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Phytoplankton in the Lower Sombreiro River, Niger Delta, Nigeria

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Abstract: The phytoplankton of the lower Sombreiro River, was studied from August 2005-July 2006 using standard methods for examination of water and waste water. A total of 43 species from 5 taxonomic groups were recorded. *Melosira granulata* occurred most (5.2%) and *Stephanodiscus asroea* the least (0.7%). The family Bacillariophyceae was highest (50.3%) and Chrysophyceae, least (2.5%). The wet season recorded more phytoplankton (57.3%) than the dry season (42.7%). Station 1 had the highest record (32.9%) and station 4, the least (19.7%). There were significant differences in mean occurence between seasons, ($F = 21.75$, d.f. = 1467, $p = 0.05$) and among the stations ($F = 11.91$, d.f. = 1467, $p = 0.05$). The diversity indices ranged from 1.053-1.505 (Shannon-Wiener); 0.849-0.950 (Evenness); 3.759-7.226 (Margalef's species richness) and 0.027-0.110 (Simpson's dominance). The percentage total collection increased with increased temperature, increased conductivity and increased flow rate. However, it reduced with reduced temperature, conductivity, increased turbidity and rainfall. The correlation coefficients of phytoplankton abundance and physico-chemical parameters were negative with dissolved oxygen and pH. However, it correlated positively with flow rate.

Key words: Phytoplankton, species composition, physico-chemistry, sombreiro river, Niger Delta, Nigeria

INTRODUCTION

Phytoplankton constitutes the bedrock or basis of grazing food chain and food web in surface water systems. They are recognized worldwide as bio-indicator organisms in the aquatic environment (Yakubu *et al*., 2000). According to Boyd *et al*. (2000), phytoplankton blooms may indicate presence of mineral ions. Populations of planktonic ciliates often develop in organic-rich, oxygen-depleted and polluted waters (Wetzel, 1983). Phytoplankton abundance increases productivity of water, as they form the basic food source in any aquatic environment (Russell-Hunter, 1970). The use of phytoplankton for monitoring pollution is based on the belief that natural, unpolluted environments are characterized by balanced biological conditions and contains a great diversity of phytoplankton with no one species dominating.

Some reports exist on plankton populations of several water bodies in Nigeria. These include those Eleyele reservoir, Ibadan (Imevbore, 1965), River Osun (Egborge, 1972), Lagos lagoon (Nwankwo, 1986) and River Sokoto (Green, 1960). Others include Nkisa and Orashi rivers, Rivers State (Yakubu *et al*., 2000), Okpoba Creek, Port Harcourt Luubara Creek, Rivers State (Kosa, 2007), Oginigba Creek, Port Harcourt (Chindah and Pudo, 1991), Bonny River (Chindah, 2003); New Calabar river (Nwadiaro and Ezefili, 1986; Chindah, 1998), Oguta Lake (Nwadiaro and Oji, 1986) and Bonny estuary (Chindah and Keremah, 2001). Information on phytoplankton of Sombreiro River is scarce.

The Sombreiro River is one of the most important river systems in the Niger Delta that provide nursery and breeding grounds for a large variety of fish species (Ezekiel *et al*., 2002). The water body also serves as the only source of surface drinking water in the area. Due to efforts at speedy industrialization and recreational activities, the Sombreiro River is fast becoming degraded (Ezekiel, 2001). Fishing is carried out indiscriminately with various traditional and modern gears.

Information on the ecology of Phytoplankton and physico-chemical characteristics in the Lower Sombreiro

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River will provide better output and optimum exploitation of fishery resources within the river basin. It will also provide a scientific basis for decision-making and comparative analysis.

MATERIALS AND METHODS

Study area: The study was carried out in the Lower Sombreiro River. The river provides nursery and breeding grounds for a large variety of fish species (Ezekiel *et al*., 2002). The Niger Delta basin covers all the land between latitude $4^0 14^1$N and $5^0 35^1$N and longitude $5^0 26^1$E and $7^0 37^1$E with a total area of 20,000 km^2. It extends along the coast from the river's basin in the West of Bonny River. The area is characterized by extensive inter-connection of creeks. It is the most important drainage feature of the Niger-Basin rivers system and covers about 2% of the surface area of Nigeria (Powell *et al*., 1985). The annual rainfall of the Niger Delta is between 2000-3000 mm per year (Powell, 1987).

The Sombreiro River is located between latitude $6^0 30^1$E and $7^0 0^1$E and longitude $4^0 12^1$N and $6^0 17$N. The river is a distributary of the River Niger system, which rises from the northern parts of Ogba/Egbema/Ndoni Local Government Area of Rivers State. It is one of the series of the Niger Delta Rivers that drain into the Atlantic Ocean. It flows southwards from its source to the Atlantic Ocean and is connected to other rivers via creeks in the coastal areas of the Niger Delta (Ezekiel, 1986). The river is relatively narrow and deep and as it flows southwards, it widens in dimension. The river is lotic throughout the year. The river is within the tropical rainforest, though the mouth is within the brackish mangrove zone. Some characteristics of the sample stations along the Sombreiro River are as follows:

Station 1 (Degema): This is the largest of all the stations. The vegation (mangrove plants) fringing the river consists *Rhizophora*, *Avicennia* and *Nypha fruticans* (Nypa palm) arising from a characteristic muddy substrate that gives a foul smell. The water is turbid in the rainy months. The site is a brackish and tidal environment.

Station 2 (Ogbele): Vegetation is mainly riverine forest, consisting mainly of *Raphia, Pandanus sanderiana, Calamas* sp. (swamp cane), *Khaya* sp. (mahogany), *Vapaca* sp. *Ficus vogeliana* and *Triculia africana***.** Aquatic macrophytes include *Nymphaea* sp. *Eichhornia crassipes, Sagittaria* sp. *Pistia stratiotes***.** The station was flooded in the rainy period when the velocity is slow. The site has little influence from the immediate tidal mangrove zone. The bottom consists mainly of sand and some gravel.

Station 3 (Ihuaba): The common vegetation present were mixture of riverine and terrestrial vegetation. Some common plants noticed included *Raphia* and *Elaeis guineensis* (palm trees). The aquatic macrophytes include *Typha lotifolia* (cat tail), *Eichhornia crassipes, Nymphaea* sp. *Utricularia* sp. and *Potamogeton* sp. (pond weed). The site was flooded in the wet season, which receded within November and February. The river bottom consisted of sand and gravel.

Station 4 (Odhieke): The vegetation consisted of terrestrial vegetation and riverine plants extending into large areas of swamps. Some include *Raphia*, *Pandanus sanderiana, Elaeis guineensis* (palm trees). Aquatic macrophytes include *Ipomea aquatica, Lemna* sp. (duck weed), *Utricularia* sp. *Nymphaea* sp. and *Pistia stratiotes* (water lettuce). The water was generally clear and water velocity increased as flood recedes. River bottom had mainly sand and gravel.

Common fishing gears used in the Sombreiro fisheries include seine nets, drift nets, cast nets, lift nets, long lines, fish fences, funnel traps, trigger traps, grass mats, hooks and lines.

Phytoplankton sampling: Samples were collected at each of the stations. The phytoplankton were randomly collected with 250 mL capacity plastic jar at subsurface (10 cm) level and emptied into a wide mouthed plastic jar and immediately preserved using 4% formalin, after proper labeling (APHA, 1989). This was stored in a cool box and taken to the laboratory.

In the laboratory, the samples were allowed to stand for at least 24 h for the plankton to settle before the supernatant was pipette off to concentrate the samples. The concentrated sample was agitated to homogenize before pipetting 1 mL sub sample. The content was placed in a Sedge wick-Rafter plankton-counting chamber and examined with Leltz-Wetzlar binocular microscope at a magnification of 200X (APHA, 1989). The plankton was identified and total number per species recorded using keys and checklists of Hutchinson (1967), Prescott (1982), Needham and Needham (1962), Jeje and Fernando (1985) and Pimentel (1967). Enumeration of plankton was done on natural unit count and reported as units or organisms per mL (APHA, 1989).

Physico-chemical characteristics: Monthly rainfall data were obtained from the Meteorological Department of the Federal Ministry of Environment, Port Harcourt. Some monthly insitu measurements of parameters were made. Surface water temperature was measured 2 min after dipping an ordinary mercury-in-glass thermometer to a depth of about 5.0 cm below water surface. Depth measurements were done using a graduated line. Each month, average depth of pre-determined points were recorded as the water level. Water velocity/flow rate was measured with a floating object. The time taken for the floating object to move past 2 fixed points was recorded. The water velocity was calculated and expressed as the time taken (in sec) to flow through 1 m (m sec^{-1}) (Welcomme, 1985).

The salinity, p^H, conductivity and turbidity were measured using a portable Horiba meter (model U10). Dissolved oxygen was measured using the Winkler method (Stirling, 1999). Total Dissolved Solids (TDS) were determined by filtering a well-mixed water sample through a fibre filter paper into a weighted dish. The filtrate (in the dish) was evaporated to dryness to a constant weight. TDS was calculated with the following formula (APHA, 1989):

$$\text{Total dissolved solids (mg L}^{-1}\text{)} = \frac{\text{(A-B)} \times 1000}{\text{Sample vol (mL)}} \quad (1)$$

Where:
A = Weight of dried residue + dish (mg).
B = Weight of dish (mg).

Statistical analysis: The SAS (2003) was used to analyze the data obtained. Analysis of variance (ANOVA) was carried out on plankton collected from the different stations and seasons. The Duncan's Multiple Range Test was used to determine significance in variation. Correlation analysis of the water parameters was done. The same analysis was done for plankton. This was to verify the factors that relate significantly to one another that could influence the abundance of plankton. The number of and plankton caught were categorized into 2 groups: Those in November, December, January and February were designated as dry season samples, while others, as wet season samples.

Monthly ecological diversity of samples were calculated by the following diversity indices: Shannon-Wiener Diversity index (H), which Ogbeibu (2005) presented as:

$$H = \sum_{i=1} \text{pi In pi} \quad (2)$$

Where:
S = The number of species in the sample.
Pi = The proportion of individuals found in the ith species.

The Shannon-Wiener diversity index measures the importance of each species in the community.

Evenness (or Equitability (J)) index (E), which Ogbeibu (2005) presented as:

$$E = \frac{H}{H_{max}} \quad (3)$$

The ratio of the observed diversity (H) to the maximum diversity (H_{max}) is taken as a measure of the Evenness (ibid). According to Krebs (1989), it measures the distribution of individuals.

Margalef's species richness index, (d), was presented by as (Ogbeibu, 2005):

$$d = \frac{S-1}{\ln N} \quad (4)$$

Where:
S = Number of species in the sample.
ln = Natural or Naperian logarithm.
N = Total number of individuals in the sample.

Simpson's Dominance index (c).

$$c = -\sum_{i=1}^{s} Pi^2 \quad (5)$$

Where:
S = Number of species in the sample.
pi = The proportional abundance of the ith specie.

$$\text{i.e.,} \quad pi = \frac{ni}{N}$$

where:
ni = Number of individuals in the ith species.
N = Total number of individuals for all species (ibid).

RESULTS

A total of 43 species from 5 taxonomic groups were recorded during the study period (Table 1). The species with the highest number was *Melosira granulata* (357 cell counts, 5.2%), while *Stephanodiscus asroea* having 47 cell counts (0.7%) was the least in abundance. At the levels of family abundande, Bacillariophyceae was the highest (50.3%), followed by Chlorophyceae, 24.8%; Cyanophyceae, 15.4%, Xanthophyceae, 7.2% and Chrysophyceae, 2.5%.

Table 2 shows the monthly number of phytoplankton from the lower Sombreiro River for the study period. The highest number (1076 cell counts) was recorded in February, giving 15.7%, while September gave the least (126 cell counts), with 1.8%. The species not recorded in some of the months were, *Amphora ovalis, Fragilaria*

Table 1: Phytoplankton species composition in the lower Sombreiro River

TAXA	No. of specimen (org mL^{-1})	Percentage number
Bacillariophyceae		*(50.3%)
Amphora ovalis	49	0.7
Cosinodiscus lacustris	221	3.2
Cyclotella comta	332	4.8
Cyclotella operculata	311	4.5
Cymbella lata	201	2.9
Fragilaria intermedia	113	1.6
Gyrosigma acuminatum	171	2.5
Melosira distans	318	4.6
Melosira granulata	357	5.2
Melosira pusilla	221	3.2
Melosira varians	263	3.8
Navicula viridula	179	2.6
Nitzschia sigma	180	2.6
Pinnularia horealis	58	0.8
Stephanodiscus asroea	47	0.7
Synedra affiinis	179	2.6
Synedra ulna	129	1.9
Tabellaria fenestrate	111	2.1
Chlorophyceae		*(24.8%)
Coelastrum reticulatum	146	2.1
Closterium gracile	138	2.0
Closterium intermedium	108	1.6
Closterium parvulum	139	2.0
Crucigenia puadrata	174	2.5
Crucigenia truncate	77	1.1
Desmidium sp.	124	1.8
Gonatozygon aculeatum	118	1.7
Netrium digitatus	132	1.9
Netrium intermedium	69	1.0
Spirogyra sp.	122	1.8
Spirotaenia condensate	165	2.4
Volvox aureus	94	1.4
Volvox globator	95	1.5
Chrysophyceae		*(2.5%)
Dinobryon sertularia	174	2.5
Cyanophyceae		*(15.4%)
Anabaenopsis affinis	106	1.5
Anabaenopsis arnoldii	177	2.6
Anabaenopsis spiroides	150	2.2
Lyngbya limnetica	107	1.6
Oscillatoria lacustris	157	2.3
Oscillatoria princeps	123	1.8
Raphidiopsis mediterranea	105	1.5
Rivularia sp.	129	1.9
Xanthophyceae		*(7.2%)
Tribonema minus	198	2.9
Tribonema viride	293	4.3
Total	6860	100

*Group (taxonomic) percentage

intermedia, *Melorisa pusilla*, *Pinnularia horealis*, *Stephanodiscus asroea*, *Synedra affinis*, *Tabellaria fenestrata* and *Ceolastrum reticulata*. Others are *Closterium intermedium*, *Netrium digitatus*, *Netrium intermedium*, *Spirotaenia condensata*, *Volvox aureus*, *Volvox globator*, *Anabaena affinis* and *Raphidiopsis mediteranea*. Others were recorded in all the months.

The wet season recorded more phytoplankton (3928 cell counts) constituting 57.3% of the annual abundance, than the dry season (2932 cell counts, 42.7%) (Table 3). All the species were recorded for both seasons. *Cosinodiscus lacustris* was the most recorded (308 cell counts) for the wet season, while *Amphora ovalis*

Table 2: Monthly number of phytoplankton from the lower Sombreiro River (August 2005-July 2006)

Months	No of Specimen (org mL^{-1})	Percentage number
August	373	5.4
September	126	1.8
October	265	3.9
November	414	6.0
December	499	7.3
January	943	13.7
February	1076	15.7
March	1002	14.6
April	750	11.0
May	776	11.3
June	430	6.3
July	206	3.0
Total	6860	100.0

Table 3: Seasonal number of phytoplankton from the lower Sombreiro River (August 2005-July 2006)

Season	No of specimen (org mL^{-1})	Percentage number
Dry season	2932^{a}	42.7
Wet season	3928^{b}	57.3
Total	6860	100.0

Wet season: March-October, Dry season: November-February, a-b = means with superscript are significantly different

Table 4: Number of phytoplankton recorded in various sampled stations in the lower Sombreiro River

Stations	No of specimen (org mL^{-1})	Percentage number
1	2257^{a}	32.9
2	1643^{b}	23.9
3	1611^{b}	23.5
4	1349^{b}	19.7
Total	6860	100

a-b = Means with superscript are significantly different

(24 cell counts) was the least. The dry season had the highest occurrence in *Melosira granulata* (189), while *Stephanosdiscus asroea* (18 cell counts) was the least.

Table 4 shows the phytoplankton distribution according to stations. Station 1 had the highest number of 2257 cell counts (32.9%), while Station 4 (1349 cell counts), with 19.7% was the lowest. Most of the species were recorded in all the sample stations. *Pinnularia horealis* was not recorded in Stations 3 and 4 *Stephanodiscus asroea* was recorded only in Station 1. *Spirogyra sp.* and *Volvox globator* were not recorded in Station 1.

Analysis of variance for the 4 sample stations and seasons, for number of phytoplankton observed showed significant differences ($p \leq 0.05$) between seasons and among the stations ($p \leq 0.05$). The combined effect of seasons and stations was not significantly different ($p \leq 0.05$)

Further analysis with the Duncan's Multiple Range Test showed that the means for the wet and dry seasons differed significantly. Also, the means for the stations showed that Station 1 differed significantly from all the other 3 stations. Stations 2, 3 and 4 did not show any

Table 5: Monthly percentage collection of phytoplankton and physico-chemical characteristics in the lower Sombreiro river (August 2005-July 2006)

Collection (monthly) (%)	Water temp (°C)	pH	Conductivity (μs cm^{-1})	Turbidity (ntu)	Salinity (%)	Dissolved oxygen (mg L^{-1})	TDS (mg L^{-1})	Depth (m)	Flow rate (m s^{-1})	Rainfall (mm)
(Aug) 5.4	26.5	6.9	3821.0	3.0	3.1	7.85	527.9	7.62	0.11	228.4
(Sep) 1.8	26.5	6.8	3755.6	2.8	2.7	7.45	590.8	7.30	0.14	285.2
(Oct) 3.9	26.5	6.8	4051.1	2.2	3.1	7.25	544.5	6.75	0.16	195.2
(Nov) 6.0	27.0	6.6	4377.6	2.7	3.2	7.24	654.9	5.73	0.20	28.7
(Dec) 7.3	27.0	6.3	4539.6	2.2	3.4	7.60	841.7	5.00	0.23	38.4
(Jan) 13.7	27.5	6.3	4821.6	1.3	3.5	6.80	874.5	4.40	0.32	39.6
(Feb) 15.7	28.0	6.0	4476.4	0.9	3.3	6.60	859.5	4.40	0.33	103.7
(Mar) 14.6	27.0	5.9	5091.2	0.8	3.4	6.50	791.1	6.33	0.27	95.6
(Apr) 11.0	27.5	6.1	5364.2	0.8	3.1	6.71	757.6	7.25	0.31	59.8
(May) 11.3	27.0	6.8	5196.8	1.6	3.0	6.50	592.9	7.50	0.21	397.4
(Jun) 6.3	28.0	6.7	4748.3	1.8	2.6	7.10	556.9	8.03	0.14	344.7
(Jul) 3.0	27.5	6.6	3939.9	1.9	2.6	7.40	487.5	8.03	0.09	392.6

Table 6: Correlation coefficients of phytoplankton and water parameters measured in the Lower Sombreiro river (August 2005-July 2006)

Correlation	Phytop -lankton	Temp. (°C)	pH	Cond. (μs cm^{-1})	Turb. (NTU)	Sal. (%)	DO (mg L^{-1})	TDS (mg L^{-1})	Depth (m)	Flow rate (m s^{-1})	Rainfall (mm)
Phytoplankto	1.0000										
Temp	-0.1870	1.0000									
pH	-0.3683*	0.2934*	1.0000								
Conductivity	-0.1891	0.4611*	0.4902*	1.0000							
Turbidity	-0.2941*	-0.1209	0.2259	0.0604	1.0000						
Salinity	-0.1940	0.4182*	0.4932*	0.9892*	0.0775	1.0000					
Dissolved oxygen	-0.4640*	0.1585	0.4248*	0.4463*	0.4544*	0.4530*	1.0000				
TDS	-0.1914	0.4568*	0.4605*	0.9792*	0.0192	0.9831*	0.4114*	1.0000			
Depth	-0.2698	0.3789*	0.6855*	0.7572*	0.2994*	0.7482	0.5348*	0.6820*	1.0000		
Flow rate	0.3312*	0.2982*	0.6536*	0.6046*	0.4197	0.6105*	0.5669	0.5321*	0.9043*	1.0000	
Rainfall	-0.1350	0.0055	0.2993	-0.0225	0.1415	-0.0554	-0.0252	-0.0890	0.4210*	0.4625	1.0000

*Significantat $p<0.05$, Sal.-Salinity, Temp-Temperature, DO- Dissolved Oxygen, TDS- Total Dissolved Solid, Turb-. Turbidity, Cond-Conductivity

significant difference. The diversity index measured by the Shannon-Wiener information function (H) ranged from 1.053-1.505. These were recorded for the months of September and January, respectively. The variations between months were relatively slight, save for the sharp drop from August to September.

The Evenness (Equitability) index, (E) had the lowest score (0.849) in May and the highest (0.950) in November. Margalef's species richness index (d) for the phytoplankton distribution had the lowest mark (3.759) in September and the highest (7.226) in May. After a sharp drop in September, there was a steady and gradual rise up to January, a slight drop and another gradual rise, up to May. The Simpson's Dominance index (c) had the lowest score (0.027) in July and the highest (0.110) in September. The fluctuations here were gradual.

The relationship between the percentage collection in phytoplankton abundance and physico-chemical characteristics in the Sombreiro River is shown in Table 5. The percentage total collection increased with increased temperature, increased conductivity, increased flow rate. However, it reduced with reduced temperature, conductivity, increased turbidity and rainfall (APHA, 1989).

Table 6 shows the correlation coefficients of phytoplankton abundance and physico-chemical parameters measured during the study. The phytoplankton collected had a negative correlation with dissolved oxygen and pH. However, it correlated positively with flow rate.

DISCUSSION

This study recorded 43 species of phytoplankton from 5 taxonomic groups. This result compared favorably with records from some other Nigerian waters (Kemdirim, 2001; Khan *et al*., 1983). Yakubu *et al*., (2000) observed 34 species in Nkisa river and 20 species in Orashi River. Also, Kosa (2007) recorded 39 phytoplankton species in the Upper Luubara Creek. Nwadiaro and Ezefili (1986) recorded a total of 56 species in New Calabar River. However, this result varies considerably from some other studies in Nigeria. Edoghotu (1998) identified 143 species in Okpoka Creek, while Chindah and Pudo (1991) had 148 species from Oginigba Creek, all in Port Harcourt. Also, Adeniyi (1978) recorded 305 species in Kainji Lake while Chindah and Keremah (2001) reported 89 species from the Bonny estuary.

According to Welcomme (1985), the major factors influencing phytoplankton abundance are temperature, velocity of current, nutrient availability and light. The highest percentage catch in this study was recorded when the temperature was high with low water depth low

Welcomme (1985) supported this view. However, the periods of high percentage collection coincided with relatively high water flow rates, contrary to reports by Welcomme (1985) and Egborge (1972). Generally, both studies reported that phytoplankton abundance inversely related to both water level and current velocity.

The relationship between phytoplankton abundance and conductivity in this study was positive. Nutrient availability may have reduced the influence of high current velocity on phytoplankton abundance. According to Welcomme (1985), when abundant nutrients are available, flow becomes a secondary factors in limiting phytoplankton number. The periods of low phytoplankton abundance coincided with relatively higher turbidity values, which may have reduced light intensity for photosynthesis.

Furthermore, *Melosira granulata* from the Bacillariophycaea was the most abundant species. Yakubu *et al*. (2000), Kosa (2007) also reported the high abundance of Bacillariophycaea in Nkisa River and Lubara creek, respectively. However, Khan *et al*. (1983) and Kemdirim (2001) reported Chlorophyceae as the most abundant group in Nigerian fresh waters. Pudo and Fubara (1988) observed *Nitzschia* sp. in considerable numbers in the estuarine zone of the River Niger. This compared favorably with results from this study.

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