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Original article

Sediment chlorophyll 'a' and nutrients characteristics of the upper bonny estuary, amadi-ama creek, port harcourt, Nigeria

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ABSTRACT

The sediment chlorophyll 'a' and nutrient characteristics of the Amadi-Ama creek was studied for 24 months between January 2009 – December 2010.Sediments samples collected from the water bed at low tide were analysed for the variable following standard methods. The data were subjected to analysis of variance(ANOVA), Duncan Multiple range test(DMR) and pearson correlation coefficient.They all showed spatial and seasonal variations with higher values in the dry season than the wet season except Chlorophyll 'a', and sulphate which did not show seasonal difference for the two years. The highest values of chlorophyll 'a' and sulphate were observed in station 3 throughout the period of study.

1. Introduction

Sediment has been described as the ultimate sink of contamination in the aquatic ecosystem (Mucha et al., 2003).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. 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. Sediments with smooth surface tends to have more organisms than those with rough surface (Guy,1992). Sediments that are temporarily or permanently inundated by water in streams, rivers and estuaries have more food materials (nutrients) and will have more organisms (algae)(Chindah, 1990).

Organic matter settles from the water column to the sediment; the sedimentation rate is related to the primary productivity of the aquatic environment. The organic matter forms the flocculent layer on the sediments which is a biodetrial layer, very active in decomposition and made up of an entanglement of bacteria, fungi, algae and detritus (Guy, 1992).

However, excessive productivity of water column expressed by high chlorophyll'a' concentrations can supply large amounts of easy decomposition (i.e.labile) of organic matter to the sediments. The decomposition of algal biomass can increase the diurnal amplitude of water column pH and dissolved oxygen fluctuations, and in some cases may lead to anoxic and hypoxic events.

Nutrients in sediment or water are the elements required in trace quantity for growth and development of aquatic micro and macro organisms. Nutrients are also the water variables that affect the survival, growth, reproduction, production and general management of aquatic organisms (Schmitt, 2005). Nutrient also affects primary productivity. Harbel (2007) disclosed that major inorganic nutrients required by phytoplankton are nitrogen and phosphorus though diatoms and dinoflagellates also require silica. These nutrients occur in small amounts and are thus limiting factors for primary productivity. Different species of phytoplankton respond to different concentrations of limiting nutrients and has a maximum growth rate. High levels of nutrients (nitrate, phosphate and sulphate) often recorded may be a reflection of direct discharges of pollutants among which domestic and wood wastes rank high directly into the creek(Flynn,2001).

Chindah et al. (2004) and Izuoafo et al. (2004) reported that nutrients in the sediments of Bonny Estuary is observed to be generally low and was ascribed to high metabolic rate in the Niger Delta waters where nutrients are quickly used up, low retention rate and intensive loss processes such as gentrification occurring in water at the sediment/water interface.

There has been no sufficient information on the chlorophyll'a' and nutrients characteristics of the upper Bonny Estuary of Amadi-Ama Creek, hence this research.

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, Alalibo, 1988).

2.2. Sampling stations

Six sampling stations were established at least 500m apart through a reconnaissance survey undertaken using boat from the eastern by-pass through the Amadi axis and on foot along the creek banks from the Rumukalagbo to the Nkpogu axis through Woji to Abuloma jetty.Station 1: (Amadi), Station 2 (Nkpogu), Station 3(Oginigba), Station 4(Woji), Station 5(Azubie), Station 6(Abuloma Jetty) (Fig. 1).

2.3. Sediment sample collection and analysis

The sediment samples were collected with Beckmans grab monthly for 24months (January 2009-December2010) to determine sediment chlorophyll 'a' and nutrients during the low tides. The collected samples were then transferred to already labeled water proof bags and taken to the

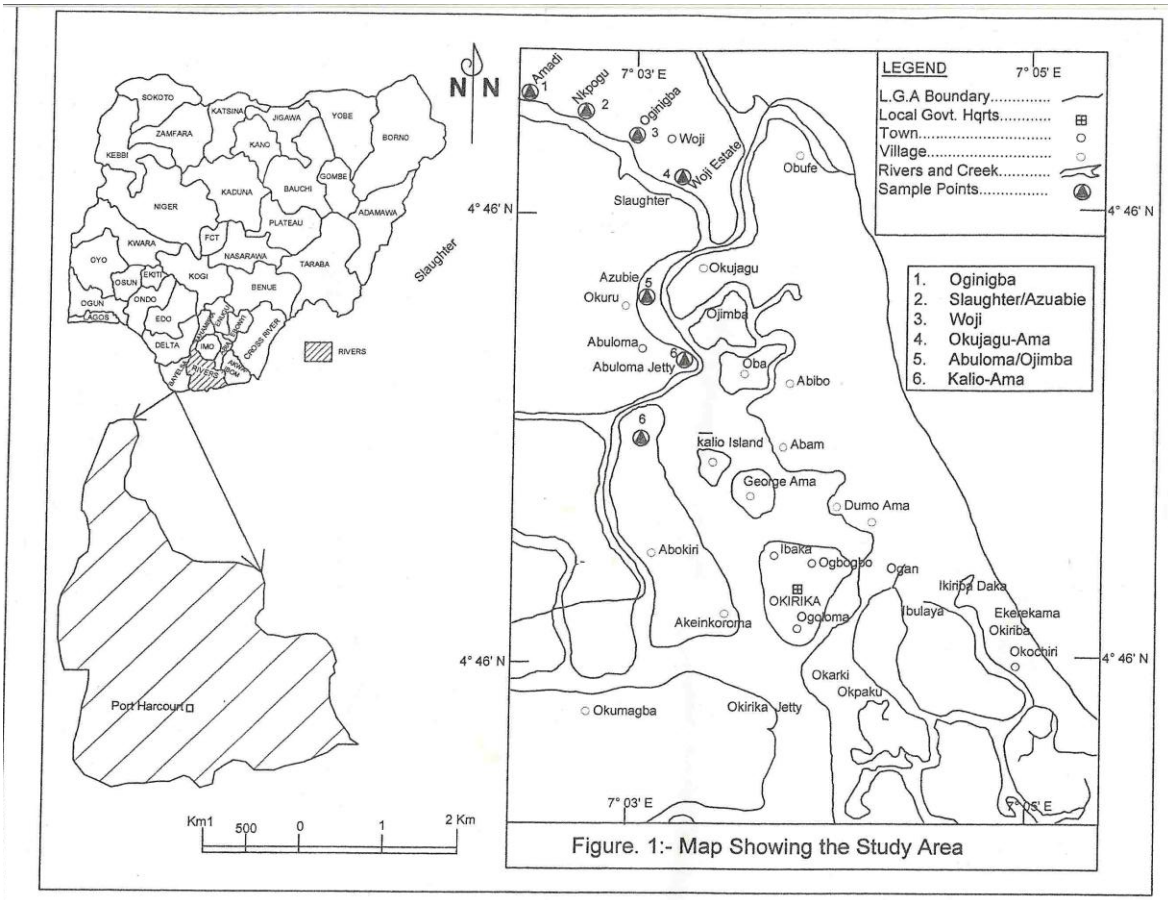

Figure. 1:- Map Showing the Study Area

Fig. 1. Map showing the study area.

Laboratory where they were air dried under a room temperature and kept for further analysis. Chlorophyll'a,'and nutrient samples were analysed following standard methods (APHA, 1998).

2.4. Statistical analysis

Analysis of variance (ANOVA) , Duncan multiple range test (DMR) and pearson correlation coefficient were used to analyse data using SAS (2003) and Microsoft Excel (2003) packages.

3. Results

The chlorophyll'a'(chl'a') values in sediment recorded during the study ranged between 0.00 and 4.1mg/l with a 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(Table1). Spatially, chlorophyll 'a' values were consistently high in station 3 and low in Station 6 during the period (Table 2). Significant differences were observed in stations 3 and 6($p<0.05$). Chlorophyll'a' value ranged from 1.00-4.10mg/l with a mean of 2.59±0.91mg/l in dry season and 0.00-3.60mg/l with a mean of 1.79±1.21mg/l in wet season in 2009(Table3). In 2010, it ranged from 4.00-6.50mg/l with the mean

value of 5.33±0.69mg/l in the dry season and 2.90-6.20mg/l with the mean value of 4.86 ± 0.82mg/l in the wet season(Table 3b).The dry season values of chlorophyll 'a' in the sediment were significantly higher than the wet season during the period.

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) ranged from 0.3-3.5mg/l with a mean value of 0.97±0.47mg/l (Table1). Spatially, nitrate values were consistently low in Station 5 and high in Station 1 during the period of study (Table 2b). The sediment seasonal nitrate concentration in the dry and wet season ranged from 0.5-2.8mg/l and 0.8-2.0mg/l respectively in the first year(Table3a) while the second year ranged from 0.6-2.2mg/l for dry season and 0.3-2.5mg/l for wet season(Table3b).Nitrate showed higher values in the wet season than dry season without significant difference.

Table 1
Sediment Nutrients and Chlorophyll 'a' in the area (January 2009-December 2010).

Parameters	Jan-Dec 2009	Range	Jan-Dec 2010	Range
Chlorophyll 'a'(mg/l)	2.20±1.14	0.00-4.10	5.09±0.79	2.90-6.50
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

Table2a
Spatial MeanValues of Sediment Parameters in Amadi-Ama Creek Jan.-Dec.2009.

Parameters	1	2	3	4	5	6
CHL'a'	2.22±1.26[b]	1.87±1.22[b]	3.50±0.49[a]	1.97±1.14[b]	1.93±0.85b	1.68±0.76[b]
	0.00-3.26	0.00-3.90	2.5-4.10	0.00-3.40	0.0-3.00	0.0-2.80
Nitrate	1.63±0.66[a]	1.17±0.38[b]	0.90±0.27[b]	0.99±0.26[b]	0.87±0.30[b]	0.99±0.17[b]
	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±227.33[c]	280.92±145[a]	310.3±137[a]	236.7±65[d]	267.92±15[b]	288.37±14[a]
	78.0-920	96.0-700	180.5-720	180-400	30.0-600	190.0-619
Phosphate	1.65±0.19[a]	1.56±0.29[ab]	1.68±0.25[a]	1.43±0.26[b]	1.44±0.12[b]	1.65±0.12[a]
	1.30-1.95	1.20-1.80	1.3-1.95	0.90-1.80	1.20-1.60	1.40-1.80

Table2b
Spatial Mean Values of Sediment Parameters in Amadi-Ama Creek Jan.-Dec.2009.

PARAM/STN	1	2	3	4	5	6
CHL'a'	5.25±0.57[b]	5.24±0.52[b]	6.15±0.24[a]	4.93±0.61[bc]	4.74±0.49[c]	4.23±0.73[d]
	3.90-6.10	4.0-6.00	5.90-6.50	4.00-5.90	3.90-5.40	2.90-5.20
Nitrate	1.48±0.60[a]	1.01±0.40[b]	0.79±0.26[b]	0.83±0.29[b]	0.73±0.17[b]	1.00±0.57[b]
	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±238[a]	270.88±14[a]	297.9±141.2[a]	238.05±77.36[a]	290.96±122[a]	286.3±15[a]
	79.20-950	90.0-680	195-730	160.5-430	201-580	150-600.1
Phosphate	1.64±0.21[ab]	1.54±0.10[b]	1.60±0.21[ab]	1.50±0.21[b]	1.49±0.17[b]	1.74±0.14[a]
	1.30-1.90	1.40-1.70	1.40-2.10	1.10-1.85	1.20-1.80	1.45-1.94

The sulphate 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) ranged from 79.2-950mg/l with a mean of 268.25±149.93mg/l)(Table 1). Spatially, Station 4 had the lowest mean value of sulphate (236.72±64.83mg/l) while the highest mean (310.33±36.66mg/l) was recorded in Station 3 in 2009 (Table2a). In 2010,the lowest mean value of sulphate (225.41±238.06mg/l) was recorded in Station 1 and the highest mean value (290.96±121.98mg/l) was recorded in Station 5 (Table 2b).Sulphate values ranged between dry and wet seasons as in table 3b.There were fluctuations in

values seasonally and spatially with observed seasonality and non seasonality during the period.

The phosphate value ranged from 0.9-1.95mg/l with a mean of 1.56±0.21mg/l in the first year (2009) and 1.1-2.1mg/l with a mean of 1.59±0.19mg/l(Table1) in 2010. Spatially,phosphate values were consistently high in Station 3 during the period)(Table2) but the lowest values fluctuate between Stations 4 and 5 in 2009 and 2010(Table 2). The phosphate values for dry and wet seasons ranged from 0.9-1.95 and 1.05-1.90mg/l respectively for the year 2009 (Table3a) and the second year values ranged between 1.3-2.1mg/l and 1.1-1.9mg/l respectively (Table 3b).There was no seasonality observed.

Table 3a

Seasonal mean values (dry and wet) of the sediment parameters and nutrients in Amadi-Ama creek (Jan-Dec 2009)

Parameters Jan-Dec 2009	Mean (dry season) Jan-Dec 2009	Range	Mean (wet season) Jan-Dec 2009	Range
Chlorophyll 'a' (mg/l)	2.59±0.91[a]	1.00-4.10	1.79±1.21[a]	0.00-3.60
Nitrate(NO^{-2}_3)(mg/l)	1.54±0.23[a]	0.50-2.80	1.58±0.19[a]	0.80-2.00
Sulphate(SO^{-2}_4) (mg/l)	315.89±191.11[a]	78.00-920	227.25±0.64[b]	30.00-310.00
Phosphate($P0^{-2}_4$) (mg/l)	1.06±0.50a	0.90-1.95	1.14±0.37[a]	1.05-1.90

Table 3b

Seasonal mean values (dry and wet) of the sediment parameters and nutrients in Amadi-Ama creek (Jan-Dec 2010).

Parameters Jan-Dec 2010	Mean (dry season) Jan-Dec 2010	Range	Mean (wet season) Jan-Dec 2010	Range
Chlorophyll 'a'(mg/l)	5.33±0.69[a]	4.00-6.50	4.86±0.82[b]	2.90-6.20
Nitrate(NO^{-2}_3)(mg/l)	1.05±0.41[a]	0.60-2.20	0.90±0.52[a]	0.30-2.50
Sulphate(SO^{-2}_4)(mg/l)	316.73±195.19[a]	79.20-950	219.78±51.64[b]	80.00-300
Phosphate($P0^{-2}_4$)(mg/l)	1.61±0.18[a]	1.30-2.10	1.56±0.21[a]	1.10-1.90

4. Discussion

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. The lowest chlorophyll 'a' concentration in this study was observed in station 6 (1.68±0.76 mg/l, and 4.23±0.73mg/l) for 2009 and 2010 respectively. The chlorophyll 'a' concentration (spatial) in 2009 appeared low while 2010 readings increased significantly. This variation in concentration of chlorophyll 'a' was previously reported by Chindah (2004) in the Bonny River and attributed to increase in the nutrient load in the aquatic environment from time to time due to addition of anthropogenic wastes containing detergent, animal wastes and others. 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. The seasonal variation observed is also in line with the report of Amy (2003) in Florida who attributed it to several factors such as nutrient flow and hydrogeo-chemical characteristics and amount of light energy impinging on the water.

The range of nitrate value and the variations between stations in this study 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 range of nitrate recorded in this present study is below the statutory limit(25-50mg/l) given by the European Economic Community(EEC,1979) and the 20mg/l by the United State Environmental Protection Agency(USEPA, 1971).The higher values of nitrate in the wet season than the dry season though without significant difference in 2009 could be due to high anthropogenic inputs during the study 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 is 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). Ganapati (1956) also stated that Phosphate level above 0.5mg/l is an indication of pollution. However, King and Nkata (1999) reported that some trophical waters have high nutrient values which agreed with the earlier observation by Chindah and Nduguibe (2003) of 0.43-3.52mg/l in the Swamp forest of Niger Delta. 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 brackish water. This observed sulphate value is below the value (2650mg/l) reported by McNeely et al., (1979).

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