Research Journal of Applied Sciences, Engineering and Technology 1 (1): 1-9, 2009
ISSN: 2040-7467

Epiphytic Diatoms Growing on *Nypa Fructican* of *Okpoka* Creek, Niger Delta, Nigeria and Their Relationship to Water Quality

Davies, Onome Augustina
Department of Fisheries and Aquatic Environment, Faculty of Agriculture,
Rivers State University of Science and Technology, Nkpolu, Port Harcourt, Rivers State, Nigeria

Abstract: *Okpoka* Creek of the Upper Bonny Estuary in the Niger Delta is a sink receiving organic anthropogenic effluents from Trans-Amadi Industrial Layout and the waterfront communities. The study investigated resultant impact on the abiotic and biotic factors hrough the assessment of the physico-chemical properties of surface waters and epiphytic diatoms. Surface water and epiphyton samples were collected monthly from May 2004 – April 2006 at low and high tides from ten stations according to APHA methods. These were analysed for temperature, transparency, turbidity, dissolved oxygen (DO), biological oxygen demand (BOD), pH and nutrients. Epiphytic diatoms were identified microscopically. Species diversity was calculated using standard indices. Data analyses were done using analysis of variance, Duncan multiple range and descriptive statistics. Water temperature 28.6±0.06°C, turbidity 3.6±0.32 NTU and transparency 0.7±0.01m showed insignificant spatial variations ($p>0.05$). Water chemical parameters were: salinity, 14.4±4.67%; DO, 5.0±0.10 mg L^{-1} and BOD, 3.3±0.09 mg L^{-1}. Phosphate and ammonia exceeded FEPA and USEPA acceptable levels for natural waterbodies. Pollution-indicator epiphytic diatom genera recorded were *Navicula, Nitzschia* and *Synedra*. The high nutrients status favours the high abundance and distribution of epiphytic diatoms. The observed implicative genera indicate organic pollution from anthropogenic sources. Discharges of untreated domestic and industrial effluents should be discouraged.

Keywords: Epiphytic diatoms, indicator species, nutrients status, *Okpoka* creek, pollution, species diversity

INTRODUCTION

The Bonny Estuary is one of the several estuaries in the Niger Delta swamps through which the Lower Niger and Benue Rivers flow into the ocean. The estuary is richly endowed with abundant aquatic resources (creeks, distributaries, flood plains and mangrove swamps with fin/shell fish resources, etc.). The estuary, its creeks and tributaries consist of rich collection of flora and fauna constituting a unique tropical biodiversity. The vegetation of Bonny Estuary is dominated by the red mangrove *Rhizophora racemosa* and *R. mangle* (Wilcox, 1980). The mangrove provides nurseries and feeding grounds for commercially important species of finfish and shellfish. Despite its good environment for aquatic life forms, the area is prone to pollution resulting from industries located along the shore of Bonny Estuary which are concentrated in this zone and they discharge their effluents directly into the estuary. The flushing action of the tidal flow contributes to moving these pollutants down into the coastal zones.

Okpoka Creek of the Upper Bonny Estuary in Port Harcourt, Rivers State, is one of the inland waters that receive municipal wastes from anthropogenic sources in its environment thus rendering the creek a sink. This creek is located between longitude 7°00 E and 7°15 N and latitudes 4°28 E and 4°40 N (Fig. 1). It is a typical estuarine tidal water, a major creek joining Upper Bonny Estuary in the Niger Delta. The stretch of the coastal front of the creek has very high population density without wastes management facilities. All the industries and companies in the Trans-Amadi Industrial Layout discharge their wastes and also serve as toilet for many riverine dwellers. *Okpoka* Creek connects hinterland through many river channels and create settlements for waterfront dwellers. There are many communities along the main water course.

Namely: Oginigba, Azubiae, Woji, Okujagu, Okuru-ama, Abuloma, Ojimba, George-ama, Oba-ama, Kalio-ama, Marine base and Okrika. Urban runoff from the whole industrial area and these communities/towns find their way into this creek. There are many human activities going on around and in the creek such as dredging (manual and mechanized) and navigation, boating, fishing, refuse dumping, domestic and industrial washings, etc.

Anthropogenic sources are industrial effluents from companies like Hallibuton, Schlumberger, Acorn, Snig, Elf, Nigeria Engineering Works (NEW), Rivers Vegetable Oil Company (RIVOC), Michelin, Rivbiscuit, Crocodile Matchet, Cocacola, Fareast Paints, First Aluminium, General-agro, West African Glass, Pinalpina to mention but a few. Domestic effluents from residential buildings and raw faeces are discharged indiscriminately into the creek (toilets built over the creek), a main abbatoir/slaughterhouse is also located close to the creek, releasing untreated wastes (raw blood, raw animal faeces, soot from burnt animal skin, ashes from used wood, etc.).

Fig. 1: Map of Africa showing West Africa and Nigeria

The physico-chemical parameters of the aquatic environment (temperature, transparency, turbidity, salinity, dissolved oxygen, biological oxygen demand, pH, nitrate, phosphate, sulphate, etc.) influence the *periphyton* population and vice versa. These abiotic features as well as the *periphyton* are used to detect any perturbation in the aquatic environment. The distribution, abundance, species diversity, species composition of the *periphyton* are used to assess the biological integrity of the water body.

The autotrophic and heterotrophic components of *periphyton* serve as food resources for estuarine biota (Vadeboncoeur *et al.,* 2001; Liboriussen and Jeppsen, 2003). They are considered relevant bioindicators of environmental condition (Nwankwo, 1991; Lewis *et al.,* 2001). Also, algal-*periphyton* are considered as effective accumulators of trace metals (McCormick and Stevenson, 1998; Ten-cate *et al*., 1999). *Periphyton* can directly and indirectly serve as major regulators of the nutrient dynamics in lakes (Wetzel, 2001). They also regulate submerged vegetation (Jones *et al*., 2002; Williams *et al*., 2002). Epiphytic algae are studied because of their significant role in energy and nutrient transformation in many lakes as well as bio-indicator of pollution. Healthy streams typically have little obvious *periphyton* because algae are eaten by invertebrates. Nuisance blooms are usually a symptom of a system stressed by factors like over-supply of nutrients and high temperatures (that increase algal growth rates but stress some invertebrate grazers) (John and Mark, 2004). The use of organisms for monitoring pollution is based on the belief that natural, unpolluted environments are characterised by balanced biological conditions and contains a great diversity of plants and animal life with no one species dominating (Ruivo, 1972).

There have been increasing concerns on the need to conserve the aquatic environment in order to ensure sustainable resources and development at the local and international levels. This can only be achieved if the physico-chemical and biological integrity of the aquatic environment are maintained. Furthermore, there have been unprecedented complaint from the local people on the dwindling fin fish and shellfish population, catches have been drastically reduced. This may be attributed largely to the alarming increase of man's activities especially industrialization, dredging and teeming urban population with high resultant waste discharges into the water bodies as well as siltation of the aquatic environment. The river systems of the Niger Delta provide nearly 100% of the Rivers State fish resources and therefore, there is urgent need to study the influence of the physico-chemical parameters on the epiphyton of *Okpoka* creek due to its location, and the various man's activities going on around and on it. This creek is under environmental stress. The Bonny Estuary east of the Niger has been of great concern to the scientific community, governmental agencies and non-governmental bodies due to its location and the various industrial set-ups and jetties located along its shores. These industries and jetties discharge effluents including crude oil and its products directly into the system. Apart from these effluents, wastes are released into the system from domestic sources. Other human activities (dredging, transportation [boating, navigation], fishing, etc.) also impact on this estuary.

However, there has been very little information on the biotic and abiotic factors of the *Okpoka* Creek, a tributary of Upper Bonny Estuary. In order to bridge the existing gap in knowledge of the biotic and abiotic features of this estuary, there is therefore the need to provide useful information on the epiphytic diatoms, water physico-chemistry and the extent of pollution of the *Okpoka* Creek. The species composition, species diversity, abundance and distribution of the epiphytic diatoms and some physico-chemical parameters were studied.

MATERIALS AND METHODS

Study Area: The *Okpoka* Creek is located between longitudes 7°00 E and 7°15 N and latitudes 4°28 E and 4°40 N. It is a tributary of the Upper Bonny Estuary in the Niger Delta, South of Nigeria (Fig. 2). The vegetation is dominated by *nypa* palm (*Nypa fructican)* and mangroves, red mangrove (*Rhizophora racemosa)* and white mangrove *(Avecennia nitida)*. It passes through many communities namely: Oginigba, Woji, Azubiae, Okujagu, Okuru-ama, Abuloma, Ojimba, Oba, Kalio and Okrika. Many man's activities going on within and around this creek include dredging, fishing, boating, navigation, washing, disposal of excreta, bathing and swimming, to mention but a few. This aquatic body receives effluent discharges from the many industries (Snig, Far East paints, RIVOC, General-agro, Michelin tyres, Cocacola, Hallibuton, Schlumberger, Acorn, etc) and the main abattoir house sited close to it.

Sampling stations: A total of ten stations were chosen at least 500 metres apart along the main creek course.

Station 1- Oginigba: This station is located upstream. The dominant vegetation is *nypa* palm, followed by red mangroves (*R. racemosa*).

Station 2 Trans-Amadi by Schlumberger: This station is upstream towards the main Trans-Amadi slaughter house and close to the Schlumberger oil company. Other companies close to this station are Snig Nigeria Limited (oil servicing company), Far East Paints and oil servicing companies on both sides of the river course. This was the point source station for industrial effluents. All these industries are sited close to the river shore. It has both *nypa* palm and drying up red mangroves.

Station 3- Trans-Amadi by Slaughter: This was the point source of the main Trans-amadi abattoir effluent discharges. Presence of nypa palm (*Nypa fructican*) and plantain trees, but absence of mangroves. The station had been dredged.

Station 4- Azubiae: This station was downstream to the main Trans-amadi abattoir and opposite to the Azubiae community toilet built over the river. The dominant vegetation is nypa palm (*Nypa fructican*) followed by drying up red mangrove. Patches of water hyacinth were seen during the rainy season. Manual dredging of sand is constantly going on.

Station 5- Woji: This station had been dredged and still being dredged manually. The dominant vegetation is *nypa* palm. An oil servicing company is sited by the shore. The muddy sediment had been replaced by sand.

Station 6 -Okujagu: This area is also downstream to the main abattoir. It is thickly vegetated by *nypa* palm on one side of the major creek course and the other side by red mangroves. Manual dredging is going on along the main creek course. Local fish processing industry is sited close to this station.

Station 7 -Okuru-Ama: The station is downstream and the main vegetation are *nypa* palm and mangroves. It is close to a dredging company and manual dredging is going on.

Station 8- Ojimba: This is also a downstream station. There is no company sited close to it. Visually, the sediment is muddy.

Station 9- Oba-ama: The sediment is muddy and the dominant vegetation are *nypa* palm and drying up mangroves.

Station 10- Kalio-Ama: This is the downstream station. It is downstream to Abuloma Jetty and Marine Base sawmills industry. It is under tidal effects. Sawmills effluents are carried to this station during high tides.

Surface water sample collections for physico-chemical parameters: Surface water sample collections were done for 24 months from May 2004 to April 2006. The following parameters: temperature, turbidity, transparency

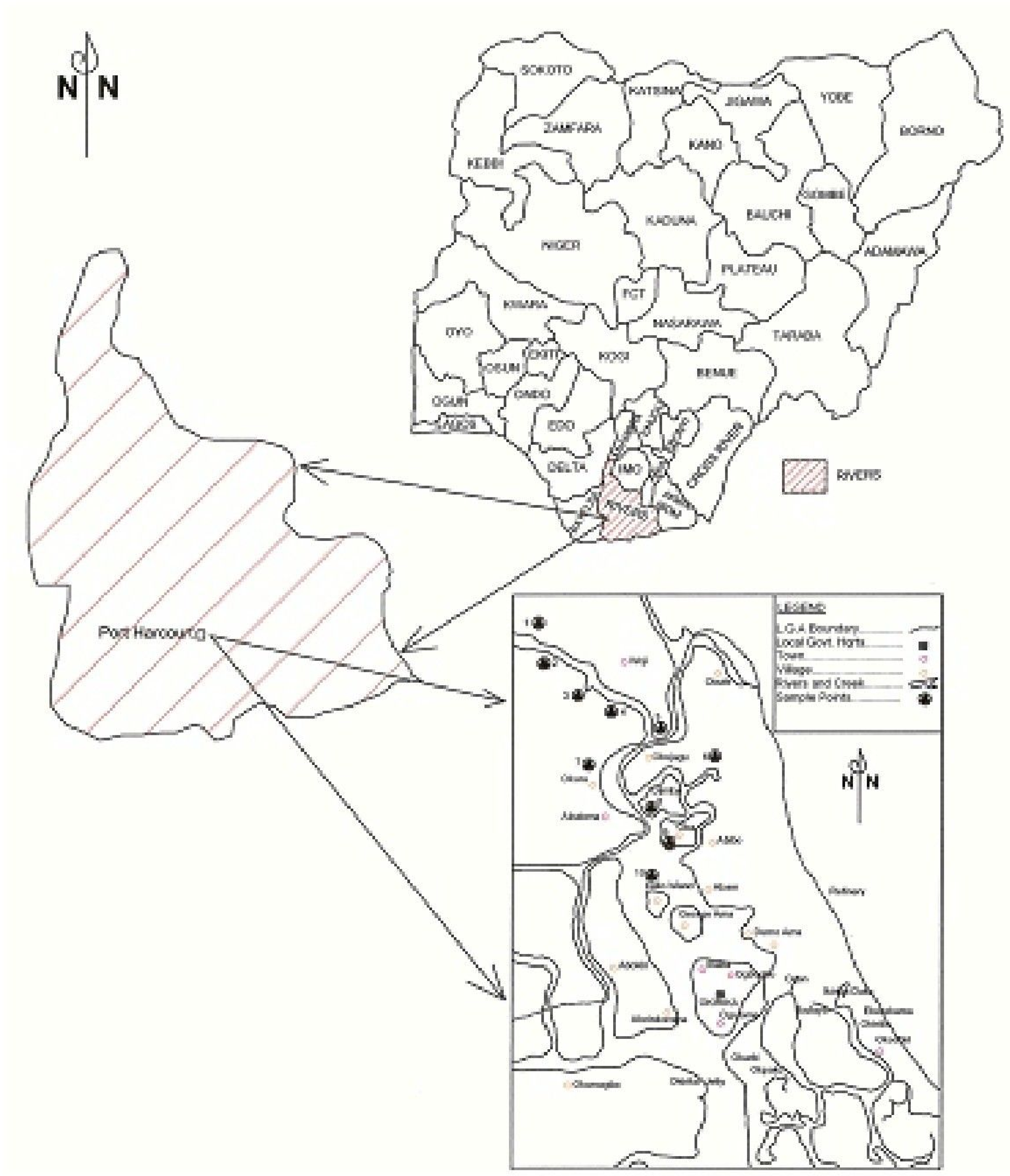

Fig. 2: Map of Nigeria showing Rivers State and the sampling stations (*Okpoka* creek)

salinity, dissolved oxygen (DO_2), biological oxygen demand (BOD), pH, nitrate (NO_3), sulphate (SO_4), phosphate (PO^3) and ammonia (NH_3) were measured in-situ and in laboratory following standard methods (APHA, 1998). One litre sterilized containers were used to collect water samples for physico-chemical parameters at each station. All the containers were kept in ice-chest box for laboratory analyses.

Collection of epiphyton and analyses: Collections of epiphyton were mostly done at low tide or ebb tide. In each sampling station, the algae were collected from a 2 x 2cm quadrant at five random points on the stem of *nypa* palm and were used for standing crop analysis. Each quadrant was carefully scrapped with a sharp scalpel to a depth of 0.2 cm. The set was stored in a vial bottle containing 50 mL of 10% formalin.

The standing crop samples were properly homogenized to break up the stem particles and disperse the algal cells throughout the sample. From the homogenized sample, 1ml sub sample was collected with a stampel pipette and transferred into a Sedgwick Rafter counting chamber for identification and enumeration under a Leitz-Wetzler binocular microscope using a combined magnification of between 100x and 400x and keys by Newell and Newell (1963), Han (1978), Prescott (1982) and Kadiri (1988). For each sample, 5 replicates were treated according to the procedures of Durans and Leveque (1980) and Chindah and Pudo (1991). The number of plankters per ml and species diversity indices were calculated following Boyd (1981) formulae.

Data analysis: Analysis of variance (ANOVA), Duncan multiple range (DMR) and descriptive statistics were used to analyse the data.

RESULTS

Surface water temperature: The surface water temperature ranged from 28.46±0.02°C (Station 1) to 28.76±0.21°C (Station 10) with a mean value of 28.64±0.06°C (Fig. 3). There was no significant spatial variation of temperature ($p>0.05$).

Surface water turbidity: The surface water turbidity ranged between 1.74±0.34 NTU (Station 2) and 5.67± 1.42NTU with a mean value of 3.59±0.32 NTU (Station 10).

Surface water transparency: The surface water transparency ranged from 0.59±0.03 m (Station 3) to 0.74±0.04 m (Station 10) with a mean value of 0.66±0.01 m and spatial variation was not significant ($p> 0.05$).

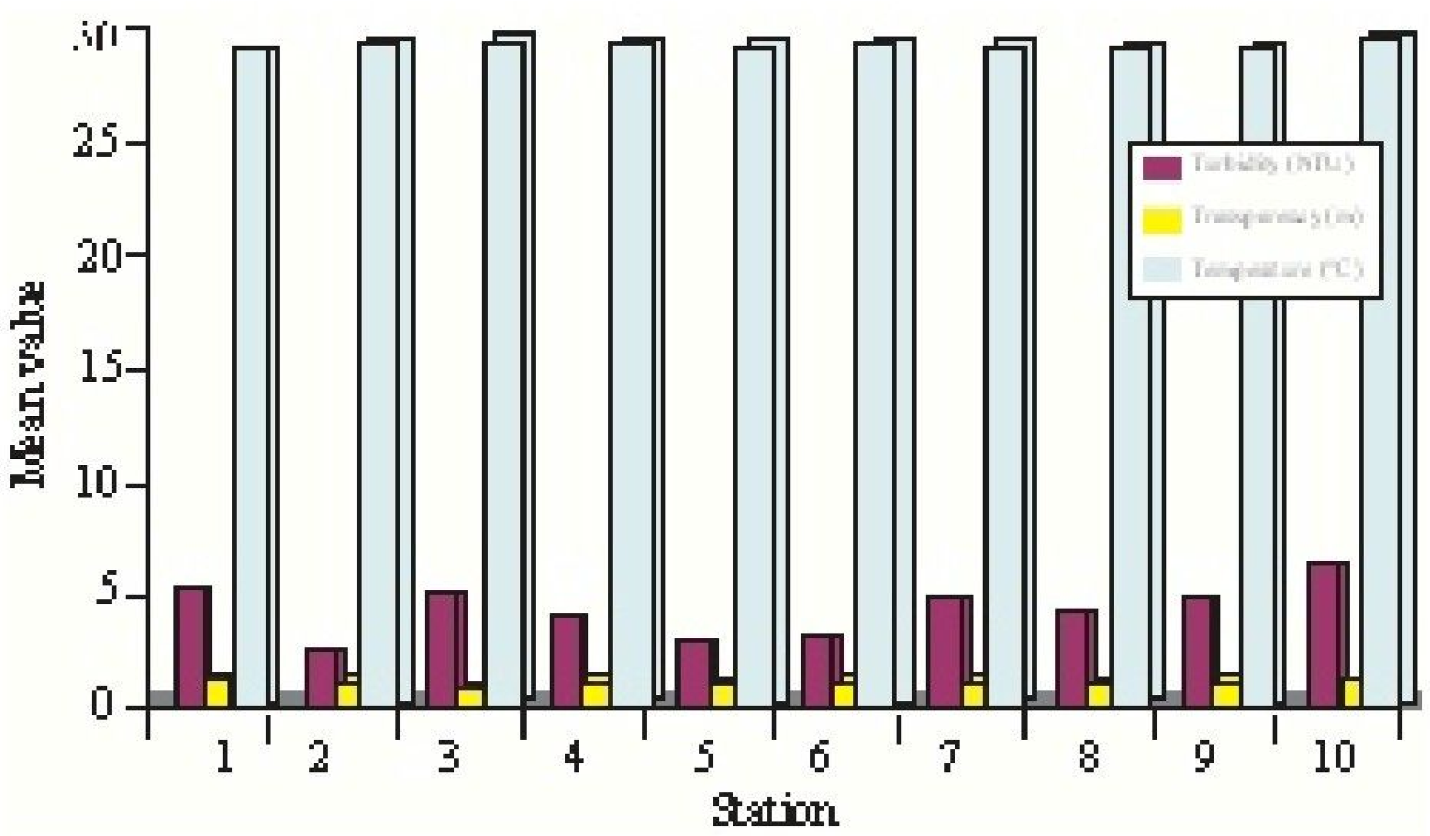

Fig. 3: Variation of turbidity, transparency and temperature in relation to station in *Okpoka* Creek

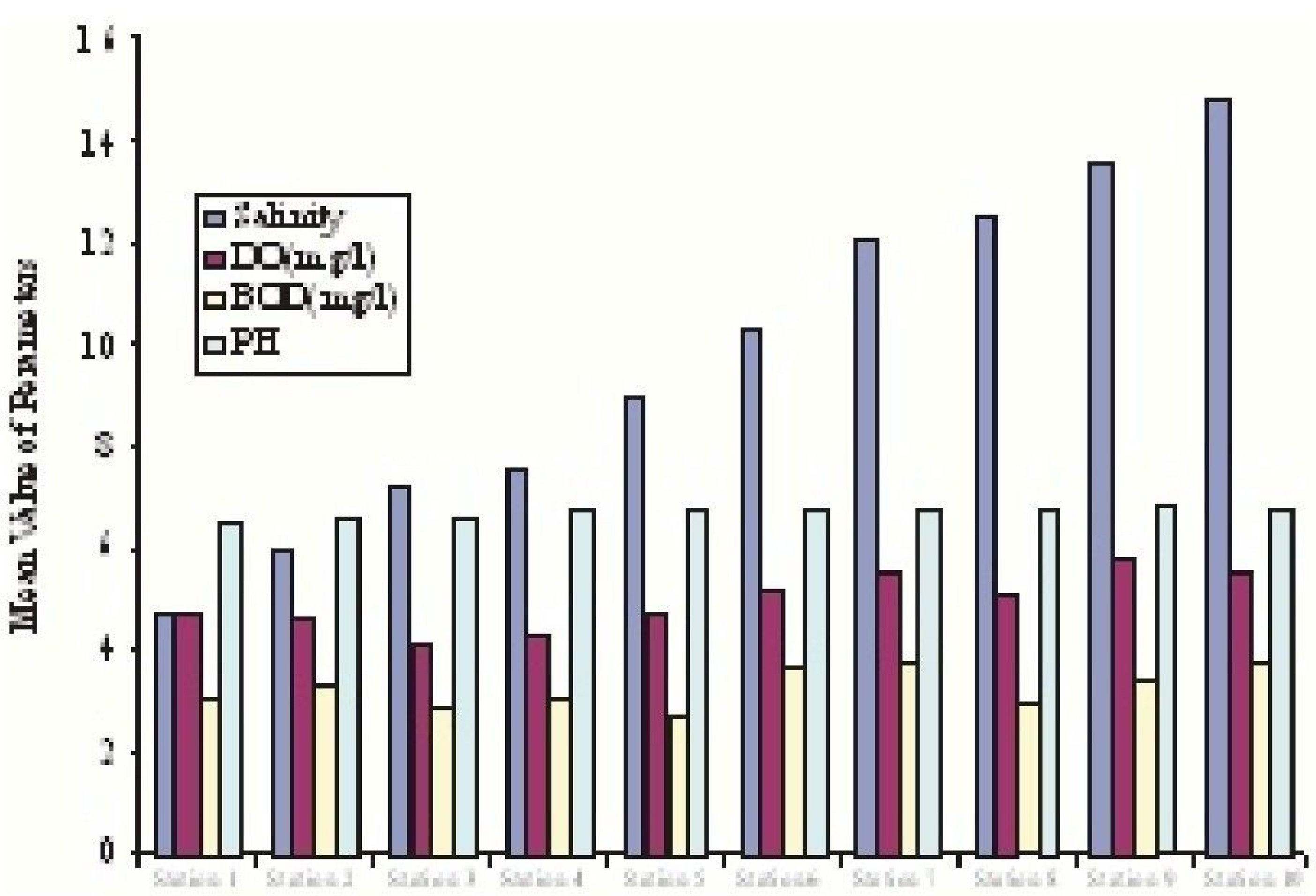

Fig. 4: Variation of Surface Water Chemical Parameter in relation to station in *Okpoka* Creek

Surface water salinity: The salinity ranged between 4.71±0.51‰ (Station 1) and 14.83±0.83‰ (Station 10) with a mean value of 14.41±4.67‰ and its variation was not significant (p> 0.05) (Fig.4).

Surface water dissolved oxygen (DO): The dissolved oxygen ranged between 4.12±0.37 mg L^{-1} (Station 3, slaughter wastes discharge point) and 5.81±0.27 mg L^{-1} (Station 9, free from wastes discharge) with a mean of 4.95±0.10 mg L−1. Spatial influence on dissolved oxygen was significant (p<0.01).

Surface water biological oxygen demand (BOD): The biological oxygen demand ranged between 2.68±0.24 mg L^{-1} (Station 5) and 3.84±0.36 mg L^{-1} (Station 7) and mean value of 3.26±0.09 mg L^{-1}. Spatial variation was significant (p>0.05).

Surface water pH: The water pH ranged between 6.49± 0.10 (Station 1) and 6.80±0.11 (Station 6) with a mean value of 6.70±0.02. Spatial effect on pH was not significant (p>0.05).

Ammonia: Ammonia concentrations ranged between 0.14±0.11 mg L^{-1} (Station 1) and 0.21±0.03 mg L^{-1} (Station 3) with a mean of 0.17±0.01 mg L^{-1} (Table 1). Spatial influence was not significant (p>0.05).

Table 1: Variations of water nutrients in relation to station and season in *Okpoka* Creek

Sta.	Ammonia (mg L^{-1})	Nitrate (mg L^{-1})	Phosphate (mg L^{-1})	Sulphate (mg L^{-1})
1	0.14 ± 0.01^{b}	1.11 ± 0.09^{a}	0.50 ± 0.17^{ab}	325.76 ± 42.11^{e}
2	0.17 ±0.02^{ab}	0.85 ±0.06^{b}	0.80 ± 0.21^{ab}	346.93 ± 42.85^{de}
3	0.21 ±0.03^{a}	0.73 ± 0.06^{bc}	0.89 ± 0.14^{ab}	347.19 ±43.86^{de}
4	0.18 ± 0.02^{ab}	0.77 ±0.05^{b}	0.62 ±0.13^{ab}	425.69 ± 47.20^{cde}
5	0.19 ± 0.02^{ab}	0.61 ±0.04^{cd}	0.44 ±0.09^{a}	525.14 ±42.85b^{cde}
6	0.19 ± 0.02^{ab}	0.47 ± 0.04^{ed}	0.94 ±0.18^{a}	751.17 ± 189.02^{ab}
7	0.17 ± 0.02^{ab}	0.44 ± 0.04^{e}	0.85 ± 0.16^{ab}	616.25 ±48.83^{abcd}
8	0.15 ± 0.02^{ab}	0.46 ± 0.05^{ed}	0.96 ± 0.20^{a}	667.88 ± 52.05^{abc}
9	0.17 ± 0.02^{ab}	0.48 ± 0.06^{ed}	0.58 ± 0.14^{ab}	881.60 ±173.37^{a}
10	0.18 ±0.02^{ab}	0.50 ±0.04^{ed}	0.49 ± 0.09^{ab}	712.91 ± 42.77^{ab}

Means with the same letter in the same column are not significantly different (P>0.05)

Table 2: Epiphytic *Bacillariophyceae* sp. of *Okpoka* Creek

S. no.	Bacillariophyceae sp. distribution (%)	Percentage
1	Bacillaria species*	1.26 ± 0.26
2	Caloneis amphisbaena	13.96 ± 0.00
3	Cyclotella species*	16.57 ± 0.00
4	C. comta	9.98 ±1.71
5	C. menephiniana	11.84 ±2.41
6	C. striata	9.81 ± 0.00
7	C. operculata	12.80 ±0.12
8	C. antiqua	19.61 ± 5.63
9	C. glomerata	14.41 ±0.97
10	Cymbella lata	3.19 ±0.00
11	C. species*	0.50 ±0.00
12	Cymatopleura species*	2.51 ± 0.00
13	Gryosigma attenuatum	5.41 ± 0.00
14	G. acuminatum	17.51 ± 2.64
15	G. paradoxa	11.84 ±0.00
16	G. species*	21.99 ± 0.00
17	Navicula placentula	13.61 ± 2.24
18	N. recognita	1.51 ± 0.00
19	N. pusilla	19.84 ±0.77
20	N. similis	1.51 ±0.00
21	N. gastrum	14.69 ±0.86
22	N. species*	31.64 ±5.50
23	Neidium species*	0.50 ± 0.00
24	Nitzschia bilobata	22.26 ±3.03
25	N. apiculata	5.47 ± 0.96
26	N. lanceolata	10.75 ± 2.10
27	N. acuta	2.51 ± 0.00
28	N. sigma	22.76 ±4.79
29	N. linearis	0.40 ± 0.00
30	N. species*	27.17 ± 0.00
31	Pinnularia horealis	6.60 ±2.83
32	P. mesolepta	6.53 ±0.00
33	P. species*	6.33 ± 0.00
34	Surirella robusta	1.65 ±0.46
35	S. constricta	0.20 ± 0.00
36	S. species*	1.31 ± 0.00
37	Stauroneis parvula	11.11 ±0.00
38	S. species*	33.39 ± 16.17
39	Stenopterobia intermedia	1.41 ±0.00
40	Synedra ulna	16.59 ±2.16
41	S. affinis	16.52 ± 1.41
42	S. acus	23.32 ± 5.63
43	S. species*	19.68 ± 5.80
44	Tabellaria species*	0.20 ± 0.00
45	T. binalis	16.07 ± 1.25
46	Tetracyclus species*	0.20 ± 0.00
47	Melosira varians	14.40 ± 1.60
48	M. listans	16.14 ±2.85
49	M. granulata	17.66 ± 4.95
50	Frustulia rhomboides	23.85 ± 4.50
51	Coscinodiscus laaistris	12.84 ± 6.12
52	Fragilaria intermedia	2.36 ± 1.05
53	Amphora ovalis	3.05 ± 0.41
54	Cocconeis placentula	2.62 ± 0.50
55	Pleurosigma species*	1.31 ± 0.00

*Unidentified species

Nitrate: Nitrate values of the creek were between 0.44±0.04 mg L^{-1} (Station 7) and 1.11±0.089 mg L^{-1} (Station 1) with a mean of 0.64±0.02 mg L^{-1}. Spatial variation of nitrate was highly significant at p<0.001.

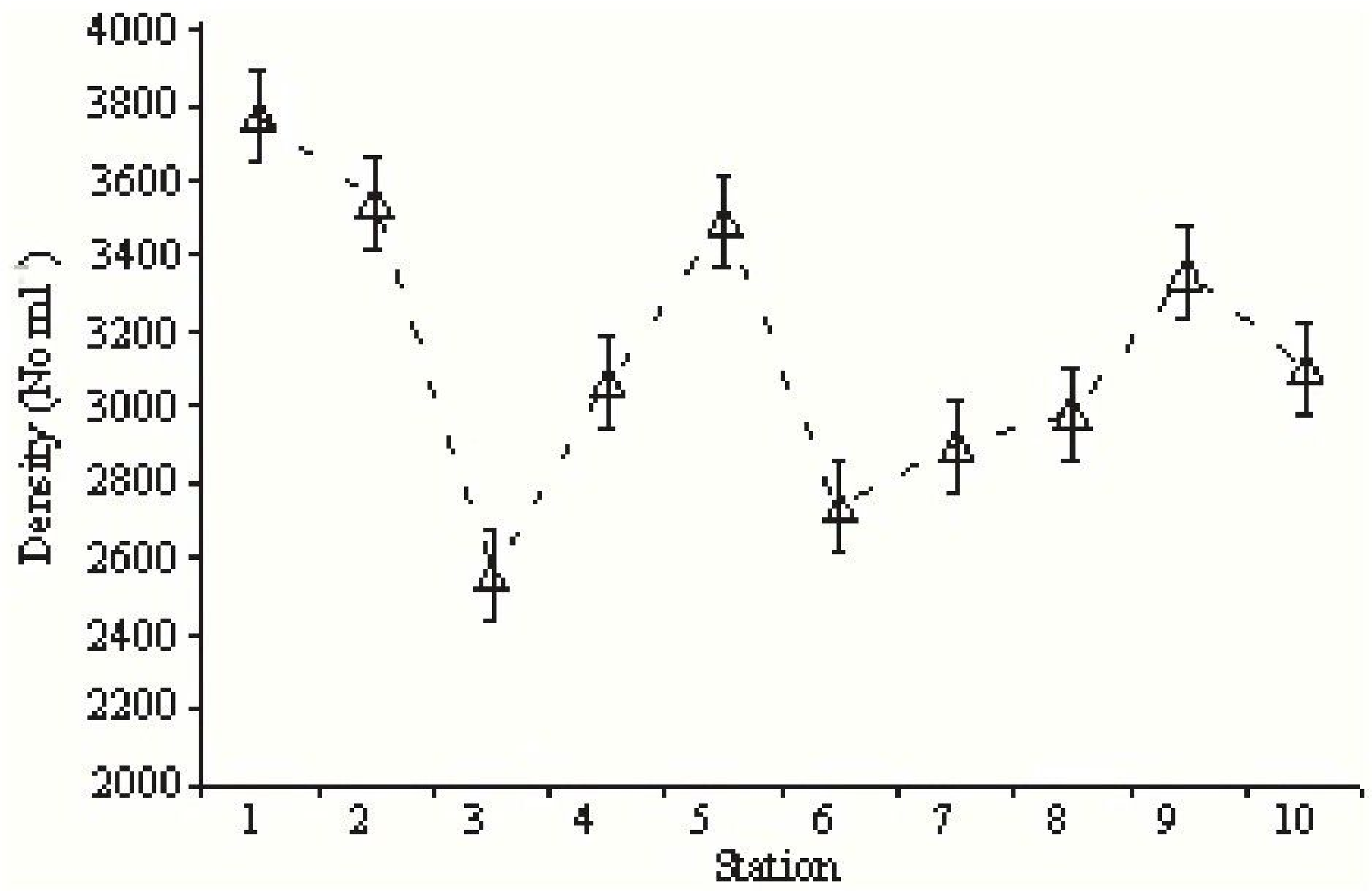

Fig. 5: Variation of Bacillariophyceae density in relation to station in *Okpoka* Creek

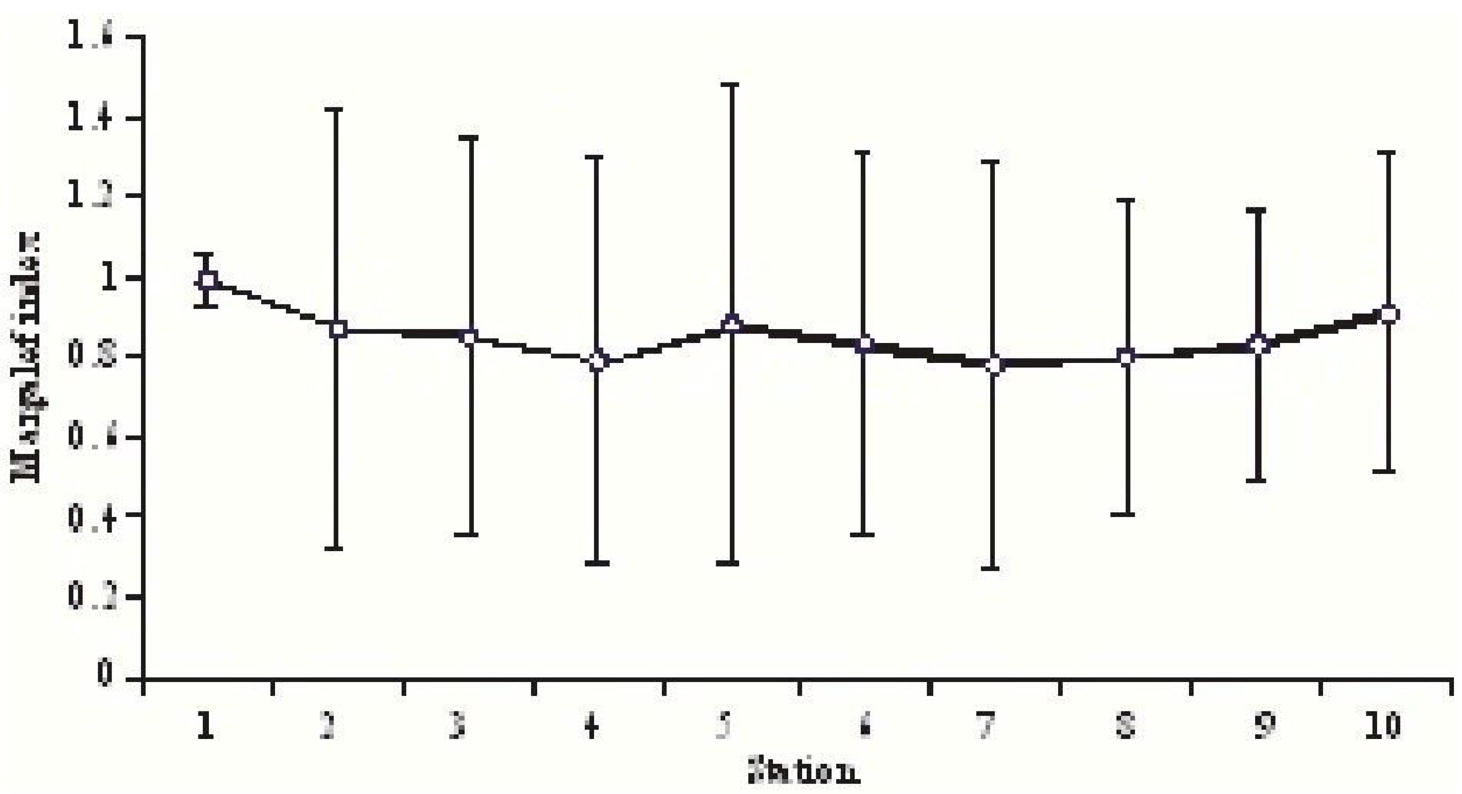

Fig. 6: Variation of Bacillariophyceae Margalef index in relation to station in *Okpoka* Creek

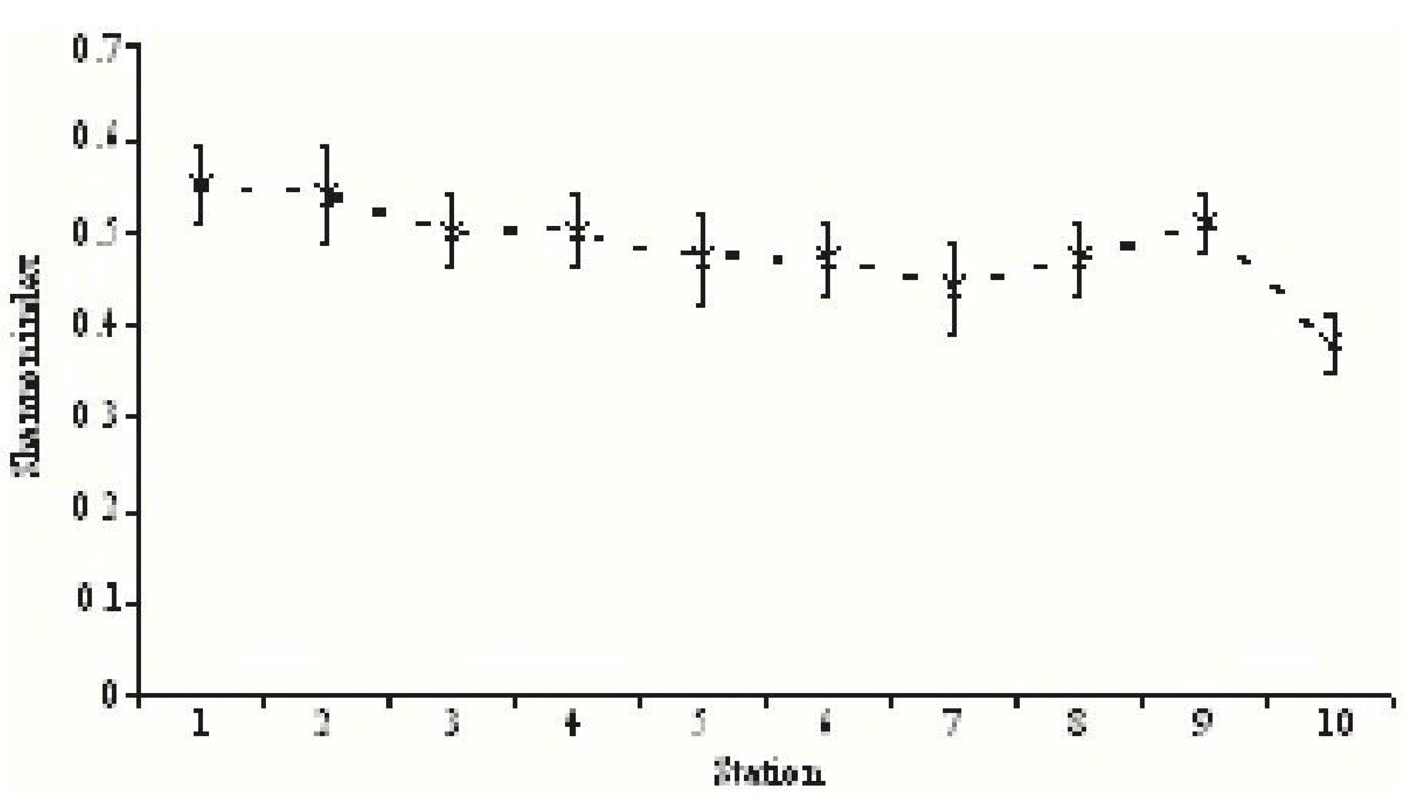

Fig. 7: Variation of Bacilliariophyceae Shannon index in relation to station in *Okpoka* Creek

Phosphate: Phosphate concentrations ranged from 0.44±0.09 mg L^{-1} (Station 5) to 0.96±0.20 mg L^{-1} (Station 8) with a mean of 0.70±0.05 mg L^{-1}. Spatial variation was significant ($p<0.01$).

Sulphate: Sulphate concentrations ranged between 325.76±42.11 mg L^{-1} (Station 1) and 881.60±173.37 mg L^{-1} (Station 9) with a mean value of 560.05±28.87 mg L^{-1} Spatial fluctuations were highly significant ($p<0.001$).

Bacillariophyceae (Diatoms): Diatoms density ranged between 2558.05±464.07 no mL^{-1} (Station 3) and

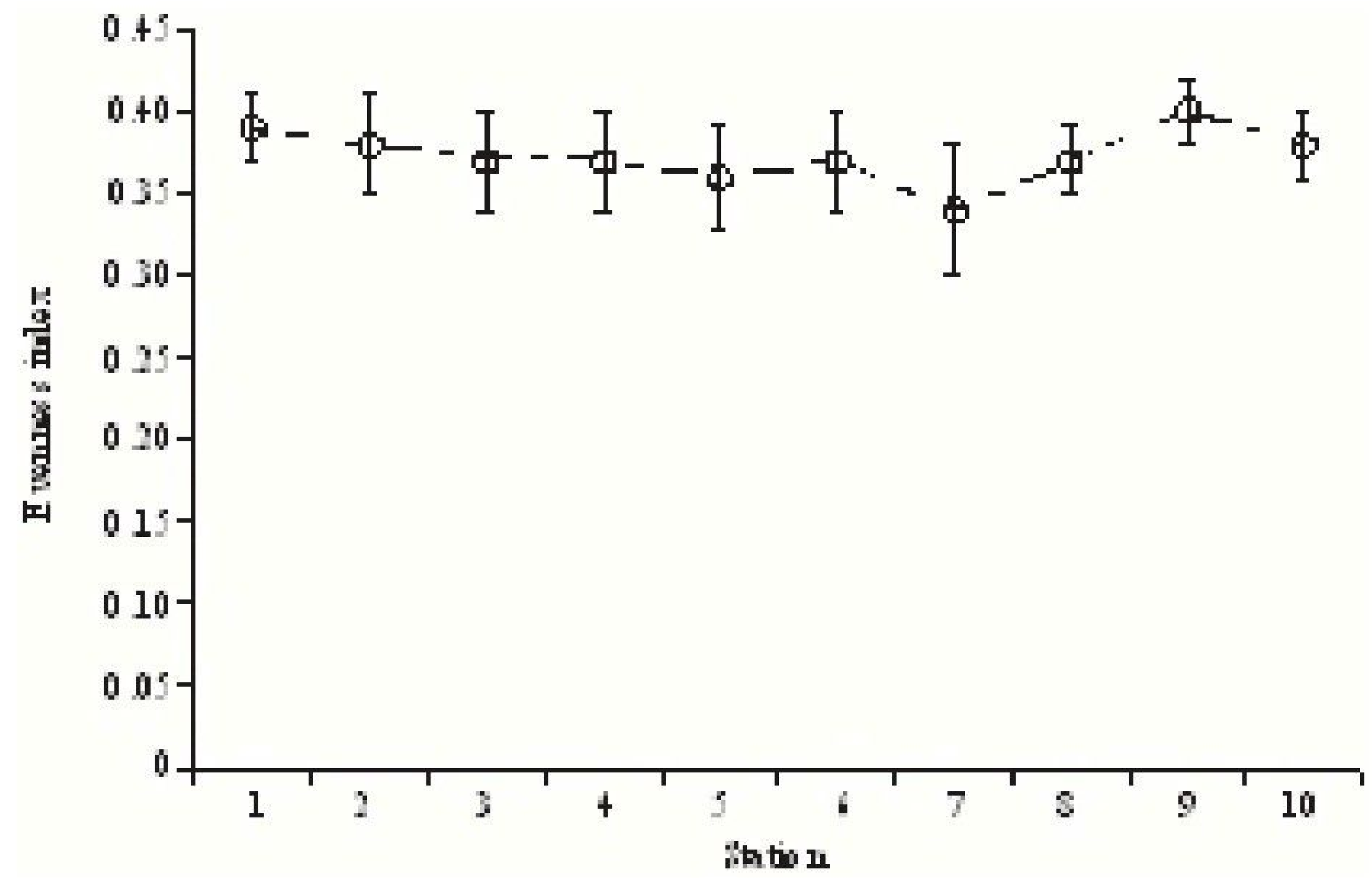

Fig. 8. Variation of Bacillariophyceae *Evennes* index in relation to station in *Okpoka* Creek

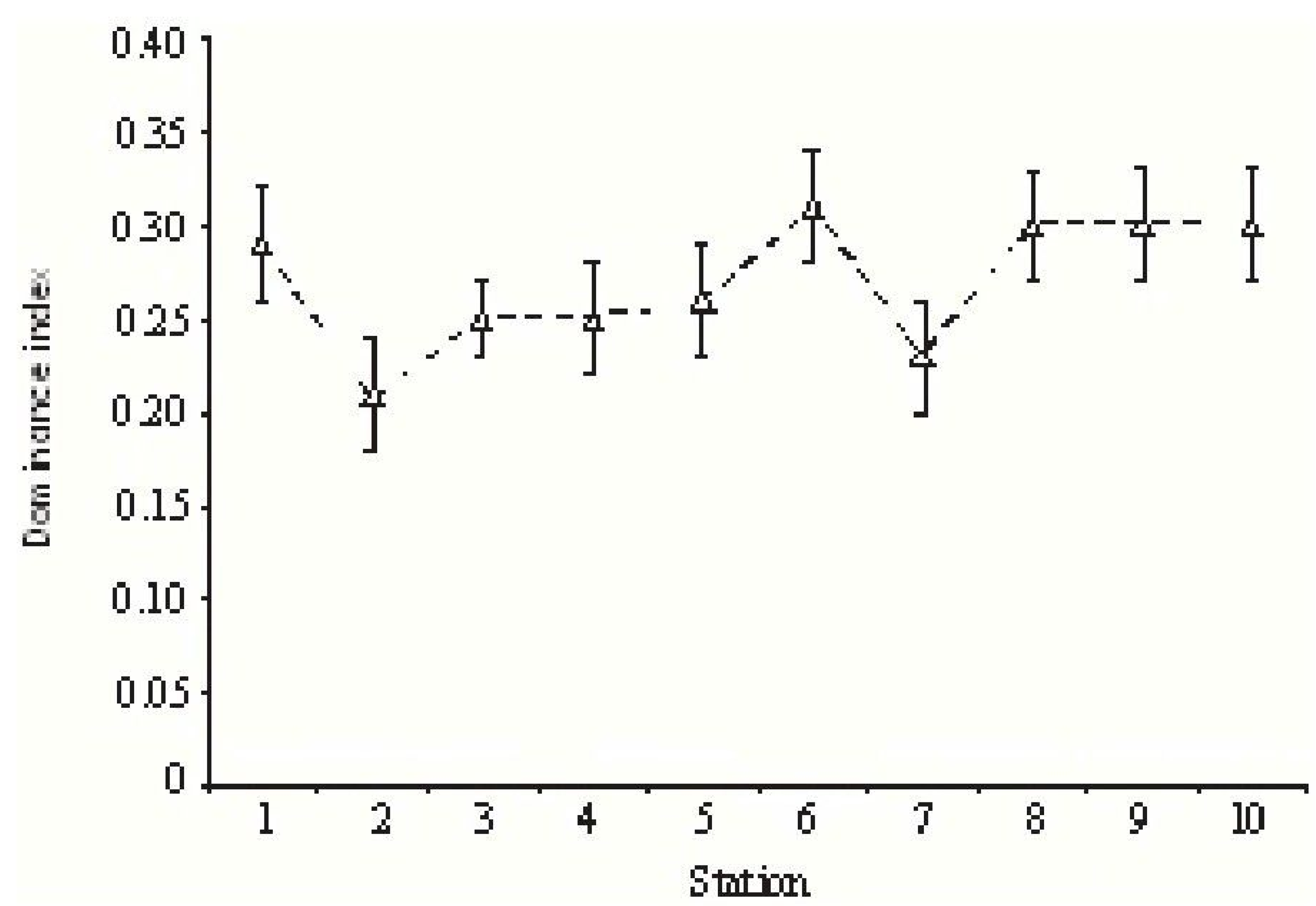

Fig. 9: Variation of Bacillariophyceae Dominance index in relation to station in *Okpoka* Creek

3770.82±614.49 no mL^{-1} (Station 1) (Fig. 5). Margalef and Shannon indices varied as follows: 0.78±0.51 (Station 7) and 0.99±0.07 (Station 1) and 0.44±0.05 (Station 7) and 0.55±0.04 (Station 1), respectively. There were no significant spatial variations of these indices (Figs. 6-9).

There were 22 genera and 55 species of epiphyton diatoms observed in *Okpoka* Creek (Table 2). *Stauroneis sp.* (33.39±16.17%), *Navicula sp.* (31.64±5.50%) and *Synedra acus* (23.32±5.63%) were abundant.

DISCUSSION

The observed temperature demonstrated narrow amplitude of variation. It showed the characteristic of the tropical environment and falls within the acceptable ranges (Obire *et al*., 2003; Chindah *et al.*, 2005; Hart and Zabbey, 2005; Sikoki and Zabbey, 2006). The insignificant spatial variations of temperature were indication of similar temperature along the creek. All stations received relatively equal amount of heat from the sun. Turbidity is a vital water quality parameter due to sediment loading and the concomitant effect it will have on the light available for phytoplankton and epiphyton growths as well as other aquatic life (IADC, 2007). The observed turbidity might be attributed to plankton. Swann (2006) reported that plankton is one of the causes of turbidity. The observed turbidity level agrees with the range of 2 NTU to 47 NTU reported by Asonye *et al.* (2007) for the turbidity of Nigerian rivers, streams and waterways. Transparency variations in the stations were insignificant indicating similar transparency level in this creek. These could be attributed to shallow water depth and brackish characteristic of the creek water.

The present study record of salinity is within the acceptable range for coastal waters. It is also within the range reported by Chindah and Nduaguibe (2003) of 11.5±1.8 to 20.3±3.0‰ for Lower Bonny River. The observed increased salinity downstream could be attributed to proximity to the estuary and sea. The DO level is within the concentration expected to be found in natural surface water and this might be traced to tide. Tide helps to circulate the atmospheric air containing oxygen within the water column. The increased dissolved oxygen level downstream might be attributed to the increased salinity downstream and reduced anthropogenic discharges into the creek (Swann, 2006). The recorded biological oxygen demand is within the acceptable range for aquatic environments. This indicates that the biological oxygen demand load in this creek did not pose a threat to the aquatic environment. The varied biological oxygen demand concentrations along the stations might be attributed to the different organic wastes of varied quantities entering the creek. The difference between the highest and lowest pH recorded was not up to 0.5 pH units. This is an indication that the various anthropogenic inputs did not alter the ambient pH. The study ammonia exceeded the concentration of less than 0.1 mg L^{-1} found in natural waters (McNeely *et al.*, 1979). This possibly indicates anthropogenic and domestic inputs. The varied ammonia concentrations in the stations indicated different levels of municipal and domestic wastes entering the creek at these points. Also, the decomposition of nitrogenous organic matter (vegetable, animal and human wastes) and the microbial reduction of nitrates or nitrites under anaerobic conditions might account for this observation. Nitrogen is most often limiting in marine systems (Creswell *et al.*, 2001). The highest nitrate recorded in Station 1 might be indicative of high human excrement and industrial discharges. The recorded phosphate concentrations in this study were higher than the acceptable limit of 0.10 g L^{-1} in flowing waters recommended by USGS (2007). This observation agrees with that of 0.43 to 3.52 mg L^{-1} of Chindah and Nduaguibe (2003). The varied phosphate levels in the stations could be attributed to the varied quantity of domestic wastes containing human faeces, residual fertilizers from National Fertilizer Company of Nigeria (NAFCON), Onne and detergents as well as industrial effluents containing phosphates. The high sulphate level observed in this study is characteristic of brackish water. The sulphate concentrations tended to increase downstream towards the Upper Bonny Estuary, indicating increasing ionic strength of the stations.

This present work recorded higher epiphytic diatom species (55) than other studies in the Niger Delta River system. It could be attributed to the high sunlight intensity in the water that helps in primary production. Also, the temperature was similar along the creek. The acceptable turbidity level favoured the growth of these algae. Sterner and Grover (1998), Chrzanowski and Grover (2001, 2005), Roelke *et al.* (2007) reported that balance of light energy is assumed to regulate algae ecosystem structure. Transparency might have regulated the present diatom ecosystem structure. Salinity affects the distribution patterns and relative abundance of organisms (Rendall and Wilkinson, 1986; Chindah, 2004; Frankovich *et al.*, 2006; Sharipova, 2005). The varied diatom density within the stations could be traced to salinity. The observed DO and BOD concentrations were good for diatoms growth. The narrow pH range recorded favours many chemical reactions inside aquatic organisms (cellular metabolism) that are necessary for their survival and growth. One of the factors that is likely to play an important role in determining community productive levels is nutrients availability; nitrogen, phosphorus and sulphate (Boney, 1983; Heyley *et al.*, 1988; Yamamuro *et al.,* 1993). However, no station showed absence of nitrogen (nitrate-nitrogen, ammonia-nitrogen) or phosphorus (phosphate-phosphorus) but the concentrations seem limiting hence the varied diatoms density. The recorded similar diatoms density in the station might be due to the similar requirements for diatoms growth along the stations. The distribution of diatoms reflects the average ecological conditions of aquatic environment (Passy *et al.*, 2004). However, some workers (Frankovich *et al.*, 2006; Passy, 2007a) have shown that diatoms favoured nutrient rich environment particularly nitrate which is in agreement with the present study of high nutrients levels especially phosphate, sulphate, ammonia-nitrogen and nitrate-nitrogen. The epiphyton can be used as a measure of river health. According to John and Mark (2004), healthy rivers typically have little obvious *periphyton* because algae are eaten by invertebrates. The diatom genera (*Navicula*, *Nitzschia*, *Synedra*) have been implicated for organic pollution in the aquatic environment (Nwankwo, 1994).

CONCLUSION

The high diatom density shows that this creek is not healthy and its nutrients capability is very high. The other recorded physico-chemical parameters favoured the diatom growth. The observed implicative genera indicate organic pollution from anthropogenic sources. Discharges of untreated domestic and industrial effluents should be discouraged. These wastes should be recycled into useful resources.

REFERENCES

American Public Health Association (APHA) 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edn., American Public Health Association, McGraw-Hill Publishers, Baltimore, Maryland, Washington DC. pp: 1213.

Asonye, C.C., N.P. Okolie, E.E. Okenwa and U.G. Iwuanyanwu, 2007. Some physico-chemical characteristics and heavy metal profiles of Nigerian rivers, streams and waterways. Afr. J. Biotechnol., 6: 617-624. http://www.bioline.org.br

Boney, A.D. 1983. Phytoplankton. 4th Edn., Edward Arnold Publishers Limited, London. pp: 115. ISBN:0713124768.

Boyd, C.E. 1981. Water Quality in warmwater fish ponds. 2nd Edn., Craftmaster Publishers, Alabama. pp: 359.

Chindah, A.C. 2004. Response of *periphyton* community to salinity gradient in tropical estuary, Niger Delta. Polish J. Ecol., 52: 83-89.

Chindah, A.C. and U. Nduaguibe, 2003. Effect of tank farm wastewater on water quality and *periphyton* of Lower Bonny River Niger Delta, Nigeria. J. Nig. Env. Soc., 1: 206-222.

Chindah, A.C., S.A. Braide and J.N. Onwuteaka, 2005. Verticaldistribution of*periphyton* onwoodysubstrate in a brackish wetland embayment of Bonny River, Niger Delta. Niger Delta Biologia, 5: 97-108.

Chindah, A.C. and J. Pudo, 1991. A preliminary checklist of algae found in plankton of Bonny River in Niger Delta, Nigeria. Fragment Flore Geobotanica, 36: 112-126.

Chrzanowski, T.H. and J.P. Grover, 2001. Effects of mineral nutrients on the growth of bacterio and phytoplankton in two Southern reservoirs. Limnology and Oceanography, 46: 1319-1330.

Chrzanowski, T.H. and J.P. Grover, 2005. Temporal coherence in limnological features of two Southwestern reservoirs. Lake and reservoir Management 21: 39-48.

Creswell, J., R. Karasack, R. Johnson and H. Shayler, 2001. Nitrogen and phosphorus in Mill and Green ponds and the effects of nutrient enrichment. Macalester Environmental Review: 1-31.

Durans, J.R. and C. Leveque, 1980. Flore and Farune Aquatiquesde 1, Afrique-an-off Erch.Science Technica Qutre-Mer., 1: 5-46.

Frankovich, T.A, E.E. Gaiser, J.C. Zieman. and A.H. Wachnicka,. 2006. Spatial and temporal distributions ofepiphytic diatoms growing on *Thalassia testudinum* Banks ex Kőnig: Relationships to water quality Hydrobiologia, 569: 259-271. DOI: 10.1007/s/0750-006-0136-10.

Han, M. 1978. Illustration of Freshwater Plankton.1st Edn., Agricultural Press, Alabama, pp: 171.

Hart, A. I. and N. Zabbey, 2005. Physico-chemistry and benthic fauna of Woji Creek in the Lower Niger Delta, Nigeria. Environ. Ecol., 23: 361- 368.

Heyley, M.J. R.A. Moli, and Daillo, C.O. 1988. Abundance and distribution of bactrio-plankton in the Gambia river, West Africa. Microbiol. Ecol., 16: 291 –310.

International Association of Dredging Companies (IADC), 2007. Facts about turbidity. An information update from the IADC. Retrieved Sept. 29th, 2007, http://www.iadc-dredging.Com/index.php?option=com_content&in\d=1088itemi.

John, Q. and M. Mark, 2004. *Periphyton* in our Rivers: Too Much of a Good Thing? NIWA.Retrieved on Oct.20,2005, http://www.niwa.co.nz/pubs/wa/10-3/periphyton

Jones, J.I., J.O. Young, J.W. Eaton and B. Moss, 2002. The influence of nutrient loading dissolved inorganic carbon and higher trophic levels on the interaction between submerged plants and *peripyton*. J. Ecol., 90: 12-24.

Kadiri, M.O., 1988. A taxonomic study of the genus closterium (Nizch. 1919, Ralfs 1945) (*Desmichaceae chlorophyta*) in small Nigeria reservoir with ecological notes. Trop. Freshwater Biol., 1: 71-90. http://www.psng/mokadiri.htm-43k.

Lewis, M.A., D.E. Weber, R.S. Stanley and J.C. Moore, 2001. Dredging impact on an urbanized florida bayou: Effects on benthos and algal-*periphyton*. Environ. Pollu., 115: 161-171.

Liboriussen, L. and E. Jeppessen, 2003. Temporal dynamics in epipelic, pelagic and epiphytic algal production in a clear and turbid shallow lake. Freshwater Biol. 48: 38-42.

McCormick, P.V. and R.J. Stevenson, 1998. Effects of snail grazing on benthic algal community structure in different nutrient environments. J. North Amer. Benthol. Soc., 8: 162-172.

McNeely, R.N., V.P. Neimanis, and L. Dwyer,1979. Water quality sourcebook. A guide to water quality parameters. Ottawa: Inland waters directorate, water quality branch. pp: 88.

Newell,G.E. and R.C. Newell, 1963. Marine plankton. A practical guide. 1st Edn., Hutchinson Publishing Limited, London. pp : 224.

Nwankwo, D.I. 1991. *Periphyton* algae on fish fences "Acadja" in a tropical open Lagoon. Intl. J. Ecol. Environ. Sci., 17: 1-10.

Nwankwo, D.I. 1994. Hydrochemical properties and bottom-dwelling diatoms of a Lagos Lagoon sewage site. Polskie ArchiwumHydrobiolog., 41: 35-47.

Obire, O. D.C. Tamuno and S.A. Wemedo, 2003. Physico-chemical quality of Elechi Creek in Port Harcourt, Nigeria. J. Applied Sci. Env. Manage. 7:43-49.

Passy, S.I. 2007. Diatomecologicalguilds display distinct and predictable behaviour along nutrient and disturbance gradients in running waters. Aquatic Botany, 86: 171-178.

Passy, S.I., R.W. Bode, D.M. Carlson and M.A. Novak, 2004. Comparative Environmental Assessment in the Studies of Benthic Diatom, Mmacroinvertebrate and Fish Communities. Intl. Rev. Hydrobiol., 89: 121-138. DOI:10.1002/iroh.200310721.

Prescott, G.W., 1982. How to Know the Freshwater Algae. McGrawHill, Washington, DC., pp : 56.

Roelke, D.L., R.M. R. Errera, R. Kiesling, B.W. Brooks J.P. Grover, L. Schwierzke, B.W. UrenaBeck, J. Baker and J.L. Pinckney, 2007. Effects of nutrient enrichment on *Prymnesium parvum* population dynamics and toxicity: Results from field experiments, Lake Possum Kingdom, U.S.A. Aquatic Microbiol. Ecol., 46:125-140.

Ruivo, M.R. 1972. Marine Pollution and Sea Life. 1st Edn., Fishing News (Books) Publishers, England. pp: 630.

Sharipova, M.Y. 2005. Changes in epiphyton of the Usolka River (tributary of the Belaya River) along a gradient of Salinity (Bashkortostan Russia). International Journal on Algae, 7: 374-387.

Sikoki, F.D. and N. Zabbey, 2006. Environmental gradients and benthic community of the middle reaches of Imo River, South-Eastern Nigeria. Env. Ecol., 24: 32-36.

Sterner, R.W. and J.P. Grover, 1998. Algal growth in warm temperate reservoirs. Kinetic Examination of nitrogen, temperature, light and other nutrients. Water Resources, 32: 3539- 3548.

Swann, L. 2006. A fish farmer's guide to understanding water quality in aquaculture. Retrieved Feb.20, 2006 from, http://www.aquanic.org.publicat/state/il-inas-503.htm

Tencate, J.H, J. Simons, H.J Schreurs, 1999. Periphytic micro and macroalgae in Dutch freshwater ditches and their significance as ecological indicators of water quality. Archives of Hydrobiologia, 122: 275-296.

United States Geological Survey (USGS). 2007. Relation between selected water quality variables and climatic factors. Retrieved Sept. 12, 2006, from, http://www.pubs.water.usgs.gov/sir20075117.

Vadeboncoeur, Y., D.M. Loge, D.M. and S.R. Carpenter, 2001. Wholelake fertilization effects on distribution of primary production between benthic and pelagic habitats. Ecol., 82: 1065-1077.

Wetzel, R.G. 2001. Limnology, lake and river ecosystems. 3rd Edn., San Diego: Academic Press.

Wilcox, B.H., 1980. Angiosperm Flora of the Niger Delta Mangal. A Taxonomic Review. Proceedings of Workshop on the Niger Delta Mangrove Ecosystem. Oct. 19-21, Port Harcourt, Pp: 19-23.

Williams, A.E., B. Moss and J.W. Eaton, 2002. Fish induced macrophytes loss in shallow lakes top-down and bottom-up processes in mesocosm experiments. Freshwater biology 47: 2216-2232.

Yamamuro, M., I. Kioke and H. Iizuumi, 1993. Partitioning of Nitrogen stock in the vicinity of a Fijian seagrass bed dominated by syingodium iosettifolum (Ascherson) Dandy. Aust. J. Mar. Freshwater Res., 44: 101-115.