The zooplankton and phytoplankton biomass in a tropical creek, in relation to water quality indices

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Abstract

The dynamics of zooplankton population and phytoplankton biomass in the Agboyi creek in relation to the water quality indices were investigated from October, 2005 to March, 2006. The water quality parameters showed monthly variations linked with tidal sea water incursion and rainfall/floodwater dynamics. Whereas, the phytoplankton biomass determined as chlorophyll a values recorded higher values in the wet season, zooplankton numbers were higher in the dry than wet season. A total of 17 zooplankton taxa and 5 juvenile stages were identified. Furthermore, chlorophyll a values ranged between 8.3 µg/L and 22.1 µg/L. Whereas 76.5% of the zooplankton taxa belonged to the phylum Arthropoda, 23.5% were grouped under the phylum Rotifera. Additionally, total zooplankton species accounted for 77.3% as against the juvenile stages that made up of 22.7%. Some dominant species recorded were *Cyclops strenus*, *Pseudocalanus elongatus*, *Lecane bulla* and *Tetrasiphon hydrocora.* Species indices and similarity index were also higher in the dry (0.5 – 0.80) than wet (0.22 – 0.33) season. [Life Science Journal. 2008; 5(4): 75 – 82] (ISSN: 1097 – 8135).

Keywords: algae; environmental characteristics; estuarine; water chemistry; tropical

1 Introduction

The creeks of South-western Nigeria form part of the numerous ecological niches associated with the Nigerian coastal environment (Onyema and Nwankwo, 2006). The creeks are of two types: the tidal freshwater and the non-tidal freshwater creeks (Nwankwo and Amuda, 1993). The physical and chemical changes observed in a creek are a reflection of the influence of seasons (Nwankwo and Akinsoji, 1992).

The ecological factors operating in aquatic ecosystems of South-western Nigeria have been documented by several workers (Hill and Webb, 1958; Olaniyan, 1969; Ezenwa, 1981; Nwankwo, 1984). The highlights include the horizontal gradient of environmental factors, the diluting effect of the rivers and tidal seawater inflow. For instance, Hill and Webb (1958), Olaniyan (1969) and Nwankwo (1991, 1993) are of the view that floods associated with rainfall in this region is known to dilute the ionic concentration of the coastal waters and breaks down horizontal environmental gradients. Furthermore, rainfall also introduces chelating agents as well as increasing the nutrient levels of the creeks and lagoons.

According to Nwankwo and Amuda (1993), there are only few records on the plankton and productivity of Nigerian creeks. The use of chlorophyll a to measure algal biomass and pollution status of aquatic ecosystems has in fact gained grounds all over the world (Lee 1999; Suzuki *et al*, 2002). Existing information on creek zooplankton spectrum of South-western Nigeria are either scanty or non-existent. Furthermore, there is no published work in South-western Nigeria on the primary production measurement using chlorophyll a method as an index of phytoplankton biomass. Nonetheless, there exists two: one in the Ikpoba reservoir and a report in the Niger Delta area (Ogamba *et al*, 2004). The primary trophic roles played by the phytoplankton and zooplankton in the ecology of the aquatic environment cannot be understated. Consequent upon this, there is a need for information on the dynamics of zooplankton and algal biomass in the Agboyi creek especially in relation

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to the water quality changes.

2 Materials and Methods

2.1 Description of study site

The Agboyi creek which is an adjourning creek to the Lagos lagoon is located on the northern part of the lagoon and also drains the Ogun river (Figure 1). The creek is located in Kosofe Local Government Area of Lagos State. The creek serves as a major drainage channel for the area, receiving domestic waste discharges as well as industrial waste, which are discharged from nearby industries at Maryland, Isheri, Magodo and Ogudu areas of the Lagos metropolis. Sand minning, mangrove cuttings for fuelwood and brush parks (Acadja) are also common practices in the area. Two stations were chosen for this study, stations A (latitude 6º 34.900 N and longitude 3º 24.400 E) and B (latitude 6º 34.053 N and longitude 3º 24.556 E).

Figure 1. The Lagos lagoon showing sampling sites on the Agboyi creek.

The creek area experiences a well marked dry (December – April) and wet season (May – November). There are two peaks of solar radiation as well as two peaks of rainfall in the region. The solar radiation peaks almost corresponds to the equinoxes while the rainfall peaks causes two different flooding seasons. The creek is open throughout the year and receives tidal influences which are experienced far inland especially during the dry season from the lagoon. These tidal influences are minimal during the wet seasons.

The creek is characterized by mangrove plants including *Acrostiscum aureum* (Halophytic fern), *Rhizophora racemosa* (red mangrove), *Phoenix reclinata*, floating plants such as the *Pistia* and an abundance of water hyacinths (*Eichhonia crassipes*) on the water surface and along the edges of the creek in the wet season. *Rhizophora racemosa* and *Paspalum orbiquilare* are the dominant riparian vegetation. The Agboyi creek also serves as a nursery ground for fish, crabs and herons that also avail the site. The creek area is lined by human settlements and it is basically a fishing community with the people, including the women and children involved in fish and periwinkle fishery and mat making using sedges.

2.2 Collection of samples

Collection of plankton samples were made at monthly intervals (October, 2005 – March, 2006) at the study sites using plastic 250 ml bottles. About 100 L of water at each site was filtered through a 55 µm standard plankton net from a motorized boat. All samples were collected between 11:00 hrs and 14:00 hrs so as to minimize the variations of zooplankton distribution that could occur due to diurnal migrations (Bainbridge, 1972). At the end of each trip, the plankton samples were preserved with 4% unbuffered formalin and then were labeled. Water samples were also collected for water chemistry analysis. Water sample for chlorophyll a estimation was collected in 500 ml plastic containers and transported immediately to the laboratory for further analysis after storing in an ice chest.

2.3 Determination of water quality indices

Air and surface water temperatures were measured *in situ* using a mercury thermometer while water depth was estimated with a calibrated pole. Transparency was measure using a 20 cm black and white secchi disc. Total dissolved solids were determined by evaporating 100 ml aliquot at 105 ºC and total suspended solids estimated by filtering 100 ml of sample through a pre-weighed filter paper, dried to constant weight and reweigh. Conductivity was measured using a Philip PW9505 Conductivity meter while salinity was determined using the silver-nitrate chromate method (APHA, 1998). The surface water pH was determined with a Griffin pH meter (model 80) while dissolved oxygen was measured using a Griffin oxygen meter (Model 40). Biological and chemical oxygen demands were measured using methods described in APHA (1998) for water analysis. Calorimetric methods using a Lovibond Nessler were adopted for the direct determination of phosphate-phosphorus and nitrate-nitrogen values while sulphate levels were measured using the gravimetric method (APHA, 1998). Calcium and magnesium ions were determined using a 400 single channel, low flame photometer (APHA, 1998). Concentrations of copper, iron and zinc were determined with an atomic absorption spectrophotometer (AAS) Uni cam 99model. Chlorophll a was determined by the flourometric method according to APHA (1998).

2.4 Biological characteristics

Fixed plankton samples were allowed to settle in the laboratory for at least 48 hours and the supernatant decanted until a concentration of 40 ml was obtained. Each sample was thoroughly mixed and two drops (0.2 ml) from each sample five different times were placed on a glass slide with the aid of a dropper and a cover slip placed over the mount. This was then thoroughly investigated under the microscope noting all fields. Outcomes on abundance were then averaged. Zooplankton species were examined, drawn, identified and counted using a Carl Zeiss monocular microscope with a calibrated eyepiece at different magnifications (× 50, × 100 and × 400). The number of each taxon occurring in each field and the total number of taxa per group were recorded as number of species per ml. Relevant texts were used to confirm identification of species (Newell and Newell, 1966; Round, 1965; Wimpenny, 1966; Olaniyan, 1975; Waife and Frid, 2001; Gibbons, 2001). Species diversity, richness and evenness or equitability indices were used to characterize the zooplankton biodiversity. Classifications were according to Barnes *et al* (1993).

2.5 Statistical analysis

2.5.1 Shannon-Wiener diversity index (Hs). This was proposed by Shannon and Wiener (1963) and it is given by the equation:

$$Hs = \sum P_i \ln P_i$$

Where Hs = Shannon-Wiener diversity index, $\sum$ = Summation, i = Counts denoting ith species ranging from 1 to n.

P_i = Proportion that the ith species represent to the total number of individuals in the sampling space.

2.5.2 Menhinick's index (D) (Ogbeibu, 2005).

$$D = S/N^{1/2}$$

S = Number of species in a population, N = Total number of individuals in S species.

2.5.3 Margalef index of species richness (d). The species richness (Margalef, 1951) was given by the equation: $d = (S - 1)/\ln N$

Where d = Margalef richness index or species diversity index, S = Number of species in the population, N = Total number of individuals in species.

2.5.4 Species equitability (j) (Ogbeibu, 2005). Species equitability or evenness was determined by the equation: $j = Hs/\log_2 S$

Where j = Equitability index, Hs = Shannon-Weiver diversity index, S = Number of species in the population.

2.5.5 Simpson's dominance index (C) (Ogbeibu, 2005).

$$C = \sum (n/N)^2$$

Where n = the total number of organisms of a particular species, N = the total number of organisms of all species.

2.5.6 Similarity index (Nwankwo, 1998). The similarity index between two samples is given by the equation:

$$2C/(A + B)$$

Where C = Number of species common to both samples, B = Number of species in sample B, A = Number of species in sample A.

2.5.7 Correlation Coefficient (Ogbeibu, 2005). The correlation between zooplankton abundance and some environmental variables (temperature, salinity, total weekly rainfall and nutrient levels [phosphorus and nitrates]) was determined by Spearman Rank correlation analysis and it is given by the equation:

$$r = 1 - [6 \sum D^2/n(n^2-1)]$$

Where r = Correlation coefficient, $\sum D^2$ = Sum of squares of difference of the ranks, n = Number of weeks.

3 Results

The result on water quality indices is presented in Table 1. The surface water temperature ranged between 27 ºC and 31 ºC with the highest value (31 ºC) recorded in March and the lowest temperature value (27 ºC) in October. The air temperature values ranged between 30 ºC and 32 ºC with the highest (32 ºC) recorded in December and February. The transparency levels were higher in the dry than wet season (13.5 cm – 78 cm).

The total suspended solids decreases steadily with each subsequent month and the highest value (180 mg/L) was recorded in October and the lowest value (20 mg/L) was recorded in March. Conversely, the total dissolved solids steadily increased with the months and values ranged between 70 mg/L and 10212 mg/L. The highest volume of rainfall (133.6 mm) was recorded in October while the lowest (11.8 mm) was recorded in December. Rainfall showed clear monthly variation. pH values ranged between 6.9 and 7.10 throughout the study. Conductivity values increased from the October (166 µS/cm) to March (16500 µS/cm). Salinity values ranged between 0.23‰ and11.55‰. The month of November had the lowest salinity value of 0.23‰ while February had the highest value of 11.55‰. Chloride values also showed a steady increase as the dry season progressed. The highest acidity value (25.5 mg/L) was recorded in October while the lowest acidity value (5.0 mg/L) was recorded in December. The surface water alkalinity also increased as the dry season progressed (October through to March). The total hardness values showed a steady increase and ranged between 86.8 mg/L and 5820.1 mg/L with the highest value (5820.1 mg/L) recorded in March and the lowest value (86.8 mg/L) in October.

For cation concentrations the lowest calcium and magnesium concentrations of 26.1 mg/L and 5.2 mg/L were recorded in October while the highest values were recorded in March and February. The dissolved oxygen content ranged between 3.0 mg/L to 4.9 mg/L. The biochemical oxygen demand was highest in October and decreased steadily. The highest value of chemical oxygen demand (106 mg/L) was recorded in October while the lowest value (22 mg/L) was recorded in February.

Table 1. Monthly variation in water quality indices and chlorophyll a concentration at two stations on the Agboyi creek (October, 2006 – March, 2007)

Parameter	Months											
	Octomber		November		December		January		February		March	
	A	B	A	B	A	B	A	B	A	B	A	B
Air temperature (ºC)	31	29	32	31	32	32	29	31	32	32	30	30
Water temperature (ºC)	27	27	30	30	30	30	29	29	30	30	31	31
Transparency (cm)	12	15	39	39	57	76	69	12	80	76	61	59
Depth (cm)	349	355	424	471	475	266	288	441	311	370	268	525
Total suspended solids (mg/L)	180	180	78	71	56	55	44	47	28	31	20	25
Total dissolved solids (mg/L)	70	78	252	272	1700	1780	2270	2343	5011	5120	10212	10508
Rainfall (mm)	133.6		32.8		11.8		17.4		36.8		51.2	
Salinity (‰)	0.048	0.052	0.231	0.301	2.532	2.741	6.899	7.205	11.550	11.65	10.450	11.05
Chloride (mg/L)	16.8	17.0	77.0	84.1	847.0	901.4	2310.0	2413.6	2850.0	2970.1	3828.0	3890.5
pH at 25 ºC	6.90	6.95	7.05	7.05	7.00	7.03	7.10	7.08	7.00	7.01	6.95	7.00
Conductivity (µS/cm)	166	170	660	688	2500	2650	3490	3534	7600	7784	16500	17050
Acidity (mg/L)	25.5	23.5	10.0	9.65	5.0	5.0	7.6	7.8	7.0	7.0	10.6	10.5
Alkalinity (mg/L)	6.8	6.8	55.0	58.4	33.8	32.4	28.8	28.3	100.0	98.7	80.1	75.7
Total Hardness (mg/L)	86.8	83.3	120.0	128.6	608.0	615.7	620.0	650.2	5625.0	5734.3	5820.1	5950.2
Nitrate (mg/L)	11.2	10.6	6.4	10.3	8.2	10.4	5.2	5.6	16.0	17.5	0.6	0.85
Sulphate (mg/L)	8.0	8.0	10.0	10.0	6.6	7.2	16.1	17.5	270.0	255	11.0	10.8
Phosphate (mg/L)	0.95	1.10	0.52	0.83	0.18	0.21	0.11	0.14	0.22	0.25	0.01	0.09
Silica (mg/L)	1.4	1.56	2.0	1.74	2.8	2.68	2.6	2.5	3.0	4.5	1.6	1.8
Dissolved oxygen (mg/L)	4.9	4.7	4.3	4.2	3.0	3.1	4.1	4.1	4.2	4.0	4.6	4.5
Biological oxygen demand (mg/L)	22	26	20	22	13	15	15	16	7	6	4	5
Chemical oxygen demand (mg/L)	106	109	60	62	72	75	88	90	22	23	38	30
Calcium (mg/L)	26.1	27.1	32.1	33.2	150.0	153	140.0	152.4	750.0	773.9	860.0	875.0
Magnesium (mg/L)	5.2	5.3	10.0	10.3	53.6	53.9	68.1	70.5	938.0	941.5	900.0	920.3
Zinc (mg/L)	0.007	0.008	0.005	0.004	0.004	0.004	0.004	0.004	0.002	0.003	0.003	0.003
Iron (mg/L)	1.40	1.45	2.2	2.7	1.80	1.75	0.26	0.28	0.15	0.21	0.08	0.09
Copper (mg/L)	0.004	0.003	0.003	0.003	0.002	0.003	0.002	0.003	0.001	0.001	0.002	0.003
Chlorophylla a (µg/L)	20.6	22.1	20.4	20.6	18.3	12.6	21	15	16	11.2	9.9	8.3

Similarly chemical oxygen demand values were lower in the dry (22 mg/L, February) than wet (106 mg/L, October) season. Silica concentrations ranged between 1.4 mg/L and 3.0 mg/L with the lowest concentration recorded in October. The nitrate-nitrogen concentrations ranged between 0.6 mg/L and 16.0 mg/L. The sulphate concentrations were lowest in December (6.6 mg/L) and highest in February (270.0 mg/L). Concentrations for phosphate-phosphorus ranged between 0.01 mg/L and 0.95 mg/L. Zinc values ranged between 0.002 m/Lg to 0.007 mg/L. Iron values ranged between 0.08 mg/L to 2.2 mg/L while Copper values were between 0.001 mg/L and 0.004 mg/L. Chlorophyll a concentrations ranged between 8.3 µg/L and 22.1 µg/L. Lower estimate were recorded as the dry season progressed. Whereas October recorded the highest value, estimates decreased till March.

The checklist of the zooplankton species at the Agboyi creek between October, 2004 and March, 2005 are presented in Table 2. A total of 17 species were recorded throughout the study period with 5 juvenile stages. More taxa were observed in the dry than wet season with the month of March recording the highest abundance and diversity. Two major phyla of zooplankton (Arthropoda and Rotifera) were represented. Of these, the phylum Arthropoda was the more abundant, accounting for 54.05% of the total species composition while the phylum Rotifera made up 45.95% of the total species composition. The major orders identified were the Order: Copepoda and Order: Ploimia.

Among the Arthropods, *Cyclops strenus* (Cyclopida) had the highest occurrence followed by *Pseudocalanus elongatus* (Calanoida). *Centropages hamastus*, *Rhincalanus nasutus*, *Corycaeus anglicus*, *Enterpina acutiforms* (Order: Copepoda); *Diaphamosoma excisum* and *Ilyocryptus* sp. (Order: Cladocera) were some other species recorded.

Among the Rotifers, *Tetrasiphon hydrocora* had the highest occurrence followed by *Keratella* sp. Among the juvenile stages the nauplii, zoea, Megalop larvae, copepod eggs and fish eggs were recorded. The nauplii larva was the highest in terms of occurrence accounting for 51.35% of total juvenile stages while the megalop larva and fish eggs accounted for 2.70% of the total. In general occurrence and diversity for juvenile stages were higher in the dry than wet season.

The indices of species richness index (d), Shannon and Wiener index (Hs), evenness (j) and similarity index (S) are presented as community composition parameters in Table 3. The Margalef index was highest (3.63) in March (Station B) and lowest (0) in December (Station B). The Shannon-Wiener index was lowest (0.86) in November (Station A) and highest (2.15) in March (Station B). The species equitability (j) ranged between 0 in December (Station B) and 2.36 in January (Station A). The menhinick index was highest (1.13) in January (Station B) and lowest (0.32) in December (Station B). The Simpson's dominance index was lowest (0.18) in March (Station A) and highest (1.00) in December (Station B). Similarity between stations A and B was highest in February (0.8) and lowest in October (0.22). The correlation coefficient between zooplankton taxa, chlorophyll a and water quality indices are presented in Table 4.

4 Discussion

Trends in variation in water quality indices were

Table 2. A checklist of zooplankton of the Agboyi creek (October, 2005 and March, 2006)

Phylum/Class	Order		Species
Arthropoda/ Crustacea	Copepoda	Sub-order I: Calanoida	*Paracalanus parvus* (Claus)
			Centropages hamastus (Lingberg)
			Pseudocalanus elongatus (Boeck)
			Rhincalanus nasutus Giesbrecht
		Sub-order II: Cyclopoida	*Cyclopina longicornis* Boeck
			Cyclops strenus Fisher
			Mesocyclops sp.
			Corycaeus anglicus Lubbock
		Sub-order III: Harpaticoida	*Enterpina acutifrons* Dana
	Cladocera	Sub-order: Eucladocera	*Diaphanosoma excisum* (Sar)
			Diaphnia sp.
			Bosmina sp.
			Ilyocryptus sp.
Rotifera/ Monogonota	Ploimia		*Lecane bulla* Gosse
			Keratella sp.
			Tetrasiphon hydrocoral Ehrenberg
			Brachionus plicatilis Muller
	Juvenile stages		Nauplii larva
			Zoeae larva
			Megalop larva
			Copepod eggs
			Fish eggs

Table 3. Variations in community composition parameters of zooplankton and chlorophyll a at Agboyi creek (October, 2005 and March, 2006)

Parameter	October		November		December		January		Febuary		March	
	A	B	A	B	A	B	A	B	A	B	A	B
Chlorophyll a	20.6	22.1	20.4	20.4	18.3	12.6	21	15	16.0	11.2	9.9	8.3
Total species diversity (S)	5	4	2	4	3	1	6	8	5	4	6	9
Total phytolplankton abundance (N)	55	45	10	25	15	10	45	50	35	70	35	160
Log of species diversity	0.70	0.60	0.30	0.60	0.48	0.00	0.78	0.90	0.70	0.60	0.78	0.95
Log of phytoplankton abundance	1.74	1.65	1.00	1.40	1.18	1.00	1.65	1.70	1.54	1.85	1.54	2.20
Shannon-Wiener index (Hs)	1.65	1.56	0.86	1.27	1.04	0.90	1.54	1.58	1.42	1.78	1.42	2.15
Menhinick index (D)	0.67	0.60	0.63	0.80	0.77	0.32	0.89	1.13	0.85	0.48	1.01	0.71
Margalef index (d)	2.30	1.81	1.00	2.15	1.70	0.00	3.02	4.12	2.59	1.63	3.24	3.63
Equitability index (j)	2.36	2.60	2.86	2.12	2.17	0.00	1.98	1.74	2.04	2.96	1.82	2.25
Simpson's dominance index (C)	0.24	0.28	0.50	0.28	0.33	1.00	0.21	0.14	0.22	0.34	0.18	0.29
Similarity index (S)	0.22		0.33		0.5		0.57		0.80		0.5	

Table 4. Pearson correlation co-efficient matrix of water quality indices chlorophyll a and zooplankton at Station A in Agboyi creek (October – March, 2006)

	1)	2)	3)	4)	5)	6)	7)	8)	9)	10)	11)	12)	13)	14)	15)	16)	17)	18)	19)	20)	21)	22)	23)	24)	25)	26)	27)	28)	29)
1)	1																												
2)	0.11	1																											
3)	–0.15	0.69	1																										
4)	0.71	–0.02	–0.32	1																									
5)	0.15	–0.89	–0.93	0.26	1																								
6)	–0.32	0.66	0.54	–0.63	–0.66	1																							
7)	–0.02	–0.73	–0.78	–0.20	–0.83	–0.16	1																						
8)	–0.31	0.55	0.83	–0.72	–0.76	0.83	–0.33	1																					
9)	–0.47	0.59	0.77	–0.75	–0.77	0.92	–0.32	0.96	1																				
10)	–0.22	0.31	0.54	0.06	–0.51	–0.20	–0.80	0.10	0.08	1																			
11)	–0.33	0.66	0.52	–0.63	–0.65	0.99	–0.15	0.81	0.91	–0.21	1																		
12)	–0.08	–0.80	–0.86	–0.15	0.89	–0.28	0.98	–0.46	–0.43	–0.69	–0.27	1																	
13)	0.23	0.77	0.69	–0.33	–0.74	0.70	–0.39	0.77	0.69	0.08	0.69	0.52	1																
14)	–0.04	0.60	0.61	–0.60	–0.63	0.90	–0.11	0.90	0.87	–0.24	0.87	–0.28	0.87	1															
15)	–0.59	–0.40	0.01	0.71	0.29	–0.40	0.22	–0.01	–0.27	–0.17	–0.42	0.14	0.10	0.02	1														
16)	0.36	0.18	0.56	–0.27	0.34	0.23	–0.12	0.62	0.39	0.02	0.20	0.27	0.70	0.62	0.74	1													
17)	0.31	–0.81	–0.89	0.27	0.96	–0.67	0.81	–0.73	–0.79	–0.48	–0.66	0.85	–0.56	0.55	0.41	–0.17	1												
18)	0.24	0.33	0.76	0.20	–0.57	–0.07	0.06	0.36	0.20	0.60	–0.11	–0.79	0.32	0.12	0.44	0.57	–0.53	1											
19)	–0.32	–0.37	–0.42	–0.64	0.40	0.18	0.73	0.06	0.09	–0.40	0.20	0.72	0.03	0.20	–0.05	0.02	0.47	–0.73	1										
20)	0.13	–0.75	–0.78	0.47	0.82	–0.92	0.41	–0.91	–0.92	0.05	–0.37	–0.64	0.01	–0.42	–0.21	–0.17	–0.29	0.45	–0.52	1									
21)	–0.30	–0.81	–0.69	0.23	0.76	–0.69	0.43	–0.73	–0.65	–0.06	–0.68	0.57	–0.99	–0.85	–0.08	–0.67	0.58	–0.35	0.07	–0.04	1								
22)	–0.09	0.63	0.62	–0.60	–0.66	–0.93	–0.15	0.91	0.89	–0.23	0.92	–0.31	0.85	0.99	–0.06	0.56	–0.60	0.11	0.17	–0.41	–0.84	1							
23)	–0.01	0.57	0.60	–0.60	–0.61	–0.88	–0.10	0.90	0.85	–0.24	0.86	–0.27	0.88	0.99	0.07	0.65	–0.52	0.13	0.22	–0.42	–0.86	0.99	1						
24)	0	–0.80	–0.95	0.33	0.94	–0.69	0.68	–0.88	–0.81	–0.33	–0.69	0.80	–0.86	–0.79	–0.01	–0.62	0.86	–0.64	0.32	–0.13	0.86	–0.80	–0.78	1					
25)	0.60	–0.22	–0.64	0.90	0.52	–0.74	0.08	–0.91	–0.91	–0.02	–0.72	0.18	–0.49	–0.75	0.06	–0.45	0.56	–0.16	–0.28	0.42	0.41	–0.76	–0.74	0.63	1				
26)	0	–0.70	–0.98	0.25	0.91	–0.56	0.73	–0.83	–0.74	–0.41	–0.53	0.84	–0.74	–0.69	–0.11	–0.64	0.85	–0.78	0.46	–0.18	0.75	0.68	–0.67	0.97	0.06	1			
27)	0.10	–0.67	–0.41	0.45	0.57	–0.96	0.08	–0.70	–0.78	–0.38	–0.96	0.22	0.69	–0.88	0.36	–0.19	0.56	0.15	–0.14	0.42	0.71	–0.91	0.85	0.62	0.56	0.46	1		
28)	–0.77	–0.13	0.29	–0.91	–0.16	–0.57	0.24	0.66	0.71	–0.17	0.56	0.18	0.10	0.49	–0.14	–0.17	–0.28	–0.13	0.44	–0.61	–0.02	0.51	0.48	–0.25	–0.90	–0.24	–0.39	1	
29)	–0.60	–0.65	–0.19	–0.71	0.39	0.10	0.65	0.21	0.22	–0.37	0.09	0.63	–0.29	0.10	0.16	0.38	0.28	–0.36	0.61	–0.72	0.38	0.09	0.11	–0.25	–0.59	0.22	0.03	0.83	1

1): Air temperature; 2): Water temperature; 3): Transparency; 4): Deph; 5): Total suspended solids; 6): Total dissolved solids; 7): Rainfall; 8): Salinity; 9): Chloride; 10): pH at 25 ºC; 11): Conductivity; 12): Acidity; 13): Alkalinity; 14): Total hardness; 15): Nitrate; 16): Sulphate; 17): Phosphate; 18): Silica; 19): Dissolved oxygen; 20): Biological oxygen demand; 21): Chemical oxygen demand; 22): Calcium; 23): Magnesium; 24): Zinc; 25): Iron; 26): Copper; 27): Chlorophlla a; 28): Species diversity; 29): Species abundance.

similar for the two stations. The continued increase in salinity values observed during the investigation could be due to increased incursion of tidal seawater from the Lagos lagoon, coupled with increase in evaporation and the drastic reduction of rain/flood water inputs. Barnes (1980) is of the view that in the wet seasons, lagoons and creeks are diluted considerably by freshwater from rain and river systems, while in the dry season, evaporation becomes more prominent. Salinity regimes in the Lagos lagoon to which the Agboyi creek is connected have also been related to rainfall distribution pattern (Olaniyan, 1969; Nwankwo and Amuda, 1993; Onyema *et al*, 2003, 2007).

Recorded high levels of nutrients (nitrate, phosphate and sulphate) may be a reflection of direct discharges of pollutants among which domestic and wood wastes rank high directly into the creek. Additionally, foliage deterioration from the riparian wetland flora may also have lead to enrichment that eventually empties into the creek. Such nutrient rich run-offs are more frequent with rain events. According to Nwankwo (1995), storm water channels, creeks and creeklets acts as conduits for land based human-induced activities into the coastal waters of Nigeria.

Reduced concentrations of chlorophyll a were recorded from October till March at both stations. Similarly, there was strong negative correlation between salinity and chlorophyll a ($r = -7.0$). It is possible that increased tidal mixing lowered chlorophyll a values as the resident time of the algae in water was reduced. Increase in salinity and other associated factors could also have acted as unfavourable factors to the development of the micro-algal community. This period is known to be associated with increased tidal and hence marine conditions (Hill and Webb, 1958; Sandison and Hill, 1966; Nwankwo, 1996; Onyema *et al*, 2003; Onyema and Nwankwo, 2006). Olaniyan (1975) is of the view that salinity level is an important ecological barrier in the Lagos lagoon to both freshwater and marine organisms at different times. A similarly strong negative correlation was also recorded by chlorophyll a and total dissolved solids and conductivity ($r = -0.96$). Conversely, a strong positive correlation was recorded between chlorophyll a and phosphate levels. According to Onyema and Emmanuel (2008) has already implicated nutrient supply especially phosphate as possible phytoplankton production in Lekki lagoon in Lagos. According to Wehr and Sheath (2003), a large body of data clearly indicates that phytoplankton production and biomass in most benthic systems is controlled by nutrients and especially phosphate supply.

However, there was an increase in the abundance and species diversity of rotifers, juvenile stages and some copepod species in the month of January and February despite the sharp increase in the salinity of the water. This maybe probably due to the high tolerance of these zooplankton species to higher variations in salinity.

Some of these species have been recorded in similarly saline environments in the region (Akpata *et al*, 1993; Onyema *et al*, 2003, 2007). On the other hand, the low abundance and diversity of species recorded in November and December may be due to decrease in volume of rainfall and associated rise in salinity (Nwankwo, 2004). Stations within the creek were also more similar in the dry (0.80) than in the dry season (0.22) in the wet season. This situation is possibly due to reduced resident time of water and the presence of higher amounts of particulate matter in suspension which may impose further unfavourable conditions. Total suspended solids values were highest also at this time.

Arthropods were the most abundant and diverse species observed during the study. However, various juvenile stages were also recorded, with the nauplii larva being the most abundant. Among the arthropods, *Cyclops strenus*, *Pseudocalanus elongatus* and *Diaphnia* sp were the most abundant. According to Onyema *et al* (2003) diatoms and copepods were the most abundant groups in the Lagos lagoon among the plankton. These authors are also of the view that calanoids were more important than cyclopoid copepods in terms of numbers in the Lagos lagoon. It is possible that species like the cladocerans and probably the rotifers were recruited from adjoining rivers and creeks. Similar recruitment of plankton species have been linked to adjoining rivers, creeks and lagoons for the Lagos lagoon (Onyema *et al*, 2003).

Conversely, the calanoid and cyclopoids copepods (except for Cyclops and Mesocyclops) recorded for this study were probably recruited from the adjacent brackish waters of the Lagos lagoon. The hydroclimatic characteristics and zooplankton diversity at the Agboyi creek exhibited a continuum from fresh through brackish water conditions. The zooplankton components also reflected this trend.

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