2003) in a Swamp forest Stream in the lower Niger Delta and Chindah (2004) in a Tropical Estuary in Niger Delta. The higher values of Nitrate in the wet season (1.58±0.19mg/l) than the dry season (1.54±0.23mg/l) though without significant difference in both years could be due to high anthropogenic inputs during the period as confirmed by Ebere (2002) in Okrika creek. The decreased value of Nitrate in the dry season could also be attributed to high uptake by Phytoplankton and epipelic algae during the study since photosynthetic activities are usually higher during dry season. The phosphate level recorded in this study from the sediment range between 0.9 – 1.95mg/l. This is also considered low and in line with the findings of Chindah and Nduaguibe (2003) in a Swamp forest Stream

in Niger Delta. This observed range is however above the range of 0.05 – 0.2mg/l considered favourable for aquatic productivity (Rout et al., 2003). The higher Phosphate value in the dry season (1.61±0.81mg/l) than the wet season(1.56±0.21mg/l) in 2010 in this study is in accordance with the observations of chindah and braide (2001) in the Bonny River which was attributed to the higher biomass of phytoplankton and epipelic algae in the dry season. Sulphate value ranged from 30.00-920mg/l in 2009 and 79.20- 950mg/l in 2010 in this study. This observed sulphate range is a characteristic of a brackish water.

Chlorophyll'a' values observed in this study ranged from 0.00-4.10mg/l in 2009 and 2.90-6.50mg/l in 2010. The lower values of chlorophyll'a' in 2009 could be due to the dredging operations carried out during the year. It could also be attributed to high rate of photosynthetic activities during the period. Chlorophyll 'a' concentration in station 3 appeared highest in both first and second year of study. This could be caused by increased nutrient load in the station noted by Chindah(2004) in Bonny River system. Also, the presence of the highest epipelic algal abundance in station 3 than any other station in this study is indicative of a stressed environment. The mean concentration of chlorophyll 'a' observed in the dry season was higher than the wet season in both years. This observation agreed with Horsley et al., (2000) and Day et al.,(1982) results in a Southern African water that chlorophyll 'a' concentration in dry season is often higher than the wet season.

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