Macrothink Institute™

Journal of Environment and Ecology
ISSN 2157-6092
2012, Vol. 3, No. 1

Effects of Physico-chemical Parameters on Phytoplankton of a Tidal Creek, Lagos, Nigeria

Taofikat Adesalu

Department of Botany, University of Lagos, Lagos, Nigeria

Tel: 234-802-312-7185   E-mail: boseadesalu@yahoo.com

Olakunbi Kunrunmi (Corresponding author)

Department of Botany, University of Lagos, Lagos, Nigeria

Tel: 234-803-856-4369   E-mail: kunbikunrunmi@gmail.com

Received: July 19, 2012   Accepted: August 27, 2012   Published: December 1, 2012

doi:10.5296/jee.v3i1.2674   URL: http://dx.doi.org/10.5296/jee.v3i1.2674

Abstract

Physico-chemical parameters have been observed to influence phytoplankton composition of coastal areas and water in Nigeria. In order to assess this, the phytoplankton composition of a tidal creek in Lagos was investigated in relation to the physico-chemical characteristics for twelve months (February 2010- January 2011). Six stations were created, phytoplankton samples were collected using 55 µm mesh size plankton net and water samples were also collected for physico-chemical parameters analysis. Four major divisions, Bacillariophyta (78%), Chlorophyta (11%), Cyanophyta (10%) and Euglenophyta (0.07%) were documented. The phytoplankton abundance was influenced by parameters such as rainfall, phosphate-phosphorus, nitrate-nitrogen and salinity. The highest (5.7mg/L) and lowest values (0.01mg/L) of phosphate-phosphorus were recorded in May 2010 (station B) and in December 2010 (station F) respectively, while nitrate-nitrogen recorded its highest (17.3mg/L) and lowest values (0.02mg/L) in May 2010 (station B) and in November 2010 (station C) respectively. The pH ranged between 6.2 and 8.4. However, the salinity values recorded corresponded with rainfall pattern of the studied area. The highest (6.7) and lowest values (0.9) of species diversity (d) were recorded in July 2010 (station D) and June 2010 (station D) respectively. Shannon-weiner (H^1) index recorded its highest (3.35) and lowest values (0.41) in July 2010 (station D) and in October 2010 (station C) respectively, while the highest (0.96) and the lowest values (0.2) of species evenness (j) where recorded in June 2010 (station D) and October 2010 (station C) respectively. Human induced stressors such as dredging, sand mining and poor sewage system might have affected the phytoplankton composition of the studied area.

Keywords: Phytoplankton, Physico-chemical parameter, Tidal creek

1. Introduction

Lagoons are dominant features along large stretches of the West Africa coast; they are of utmost importance as natural harbours, nursery grounds for marine fishes, shrimps and often sustain significant fisheries (Pauly, 1975). The functions of lagoons include sediments retention nutrient retention, biomass export, water transport and recreation (Finlayson *et al.*, 2000). Lagoons have shrunk in area and become reduced in volume and in average depth, but they have also become very much less active environments because fetches for wave action, seiching, and current formation have also been reduced (Kirk and Lauder, 2000). Major threats to lagoons include water pollution, physical modification, exploitation and loss of production.

The high level of pollution in the aquatic environment in West African wetlands has been attributed to human activities. An investigation into the water pollution sources in Keta and Songor lagoons in Ghana, showed that a good percentage of people have no access to toilet facilities and as such use defecation that poses a threat to the shallow groundwater resource especially along the coast, also 80% of refuse generated within these areas were identified to be of domestic origin (Finlayson *et al.*, 2000).

Briton *et al.*, (2007) on the evaluation of the pollution of Abijan lagoon reported that the discharge of household and toilet waters (which are very charged in phosphates and nitrates salts) from a strongly populated district into the lagoon resulted in an increase in the rate of conductivity. The presence of strong content of suspended matter (biodegradable and mineral organic matter in suspension) increases the rate of oxidation reaction thereby resulting in low dissolved oxygen content of lagoons.

Adesalu and Nwankwo (2005) also identified petroleum industry related contamination through sabotage, equipment failure, human error, leakages and inappropriate practices of refined petroleum and spent dispensers as sources of contamination of the lagoon.

The Lagos lagoon, Nigeria is an open, shallow and tidal lagoon, with a surface area of 208km^2, an average depth of 1.5m and it is one of the nine lagoons in South-western Nigeria (Webb, 1958; Nwankwo, 2004). The Lagos lagoon borders the forest belt and receives a number of large rivers (Ogun, Yewa, Oshun, Oni) and it drains more than 103,626km of the country (Ajao, 1989). Adesalu *et al.*, (2010) stated that the Lagos lagoon consists of three main segments: Lagos Harbour, the metropolitan end and Epe division segments. The highest level of pollution is recorded in the Lagos harbour segment, decreases in the metropolitan end of the lagoon, and the lowest pollution level is at the Epe segment (Okusipe, 2004).

There are four ecologically important periods in the Nigeria coastal waters and this is due to the distributive rainfall pattern in southwestern Nigeria. These are the dry months (January-March/April), when high salinity is experienced in the coastal waters and lagoons; April/ May, when the salinity drops drastically causing a stress condition and a resultant loss of biodiversity arising from the death of marine biota that invade the coastal water in the dry high salinity months; June-November when the coastal lagoons are fresh and December when the salinity rises sharply, excluding freshwater forms (Nwankwo, 2004).

Various ecologists (Hill and Webb, 1958; Olaniyan, 1975; Nwankwo, 1986) have attributed salinity gradients within the lagoon to two main factors; influx of floodwater from rivers and creeks surrounding wetlands and tidal seawater inflow through the Lagos harbor. According to Nwankwo (1996), the dynamic interplay between freshwater inflow and tidal seawater incursion determine the Lagos lagoon environment from year to year.

Investigations of anthropogenic wastes and environmental modifications in the Lagos lagoon, Nigeria revealed increased levels of pollution stress (Edokpayi and Nkwoji, 2007). Nwankwo (2004) reported that the implication of increasing population pressure, poor sewerage system, industrialization and poor waste management in Nigerian's coastal areas is that pollutants freely find their ways into the coastal waters through drains, canals, rivers, creeks and lagoons that act as conduits.

Moreover, apart from enriching the water with high amounts of biodegradable matter, these discharges introduces nutrients, toxic and other land based substances that may consequently signal epidemiological problems and an increase in human induced stressors which impairs aquatic biodiversity (Nwankwo and Akinsoji, 1988).

Creeks are valuable part of the aquatic resources serving as feeder-rivers, providing flood control, storm water drainage, habitat to wildlife, creating neighborhood beauty and improving quality of life (Saliu and Ekpo, 2006).

According to Adesalu and Nwankwo (2008), there are two types of creeks associated with the Nigerian coastal environment: the tidal freshwater creeks which are surrounded partly by mangrove swamps and partly by freshwater swamps while the non-tidal creeks are surrounded by freshwater and are infested by aquatic macrophytes all year round.

Few authors are of the view that the most productive period in the coastal waters of South western Nigeria occurs after the second rainfall period (October or November) and that plankton diversity in the Lagos lagoon increased towards the harbor (Nkwoji *et al.*, 2010).

Plankton refer to a collection of small or microscopic organisms (2-200 μm) that float or drift in great numbers in fresh or marine water especially at or near the surface and serve as food for fish and other larger organisms (Nwankwo, 1988). The plankton is divisible into phytoplankton (plants), zooplankton (animal) and nannoplankton (minute organisms like bacteria) and the simple equipment used for collection is called the plankton net (Olaniyan, 1975).

The phytoplankton are the first step of the aquatic food chain (Odum, 1977; Nwankwo, 2004). Phytoplankton photosynthesize in the presence of sunlight and nutrients such as nitrogen and phosphorus, they form the basis of ocean productivity and are referred to as the 'grasses of the sea', and some are grazed by zooplankton (Suthers and Rissik, 2009).

The rate of production of phytoplankton biomass depends directly on the rate of photosynthesis, and this in turn is controlled by the light intensity (Ghosal *et al.*, 2000). Phytoplankton are known to survive in the upper layers of oceans and lakes known as the euphotic zone which varies widely (50-100m) depending on water clarity, latitude and season.

Variation in some of the physical and chemical parameters such as rainfall, temperature, salinity, nitrate-nitrogen, phosphate-phosphorus, sulphate, biological oxygen demand and chemical oxygen demand have been reported to influence phytoplankton abundance (Adesalu *et al.*, 2010).

According to Suthers and Rissik (2009), the major limiting nutrients for phytoplankton are nitrogen in form of ammonium (NH_4^+), nitrite (NO_2^-) and phosphate (PO_4^-). Nitrogen tends to be the limiting nutrients in marine systems, while phosphate in the limiting nutrient in the freshwater systems (Suthers and Rissik, 2009). These two nutrients are needed for cell membranes and for proteins such as enzymes.

Adesalu and Nwankwo (2010) indentified phytoplankton as one of the useful indicators of aquatic environmental quality because they act as early warning signals thereby provoking appropriate remediation. Nwankwo (1993) reported that high ammonium compound and low react-nitrogen promoted the increase of *Anabaena* and *Nostoc.* Meso-eutrophic surface waters of creeks, rivers and lagoons that are moderately contaminated by organic matter with Biological Oxygen Demand (BOD) <8.0mg/L favors proliferation of *Microcystis aeruginosa, Microcystis flosaquae* and luxuriant growth of *Eichhornia crassipes* (Adesalu and Nwankwo, 2008).

Furthermore, Adesalu and Nwankwo (2009) related the abundance of *Bacillaria paxillifer* and *Aulacoseira* to low moderate brackish conditions in open water, lagoons and tidal creeks.

Various ecologists have worked on creeks, rivers and lagoons within and outside Nigeria. Existing reports include: Saliu and Ekpo (2006) on the preliminary chemical and biological assessment of Ogbe creek, Lagos; Nyananyo *et al.*, (2006) assessed the physico-chemical conditions and distribution of phytoplankton in the Brass River, Nigeria and concluded that effluent from oil industries could have contributed to the relatively turbid and acidic levels of the water. Davies *et al.*, (2009) on the phytoplankton community of Elechi creek, Niger Delta in Nigeria reported that the high level of phosphate above permissive limit showed that the creek is hypereuthrophic and organic polluted.

Other works include: Adesalu (2005) reported the diatoms of Olero creek; Oyema (2008) observed a total of 129 species of phytoplankton in Iyagbe lagoon, Lagos while Adesalu and Nwankwo (2009) reported the diatoms of Lekki lagoon, Lagos. Adesalu and Nwankwo (2010) reported 179 species of cyanobacteria in which the blue green algae *Oscillatoria* formed the most abundant genus. Adesalu *et al.*, (2010) on the hydrochemistry and phytoplankton composition of Tomaro and Ajegunle creeks in Lagos, where only three divisions (Bacillariophyta, Chlorophyta and Cyanophyta) were observed throughout the investigation and this was suggested to be as a result of the pollution status of the creeks.

The aim of this study was to investigate the phytoplankton composition in relation to the physical and chemical characteristics of Majidun creek of the Lagos lagoon, Nigeria.

Journal of Environment and Ecology
ISSN 2157-6092
2012, Vol. 3, No. 1

2. Materials and methods

2.1 Description of Study Site

Majidun creek (Figure.1) is one of the polluted water bodies in Ikorodu area of Lagos state; the creek is tidal and it flows into the Lagos lagoon. Majidun creek is slow flowing and the shore is characterized by macrophytes vegetation which is mostly mangrove and freshwater types. The mangrove species is dominated by *Rhizophora racemosa* (Red mangrove) and *Raphia hookeri* while macrophytes include *Eicchornia crassipes*, *Nymphae lotus* and *Pandanus candelatra*. The creek is bordered by a rural community showing little signs of urbanization. The inhabitants of the study site dump their domestic waste directly into the water and they have poor sewage system with their bathrooms and toilets piped directly into the water body. Dredging, sand mining, fishing and wood logging are the prominent activities that take place in the area. The waterway is often used for transporting smuggled fuel.

The annual rainy season in the study area occurs from May to October while the dry season occurs between the months of November and April. The area experiences tidal influences from the sea via the Lagos lagoon, rising tide ushers in high water level which reduces salinity, while at low tide salinity of the water is increased.

The colour of the water is usually black and have unpleasant odour at areas farther away from human settlement and which also experience low tidal influences from the sea, while the water is clearer at areas closer to human settlement and experience high tidal influence.

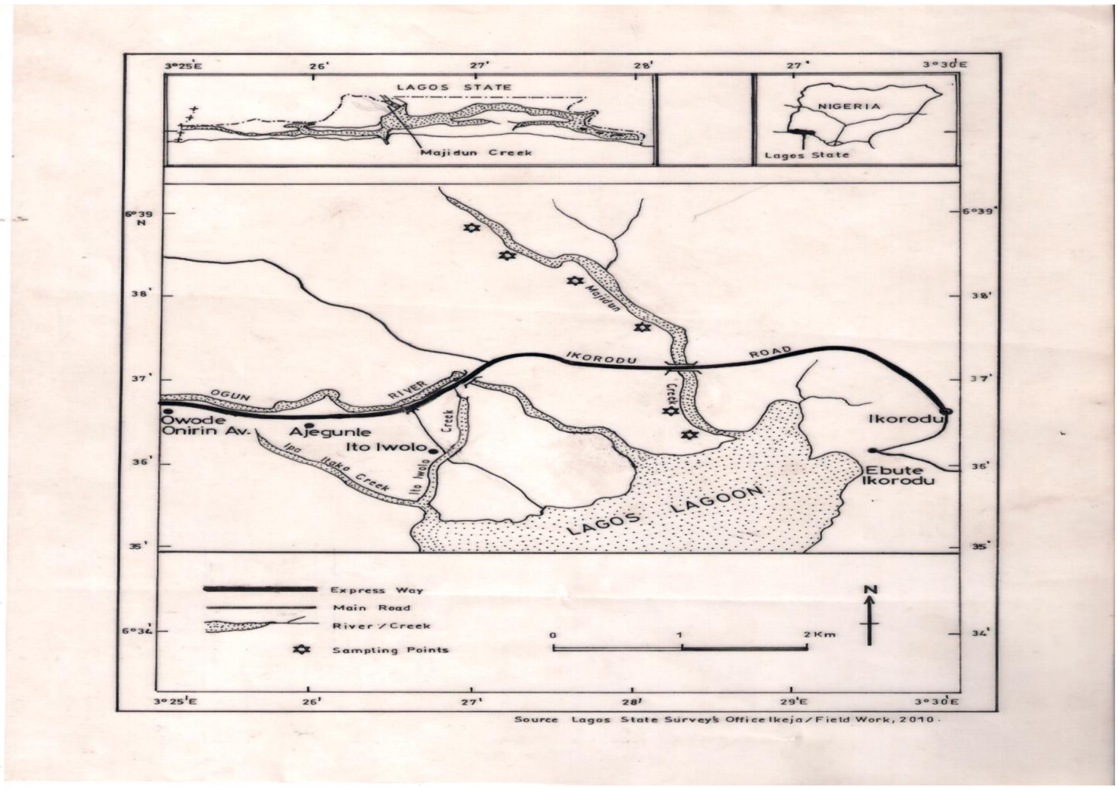

Figure 1. Map showing Majidun creek in Ikorodu area of Lagos with sampling sites

2.2 Methods of Collection

Six sampling stations were created in the area, designated as station A (06^{0} $338'$ 37N, 003 $102'$ 28E), station B (06^{0} $583'$ 37N, 003 $135'$ 28E), station C (06^{0} $802'$ 37N, 003 $877'$ 27E), station D (06^{0} $998'$ 37N, 003 $877'$ 27E), station E (06^{0} $223'$ 38N, 003 $617'$ 27E) and station F (06^{0} $384'$ 38N, 003 $557'$ 27E). All samples were collected during the hours of daylight to minimize variations of phytoplankton distribution that could occur due to migration. Biological samples were collected using 55 µm mesh sixe standard plankton bet tied unto a motorized boat and towed horizontally at low speed for ten minutes. The samples were transferred into well labeled plastic containers with screw caps and preserved with 4% unbuffered formalin. The plastic containers were labeled to reflect appropriate details such as station, date and time of collections.

Water samples for the analysis of physicochemical parameters were also collected just below the water surface (without the aid of plankton net) in well labeled 1litre plastic containers with screw caps. All samples were transferred to the laboratory for further analysis.

2.3 Physico-chemical Analysis

Surface water temperature was measured in-situ using mercury in glass thermometer while pH was determined using Philip pH meter. Total dissolved solids and conductivity were determined using and Adwa AD31& AD32 instrument. Transparency was measured using the Secchi disc while salinity was determined using a portable Refractometer. Titrimetric method (APHA, 1998) was applied for both dissolved oxygen and chemical oxygen demand while Gravimetric method (APHA, 1998) and Winkler's method were used to determine total suspended solids and biological oxygen demand respectively. Colorimetric method was applied for nitrate-nitrogen content and silica content; while stannous chloride method was applied for phosphate-phosphorus content. Sulphate content was determined using the Turbidimetric method (APHA, 1998) while chlorophyll *a* was determined using Fluorometer equipped with filters for light emission and excitation. Copper, Lead and Mercury were determined using Atomic Absorption Spectrophotometer (AAS).

2.4 Phytoplankton Identification

Biological samples preserved in 4% unbuffered formalin were allowed to settle for 24hours in the laboratory, after which the supernatant was decanted until a concentrate of 10ml was achieved. The biological samples were analyzed using a Wild II Binocular microscope with calibrated eye piece at different magnifications (x10 and x40). Identification of species was done using relevant texts (Whitford and Schumacher, 1973; Nwankwo, 1984; Krammer and Bertalot, 2000).

2.5 Community Structure Analysis

Three indices were used to obtain the estimate of species diversity in the samples analyzed: Species richness index (d) (Margalef, 1970), Shannon-Weiner index (H^1) (Shannon and Weiner, 1963) and Species evenness (j) (Pielou, 1975).

3. Results

3.1 Physico-chemical Parameters

The results of the physico-chemical parameters analyzed in this study are presented in Table 1. The water sample in the study area ranged from slightly acidic to being neutral to slightly alkaline throughout the sampling period with the highest pH value (8.4) recorded in June 2010 at stations A and B, while the lowest pH value (6.5) was recorded in October 2010 at station A. The highest phosphate-phosphorus and nitrate-nitrogen values (5.7mg/L and 17.3mg/L) were recorded in May 2010 at station B, while the lowest phosphate-phosphorus value (0.01mg/L) was recorded in November 2010 (station C and F) with the lowest nitrate-nitrogen value (0.02mg/L) recorded also in November 2010 at station C (Figures 2 and 3). Sulphate content was highest (23.4mg/L) in April 2010 (station A) while the lowest value (0.06) was recorded in September 2010 (station D). Silicate content values were relatively low (<0.65mg/L) throughout the sampling period; the lowest silicate content (0.01mg/L) was recorded in August 2010 (station C), September 2010 (station B), October 2010 (station B) and November 2010 (station A). The highest copper content value (7.1mg/L) was recorded in May 2010 (station A) while the lowest value (1.1mg/L) was recorded at station B in November 2010, December 2010 and January 2011. Lead content values were comparatively low (<0.8mg/L) throughout the sampling period (February 2010- January 2011), however, higher values were recorded in the dry months (February 2010- April 2010) while the values were very low, or Lead was not detected at all from May 2010 – January 2011. Mercury was not detected at all in all the six stations throughout the sampling period. The highest dissolved oxygen value (5.6mg/L) was recorded in July 2010 while the lowest value (4.0mg/L) was recorded in February 2010 (station A and E). Biological oxygen and chemical oxygen demand values were higher (>65mg/L) in February 2010 (Figure 4); lower values (<25mg/L) were recorded in all stations from March 2010 to January 2011. Chlorophyll *a* values were relatively low (<0.04) throughout the sampling period, the lowest value (0.001) was recorded for six months in different stations. The highest transparency value (1.77m) was recorded in January, 2011 (station D) while the lowest value (0.36m) was recorded in May 2010 (station A). Conductivity values were generally high in the dry months (February 2010 – April 2010) with the highest value (13.91mScm^{-1}) recorded in March 2010 (station B); lower conductivity values were recorded in the wet months with the lowest value (0.01mScm^{-1}) recorded in August 2010 (station A) and in October and December 2010 (station C). However, conductivity values kicked up again in January 2011. Salinity values and total dissolved solute values followed the same pattern as conductivity values; the highest salinity value (8.0$^0/_{00}$) was recorded in February 2010 (station A and B) and in April 2010 (station A) while the highest total dissolved solute value (6.94mg/L) was recorded in March 2010 (station A). Salinity values and total dissolved solute values were generally low (<1$^0/_{00}$ and <0.33mg/L respectively) in the wet months (May – October 2010) while the values increased in December 2010 and January 2011. The highest surface water temperature value (32.6^{0}C) was recorded in April 2010 (station B) while the lowest value (20.9^{0}C) was recorded in June 2010 (station E). The study site was shallow. The highest rainfall value (676.3mm) was recorded in June 2010 while there was no rainfall at all in December 2010 and January

2011(Figure 2). The depth ranged from 1.54m at station F to 9.24m at station A in January 2011 and June 2010 respectively.

Table 1. Variation in physico-chemical parameters in Majidun creek

PARAMETERS (mg/L)	FEBRUARY, 2010						MARCH, 2010					
	A	B	C	D	E	F	A	B	C	D	E	F
Transparency (m)	0.67	0.73	0.85	0.79	0.49	0.52	0.83	0.86	0.89	1.35	0.79	0.79
Conductivity (mS/cm)	10.46	7.7	12.82	6.51	3.49	3.66	13.91	9.21	5.82	4.2	1.51	0.66
pH	7.3	7.1	6.9	6.9	6.9	6.5	7.1	7.2	7	6.8	6.8	6.7
Phosphate-phosphorus	0.75	0.79	1.1	0.27	1.7	0.23	4.93	3.06	1.94	1.5	1.3	1.1
Sulphate	8.14	8.4	8.7	2.97	2.63	2.49	22.5	15	10.7	8	6.3	5.5
Nitrate-nitrogen	5.5	5.55	5.6	2.1	1.9	1.6	16.63	16.33	15.55	13.4	11.2	9.6
Silicate	0.14	0.2	0.32	0.05	0.04	0.02	0.64	0.49	0.32	0.22	0.2	0.17
Copper	1.29	1.45	2.15	1.47	1.42	1.39	6.54	5.4	4.7	4.12	3.6	2.9
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved oxygen	4	4.3	4.2	4.2	4.2	4.3	5.4	5	5.5	5	4.6	4.4
Biology oxygen demand	60	55	57	50	55	65	10	9	11	8	13	14
Chemical oxygen demand	112	118	120	100	120	110	12	14	13	15	17	20
Chlorophyll *a*	0.01	0.01	0.04	0	0	0	0.04	0.02	0.02	0.02	0.02	0.01
Salinity (0/00)	8	8	3	6	7	1	5	5	5	1	1	1
Surface water temperature (0C)	30.2	30.5	30.1	29.4	28.8	28.5	30.1	29	28.8	29.1	28.4	28.2
Total dissolved solute	5.23	4.8	6.41	3.26	1.74	1.82	6.94	4.63	2.89	2.09	0.71	0.33
Depth (m)	8.22	7.99	7.01	6.07	6.07	3.96	8.89	4.52	4.52	4.57	5.16	5.16
Lead	0.02	0.03	0.07	0.01	0.01	0.03	0.07	0.05	0.03	0.02	0.01	0.01
Total suspended solids	1	5	7	3	6	4	1.2	1.1	1.5	1.11	1.3	1

PARAMETERS (mg/L)	APRIL, 2010						MAY, 2010					
	A	B	C	D	E	F	A	B	C	D	E	F
Transparency (m)	0.6	0.59	0.74	0.48	0.48	0.37	0.36	0.43	0.43	0.43	0.43	0.46
Conductivity (mS/cm)	11.32	13.15	13.04	11.86	10.42	3.15	0.07	0.1	0.04	0.04	0.04	0.02
pH	7.6	7.6	7.5	7.4	7.4	7.4	7.6	7.3	7	6.8	6.7	6.7
Phosphate-phosphorus	5.6	4.02	2.2	1.7	2.1	1.6	4.4	5.7	3.8	2.9	1.8	1.9
Sulphate	23.4	16.1	11.7	9.2	7.2	6.5	22.5	15.6	10.7	8.2	6.4	5.7
Nitrate-nitrogen	17.2	16.9	15.7	13.7	11.5	9.9	15.4	17.3	16.4	12.4	11.9	9.9
Silicate	0.7	0.55	0.45	0.33	0.25	0.19	0.5	0.42	0.55	0.4	0.3	0.2
Copper	6.9	5.7	5.5	4.2	3.4	2.7	7.1	6.2	5.7	5.9	4.4	3.6
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved oxygen	5.2	5.1	5.4	5.2	4.8	4.5	4.4	4.6	5	5.1	4.5	4.3
Biology oxygen demand	9	12	10	7	12	11	13	12	8	9	12	10
Chemical oxygen demand	13	15	16	14	15	19	20	25	11	13	22	24
Chlorophyll *a*	0.02	0.02	0.01	0.02	0.01	0.02	0.02	0.01	0.01	0.01	0	0.01
Salinity (0/00)	8	6	6	5	5	2	0	0	0	0	0	0
Surface water temperature (0C)	32.2	32.6	32.3	31.6	31.9	31.2	29	29.3	28.1	27.5	27.6	28.1

Total dissolved solute	5.67	6.63	6.5	5.9	5.2	1.72	0.15	0.2	0.09	0.09	0.08	0.04
Depth (m)	7.63	6	7.52	7.52	4.73	6	3.16	6.13	6	4.63	4.6	4.51
Lead	0.04	0.03	0.04	0.02	0.03	0.03	0	0.01	0.03	0	0.1	0.04
Total suspended solids	1.4	1.3	1	1.2	1.5	2.2	2.5	2	2.4	1.5	2.2	2

PARAMETERS (mg/L)	**JUNE, 2010**						**JULY, 2010**					
	A	**B**	**C**	**D**	**E**	**F**	**A**	**B**	**C**	**D**	**E**	**F**
Transparency (m)	0.45	0.46	0.44	0.56	0.52	0.48	0.52	0.63	0.61	0.58	0.71	0.66
Conductivity (mS/cm)	0.55	0.49	0.35	0.18	0.12	0.07	0.11	0.17	0.16	0.12	0.1	0.08
pH	8.4	8.4	8.3	8.1	8.1	7.9	8.2	8	7.8	7.6	7.5	7.6
Phosphate-phosphorus	3	4.5	3	2.2	2.3	2.5	0.23	3.5	0.22	0.34	0.45	0.56
Sulphate	15.7	14.2	11.5	9.2	7.7	4.5	9	7	6	7.7	6.6	8
Nitrate-nitrogen	12.4	13.5	12	9.4	7.5	6.6	3.4	4.4	4.7	3.9	4.9	0.55
Silicate	0.3	0.32	0.37	0.2	0.32	0.22	0.33	0.05	0.02	0.02	0.04	0.06
Copper	5.2	4.4	4.6	5	4.7	4.9	2.24	1.76	1.66	1.59	1.7	1.69
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved oxygen	5	5.1	5.3	5	5	5.2	5.6	5.2	5	5.1	4.9	4.8
Biology oxygen demand	9	11	8	7	8	9	9	8	10	8	9	10
Chemical oxygen demand	12	14	13	10	15	19	11	10	12	13	12	14
Chlorophyll *a*	0.02	0	0.01	0.01	0	0.01	0.02	0.01	0.01	0.02	0.01	0.15
Salinity (0/00)	0	1	0	0	0	0	1	0	0	0	0	0
Surface water temperature (0C)	26.8	28.8	26.5	26.3	20.9	27.2	27.2	27.2	26.9	26.5	26.2	25.9
Total dissolved solute	0.27	0.24	0.17	0.09	0.03	0.03	0.05	0.08	0.08	0.06	0.05	0.05
Depth (m)	9.24	6.84	6.06	6.06	5.54	3.63	6.19	6.68	6.62	6.28	4.1	2.63
Lead	ND	0	0.01	0	0.01	0.02	ND	ND	ND	ND	ND	ND
Total suspended solids	1	1.1	1.2	1	1.1	1	1	1	1	1.1	1.2	1.3

PARAMETERS (mg/L)	**AUGUST, 2010**						**SEPTEMBER, 2010**					
	A	**B**	**C**	**D**	**E**	**F**	**A**	**B**	**C**	**D**	**E**	**F**
Transparency (m)	0.46	0.51	0.6	0.41	0.66	0.55	0.65	0.71	0.72	0.66	0.74	0.68
Conductivity (mS/cm)	0.01	0.15	0.13	0.13	0.05	0.08	0.17	0.12	0.06	0.05	0.12	0.06
pH	7.8	7.5	7.3	7.3	7.1	7	6.36	6.79	6.78	6.74	6.71	6.6
Phosphate-phosphorus	0.21	0.39	0.1	0.23	0.36	0.36	0.22	0.25	0.11	0.19	0.27	0.25
Sulphate	0.14	0.14	0.18	0.16	0.16	0.13	0.08	0.08	0.07	0.06	0.08	0.07
Nitrate-nitrogen	2.2	3.7	2.7	2.9	1.7	3.3	1.2	2.6	1.6	1.7	1.2	2.2
Silicate	0.04	0.03	0.03	0.01	0.05	0.04	0.02	0.01	0.02	0.03	0.02	0.03
Copper	3.12	1.6	1.24	1.49	1.9	1.8	2.1	1.2	1.12	1.3	1.5	1.4
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved oxygen	5.1	5.2	5.1	5	5.3	5.2	5.2	5	5.2	5.1	5.2	5
Biology oxygen demand	7	6	8	7	9	8	8	7	7	8	8	7
Chemical oxygen demand	12	10	13	11	14	13	10	9	12	9	12	10
Chlorophyll *a*	0.001	0.009	0.011	0.024	0.015	0.002	0.002	0.005	0.013	0.015	0.012	0.003
Salinity (0/00)	0	0	0	0	0	0	0	0	0	0	0	0
Surface water temperature (0C)	26.5	27.5	26.2	27.3	27.5	28.4	26.3	27.7	26.8	27.5	26.6	27.4

Total dissolved solute	0.02	0.04	0.03	0.01	0.02	0.05	0.02	0.01	0.03	0.04	0.03	0.03
Depth (m)	5.12	6.21	5.43	3.35	2.16	4.12	7.23	6.45	4.45	3.98	5.55	6.72
Lead	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total suspended solids	2.2	2.3	1.2	2.4	2.5	1.3	1.2	1.1	1	1.3	1.5	1.1

	OCTOBER, 2010						**NOVEMBER, 2010**					
PARAMETERS (mg/L)	**A**	**B**	**C**	**D**	**E**	**F**	**A**	**B**	**C**	**D**	**E**	**F**
Transparency (m)	0.74	0.75	0.67	0.56	0.77	0.83	0.73	0.71	0.67	0.68	0.67	0.67
Conductivity (mS/cm)	0.17	0.03	0.01	0.04	0.07	0.19	0.16	0.11	0.09	0.08	0.06	0.06
pH	6.2	6.66	6.8	6.41	6.68	6.61	6.45	6.53	6.53	6.83	6.42	6.65
Phosphate-phosphorus	0.2	0.13	0.07	0.12	0.17	0.14	0.03	0.01	0.02	0.04	0.06	0.02
Sulphate	0.1	0.12	0.07	0.1	0.12	0.1	0.11	0.15	0.12	0.14	0.16	0.13
Nitrate-nitrogen	0.63	0.62	0.81	1.46	1.15	1.85	0.06	0.04	0.02	1.22	1.1	1.5
Silicate	0.02	0.01	0.02	0.02	0.02	0.02	0.01	0.013	0.014	0.002	0.006	0.004
Copper	1.67	1.6	1.13	1.25	1.85	1.35	1.23	1.1	1.14	1.2	2.2	1.3
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved oxygen	5.1	5.2	5.1	5.1	5.1	5	5	5.1	5	5.1	5	5
Biology oxygen demand	9	9	8	8	9	8	10	11	10	9	10	9
Chemical oxygen demand	11	11	12	11	13	12	12	13	12	12	13	14
Chlorophyll *a*	0.001	0.009	0.008	0.01	0.011	0.008	0.002	0.012	0.003	0.004	0.01	0.013
Salinity (0/00)	0	0	0	0	0	0	0	0	0	0	0	0
Surface water temperature (0C)	26.4	27.9	26.7	27.6	26.5	27.4	27.6	27.6	27.5	27.2	26.8	26.9
Total dissolved solute	0.06	0.08	0.07	0.08	0.03	0.02	0.08	0.06	0.04	0.04	0.03	0.03
Depth (m)	3.36	4.98	5.23	7.65	4.66	8.42	7.5	7.01	6.49	5.22	4.87	3.34
Lead	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total suspended solids	1.1	1.1	1.6	1.2	1.4	1.1	1	1.1	2.1	1.1	1.3	1

PARAMETERS (mg/L)	DECEMBER, 2010						JANUARY, 2011					
	A	B	C	D	E	F	A	B	C	D	E	F
Transparency (m)	1.1	0.81	0.82	0.86	0.76	0.83	0.92	0.76	0.75	1.77	0.72	0.75
Conductivity (mS/cm)	2.34	1.64	0.01	1.81	1.42	0.39	11.45	6.5	12.62	6.31	3.13	5.44
pH	7.1	7.1	7.1	7	7.2	7.2	7	7.1	7.2	7	7.1	7
Phosphate-phosphorus	0.13	0.23	0.22	0.09	0.19	0.01	0.68	0.8	1.3	0.28	1.5	0.31
Sulphate	0.17	0.21	0.16	0.08	0.07	0.2	6.12	7.5	8	2.87	1.35	2.13
Nitrate-nitrogen	1.2	1	1.3	1.6	1.2	1.1	0.63	0.52	0.66	1.41	1.15	1.3
Silicate	0.03	0.04	0.02	0.02	0.04	0.03	0.15	0.1	0.3	0.02	0.03	0.02
Copper	1.2	1.1	1.9	1.02	1.7	1.6	1.21	1.1	1.52	1.11	1.95	1.45
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved oxygen	5.4	5.4	5.2	5.3	5.5	5.1	5.2	5.25	5.1	5.2	5.3	5.05
Biology oxygen demand	11	9	8	9	10	9	10	11	9	9	10	9
Chemical oxygen demand	13	11	12	13	14	16	12	11	13	15	8	14
Chlorophyll *a*	0.001	0.003	0.002	0.003	0.004	0.001	0.002	0.001	0.002	0.003	0.002	0.012
Salinity (0/00)	5	3	3	2	1	0	8	8	7	8	5	3
Surface water temperature (0C)	25.8	25.9	25.9	25.7	25.4	25.8	31.2	29.3	30.1	28.8	30.1	29.9
Total dissolved solute	2.72	0.8	0	0.91	0.69	0.2	5.23	3.21	4.21	1.21	2.62	5.02
Depth (m)	8.57	6.12	5.77	5.71	4.11	2.23	7.35	8.13	8.22	6.21	7.23	1.54
Lead	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total suspended solids	1	1.5	2	2.1	2	2.2	2	1	5	8	7	3

ND = not detected

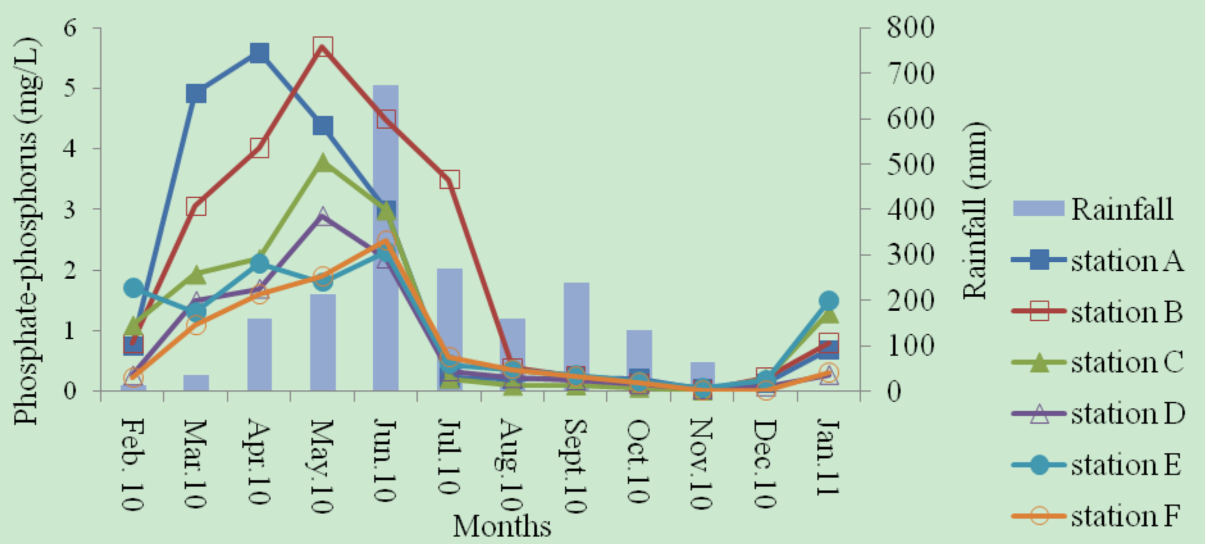

Figure 2. Relationship between Rainfall and Phosphate-phosphorus in all stations throughout the sampling period.

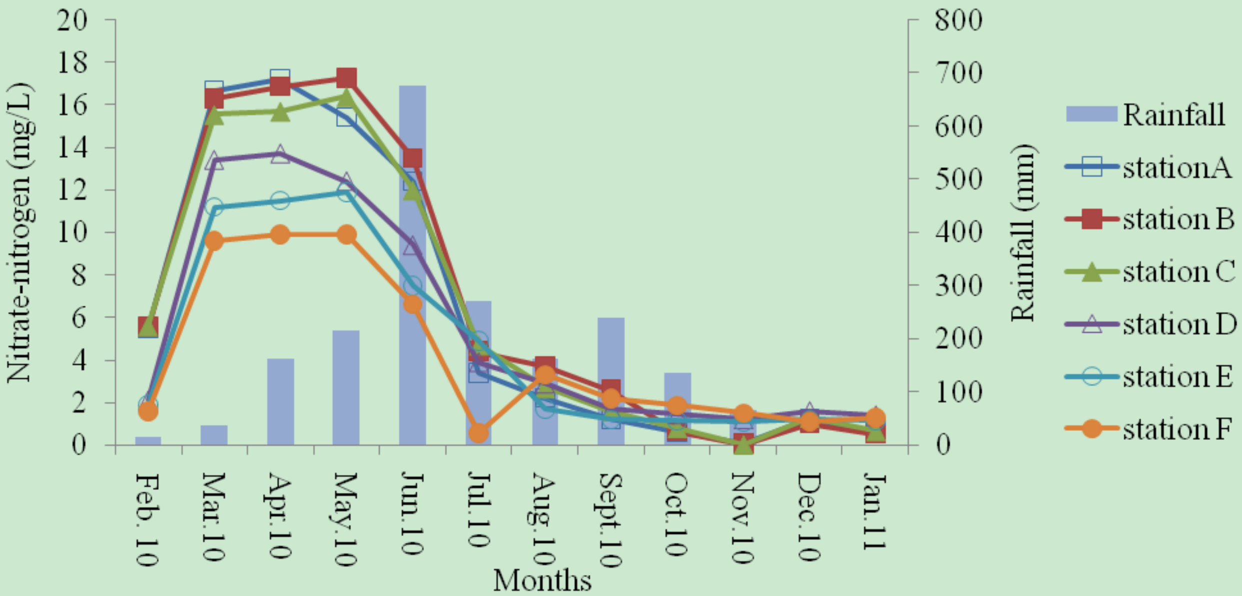

Figure 3. Relationship between Rainfall and Nitrate-nitrogen in all stations throughout the sampling period.

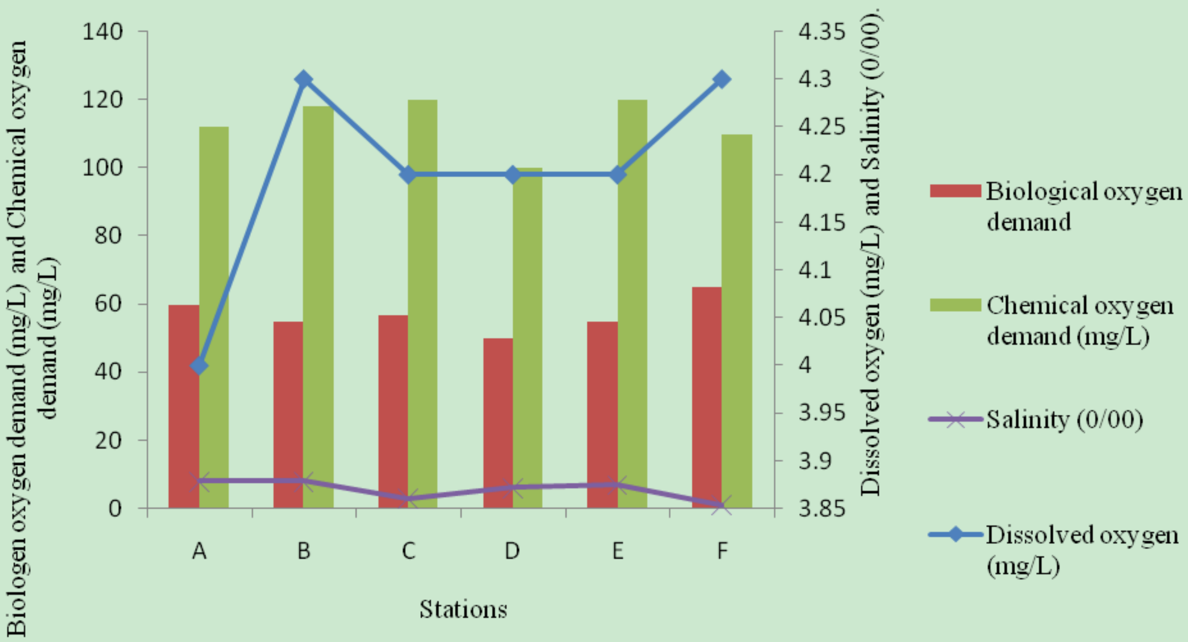

Figure 4. Variations in Biological oxygen demand, Chemical oxygen demand, Dissolved oxygen and Salinity for February 2010 in all stations.

3.2 Biological Samples

A total of 222 taxa belonging to 61 genera were observed in this study. Bacillarophyta, Cyanophyta, Chlorophyta, and Euglenophyta are the four divisions represented in the creek. Highest species diversity (6.7) was recorded in July 2010 at station D while station A in June 2010 (Figure 5) had the lowest species diversity (0.9). The highest and lowest Shannon-weiner index values (3.35 and 0.41) were recorded in July 2010 (station D) and October 2010 (station C). The species evenness was highest (0.96) in June 2010 at station D (Figure 5) while the lowest value (0.2) was recorded at station C in August 2010 and October 2010 (Figure 5). The phytoplankton biomass of the creek was dominated by diatoms, followed by green algae, blue-green and euglenoids (Figure 6).

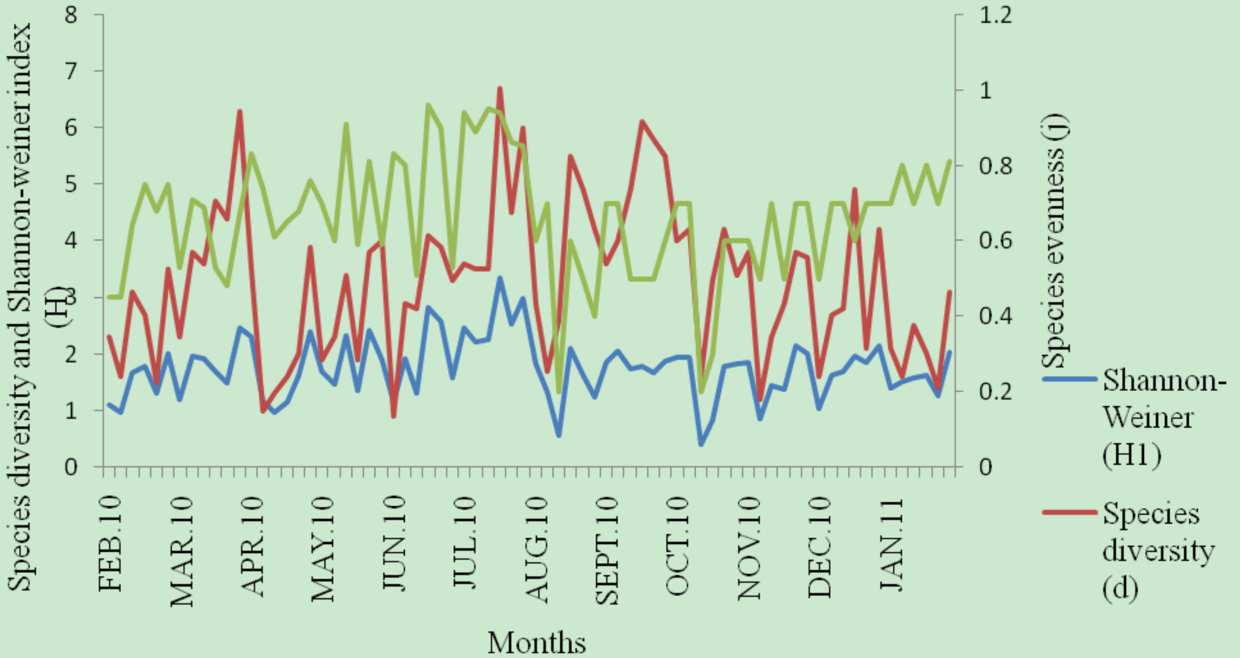

Figure 5. Relationship between species diversity, Shannon-weiner index and species evenness at Majidun creek.

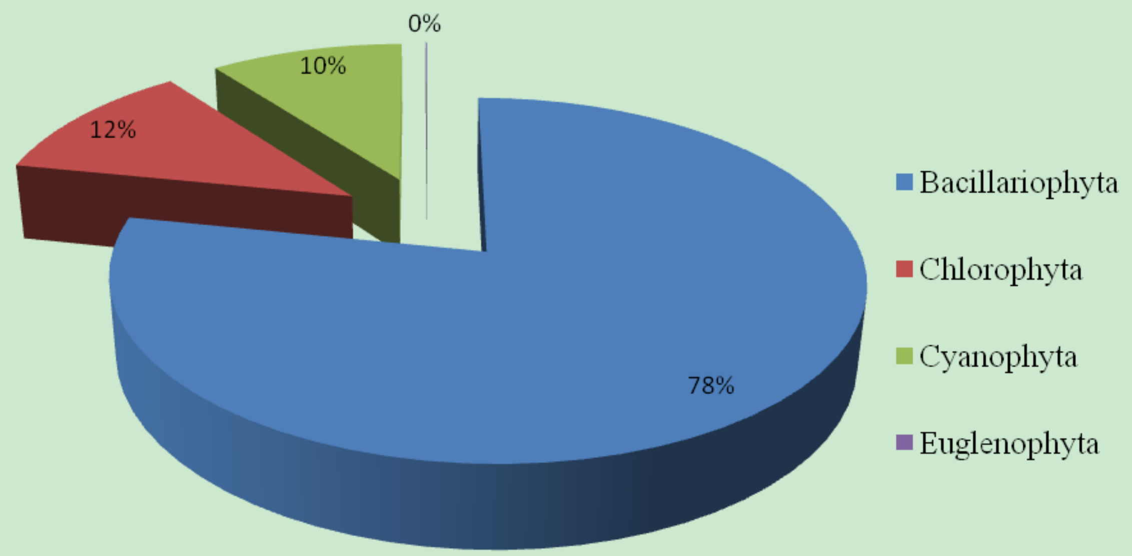

Figure 6. The phytoplankton biomass in sampling sites along the Majidun creek.

4. Discussion and Conclusion

Phosphate-phosphorus and Nitrate-nitrogen values were higher in dry months. This observation at Majidun creek is supported by earlier report by Adesalu *et al.*, (2010) who worked on Tomaro and Ajegunle creek of the Lagos lagoon and associated the decrease in nutrients to high rainfall in wet season. The higher values of nutrients recorded in the dry months could also be as a result of difference in evaporation and precipitation rate. As observed, there was an increase in the phosphate-phosphorus values (0.23mg/L to 5.7mg/L) and nitrate-nitrogen values (1.6mg/L to 17.3mg/L) from February 2010 to May 2010 when rainfall pattern was between 14.3mm to 215mm, but an increase in rainfall value (676mm) in June 2010 led to a rapid and continuous decrease in the nutrients value of the creek. However, the nutrients values rose again in December 2010 and January 2011 when there was no rainfall at all. High levels of phosphate-phosphorus values (4.4mg/L, 5.7mg/L, 1.9mg/L) and nitrate-nitrogen values (15.4mg/L, 17.3mg/L, 9.9mg/L) recorded in May 2010 at stations A, B and F accounts for the high phytoplankton abundance of these stations. This observation favored the proliferation of diatoms in the creek and it is supported by Blum (1957) and Adesalu *et al.*, (2010) who reported that diatoms are favored in nutrients rich environment particularly nitrates. Nwankwo (2004) also stated that high levels of nutrients usually give rise to high abundance of some micro algal species in aquatic water environments.

According to Kirk and Lauder (2000), the solar irradiation available controls the increase and decrease in dissolved oxygen levels in lagoons throughout the day. The higher dissolved oxygen values recorded at Majidun creek during wet season is contrary to the observation of

Chindah (2003; 2004) who worked on a tropical estuary in Niger delta. The decrease in dissolved oxygen values at the study site as salinity increased is similar to the observation of Adesalu *et al.*, (2010) who worked on Tomaro and Ajegunle creek and suggested that the trend might probably be as a result of domestic sewage from various activities of human residing around the study area and the reception of effluents containing oxygen-demanding substances. Chapman (1992) also stated that the solubility of oxygen decreases as salinity increases. The higher salinity values in dry months (February-April) are in relation to the high rate of evaporation from water bodies; however, salinity values were very low in the rainy season and this observation is in line with Adesalu *et al.*, (2008b). It was observed that there was an increase in conductivity as salinity increased at the study site. Similar observation has been recorded by some workers (Brown, 1972; Pauly, 1975; Ogbeibu and Egborge, 1995; Adesalu *et al.*, 2010). Biological oxygen demand (BOD) values and chemical oxygen demand (COD) values recorded at the creek in all stations were high (>50mg/L and >100mg/L respectively) in February 2010. Similar to the observation of Adesalu *et al.*,, (2010) at Ajegunle creek, the biological oxygen demand and chemical oxygen demand values recorded in Majidun creek increased as dissolved oxygen decreases; Briton *et al.*,, (2007) also observed low values of dissolved oxygen in Abijan lagoon and suggested that it might be due to the presence of strong contents of suspended matter reducing the quantity of oxygen via oxidation reaction.

The highest Shannon-weiner index value (3.35) was recorded in July 2010 (station D), this consequently resulted in the highest species diversity value (6.7) recorded in July 2010 at station D (Figure. 10). This observation is in line with the earlier work reported by Dash (1996) that the higher the value of Shannon- weiner index (H^1) the greater the phytoplankton diversity. The highest chlorophyll *a* value (0.15) was also recorded in July (station F); it was also observed that Shannon-weiner index values were higher in July 2010 in all stations and this concise with the higher Chlorophyll *a* values recorded in July 2010, whereas, lower values of Shannon-weiner index and Chlorophyll *a* where recorded in February 2010 in all stations. This observation at the creek suggests that the higher the value of Chlorophyll *a* the higher the Shannon-weiner index value recorded.

The dominance of diatoms at the study site is similar to the observation of Nkwankwo *et al.*, (2003) and Adesalu *et al.*, (2010) who stated that this might be due to their wholly planktonic and neritic nature. According to Adesalu *et al.*, (2010), the presence of more bottom dwelling forms (pennate) than the truly planktonic forms (centric) may be as a result of continuous dredging of the study site. This observation has earlier been reported by Nwankwo (1986, 1991) in the Lagoons of South western Nigeria, Nwadiro (1990) in Chanomi creek system of the Niger Delta, Chindah and Pudo (1991) in Bonny River, Erondu and Chindah (1991) in new Calabar River, Ohimain (2004), Adesalu *et al.*, (2008) and Davies *et al.*, (2009). Some of the more abundant diatoms recorded in the area are *Synedra* sp, *Tabellaria fenestrata, Navicula radiosa, Fragilaria* sp, *Fragilaria virenscens, Bacillaria paxillifer, Asterionella formosa*.

Blue-green algae were also observed in the study area where mostly filamentous forms and *Oscillatoria formosa* was the most abundant species which was followed by *Oscillatoria* *limosa*. According to Nwankwo (2004), the filamentous forms of blue-green algae found in the study site could be opportunistic forms which by biomodification of physical process usually proliferate at the advantage of other species. Adesalu *et al.*, (2008) also stated that the presence of *Oscillatoria limosa* might indicate that the site is organically polluted. Some green algae recorded in the study site were *Cosmarium* sp, *Spirogyra* sp, and *Closterium* sp. The presence of *Spirogyra* sp has been reported to indicate the eutrophic nature of water bodies (Bajpai and Agarkar, 1997; Adesalu and Nwankwo, 2008).

The Division Euglenophyta was only represented by three genera namely: *Euglena*, *Phacus* and *Trachelomonas*. The presence of *Euglena, Phacus and Closterium* is also a pointer to the fact that Majidun creek is organically polluted (Palmer 1969, Munawar, 1972).

Shannon-weiner index, species diversity and species evenness were generally higher in wet months than in dry months. Phosphate-phosphorus and nitrate-nitrogen values were higher in stations A, B and C because these stations were closer to human settlement where anthropogenic wastes were discharged directly into the creek. However, community structure was higher in stations (D, E and F) with lower levels of nitrate-nitrogen and phosphate-phosphorus; this observation might be as a result of the tidal mixture that the creek undergoes.

It would be necessary to conclude that most of the species observed in the study site showed that the site is organically polluted probably as a result of indiscriminate discharge of municipal waste in the water body. The creek has probably been prevented from epidemiological outbreak as a result of the semi-diurnal oscillation it undergoes, which results in the dilution of the creeks polluted waters (at high tide) and the eventual out flowing (at low tide) to the sea (Adesalu *et al.*, 2010). However, dredging and sand mining activities should be discouraged in the study site in order to enhance its phytoplankton biodiversity.

References

Adesalu, T. A, Abiola, T. O., & Biofa, T. O. (2008b). Studies on the epiphytic algae associated with two floating aquatic macrophytes in a sluggish non-tidal polluted creek in Lagos, Nigeria. *Asian Journal of Scientific Research, 1*(4), 363-373. http://dx.doi.org/10.3923/ajsr.2008.363.373

Adesalu, T. A, Bagbe, M., & Keyede, D. (2010). Hydrochemistry and phytoplankton composition of two tidal creeks in south-western Nigeria. *International Journal of Tropical Biology*, *58*(3), 827-840.

Adesalu, T. A., & Nwankwo, D. I. (2005). Studies on the phytoplankton of Olero creek and parts of Benin River, Nigeria. *The Ekologia*, *3*(2), 21-30.

Adesalu, T. A., & Nwankwo, D. I. (2008). Effect of water quality indices on phytoplankton of a sluggish tidal creek in Lagos, Nigeria. *Pakistan Journal of Biological Sciences*, *11*(6), 836-844. http://scialert.net/abstract/?doi=pjbs.2008.836.844

Adesalu, T. A., & Nwankwo, D. I. (2010). A checklist of desmids of Lekki lagoon, Nigeria. *International Journal of Biodiversity and Conservation*, *2*(3), 33-36.

Adesalu, T. A., &Nwankwo, D. I. (2009). A checklist of Lekki lagoon diatoms. *International Journal of Botany*, 5(2), 126-134. http://scialert.net/abstract/?doi=ijb.2009.126.134

Ajao, E. A. (1985). *The influence of domestic and industrial effluent on populations of sessile and benthic organisms in Lagos lagoon.* Ph.D Thesis, University of Ibadan. 411p.

APHA. (1998). *Standard method for the examination of water and waste-water*. 20th edition. Washington D. C. 1213p.

Blum, J. L. (1957). An ecological study on Algae of the saline siver, Michigan. *Hydrobiology, 9,* 361-408.

Briton, B. I., Yao, B., & Ado, G. (2007). Evaluation of the Abijan lagoon pollution. *Journal of Applied Science and Environmental Management, 11*(2), 173-179. http://dx.doi.org/10.4314/jasem.v11i2.55030

Brown, G. I. (1972). *Introduction to physical chemistry*. Longman, United Kingdom. 508p

Chapman, D. (1992). Water quality assessment. A guide to the use of biota, sediments and water in environmental monitoring. Chapman on Behalf of UNESCO, WHO and UNEP. Chapman & Hall, London, England.

Chindah A. C. (2003).The physico-chemistry, phytoplankton and periphyton of a swam forest stream in the lower Niger Delta. *Scientia Africana*, *1*(2), 1-15.

Chindah, A. C, & Pudo, J. K. (1991). A premilinary checklist of algae found in plankton of Bonny River in Niger Delta, Nigeria. *Fragment Flora Geobotanical*, *36*(1), 117-126.

Chindah, A. C. (2004). Response of periphyton community to salinity gradient in tropical estuary, Niger Delta. *Pollution Journal of Ecology*, *52*(1), 83-89.

Dash, M. C. (1996). *Fundamentals of ecology*. 3rd edition. Tata McGraw Hill Publishing Company Limited, New Delhi. 543p.

Davies, O. A., Abowei, J. F. N, & Tawari, C. C. (2009). Phytoplankton community of Elechi creek, Niger Delta, Nigeria. A nutrient polluted tropical creek. *American Journal of Applied Sciences*, *6*(6), 1143-1152. http://doi 10.3844/ajassp.2009.1143.1152

Davies, O. A., Abowei, J. F. N., & Otene, B. B. (2009). Seasonal abundance and distribution of plankton of Minichinda stream, Niger Delta, Nigeria. *American Journal of Scientific Research*, *2*, 20-30.

Edokpayi, C. A., & Nkwoji, J. A. (2007). Annual changes in the physic-chemistry and macro-benthic invertebrate characteristics of the Lagos lagoon sewage dump site at Iddo, Southern Nigeria. *Ecology, Environment and Conservation. 13*(1), 13-18.

Erodu, E. S., & Chindah, A. C. (1991). Physico-chemical phytoplankton changes in a tidal freshwater station of the New Calabar River South Eastern Nigeria. *Environment and Ecology*, 9(3), 561-570.

Finlayson, C. M., Gordon, C., Nitiamoa-Baidu, Y., Tumbulto, J., & Storrs, M. (2000). Hydrobiology of the Songor and Keta lagoons: implications for wetland management in Ghana. *Environmental Research Institute of the Supervising Scientist*, *11*, 379- 386.

Ghosal, S., Rogers, M., & Wray, A. (2000). *The turbulent life of phytoplankton*. Standford University Press, Standford. p 13-45.

Kirk, R. M., & Lauder, G. A. (2000). Significant coastal lagoon systems in the South Island, New Zealand. Coastal processes and lagoon mouth closure. *Science for Conservation*, *146*, 1-47.

Krammer, K., & Bertalot, H. (2000). Bacillariophyceae. Berlin. 482pp.

Margalef, R. (1970). *Perspective in Ecological Theory*. University of Chicago Press. Chicago.111p.

Munawar, M. (1972). Ecological studies of euglenincae in certain polluted and unpolluted environments. *Hydrobiology*, *39*, 307-320. http://dx.doi.org/10.1007/BF00046647

Nkwoji, J. A., Onyema, I. C., & Igbo, J. K. (2010). Wet season spatial occurrence of phytoplankton and zooplankton in Lagos lagoon, Nigeria. *Science World Journal*, *5*(2), 7-14. http://dx.doi.org/10.4314/swj.v5i2.61487

Nwankwo, D. I. (1984). *Seasonal changes of phytoplankton of Lagos lagoon and the adjacent sea in relation to environmental factors*. Ph.D. Thesis, University of Lagos, Lagos, Nigeria.

Nwankwo, D. I. (1986). Phytoplankton of a sewage disposal site in Lagos lagoon, Nigeria. *Nigeria Journal of Biological Sciences*, *1*, 89-91.

Nwankwo, D. I. (1991). A survey of the dinoflagellates of Nigeria I. Armoured dinoflagellates of Lagos lagoon and associated tidal creeks. *Nigerian Journal of Botany*, *4*, 49-60.

Nwankwo, D. I. (1993). Cyanobacteria bloom species in coastal waters of South-western Nigeria. *Archiv. Hydrobiologie Supplement*, *90*, 553-542.

Nwankwo, D. I. (1996). Phytoplankton diversity and succession in Lagos lagoon. *Archiv Fur Hydrobiologia*, *135*(4), 529-542.

Nwankwo, D. I., & Akinsoji, A. (1988). Periphyton algae of Eutrophic creek and their possible use as indicator. *Nigeria Journal of Botany*, *1*, 47-54.

Nwankwo, D. I., Onyema, I. C., & Adesalu, T. A. (2003). A survey of harmful algae in coastal waters of south western Nigeria. *Journal of Nigeria Environmental Society*, *1*, 241-246.

Nwankwo. D. I. (2004). Studies on the Environmental preference of blue-green algae (cyanophyta) in Nigeria coastal waters. *Nigeria Environmental Society Journal*, *2*, 44-51.

Nyananyo, B. L., Okeke, C. U., & Mensah, S. I. (2006). Physico-chemical conditions and distribution of phytoplankton in the Brass River, Nigeria. *Journal of Applied Science and Environmental Management*, *10*(1), 43-45. http://dx.doi.org/10.4314/jasem.v10i1.17302

Odum, E. P. (1977). The emergence of ecology as a new integrative discipline. *Science*, *195* (4284), 1289-1293. http://dx.doi.org/10.1126/science.195.4284.1289

Ogbeibu, A. E., & Egborge, A. B. M. (1995). Hydrobiological studies of water bodies in the Okomu Forest Reserve (Santuary) in southern Nigeria, distribution and diversity of the invertebrate fauna. *Tropical Freshwater Biology*, *4*, 1-27.

Ohimain, E. I. (2004). Environmental impacts of dredging in the Niger Delta. *Terra et Aqua*, *97*, 9-19.

Okusipe, O. M. (2004). Lagos lagoon coastal profile: Information database for planning theory. Lagos State Environment Report.

Olaniyan, C. I. O. (1975). The seasonal variation in the hydrological and total plankton of the lagoons of South-Western Nigeria. *Nigerian Journal of Marine Research*, *8*, 36-59.

Oyema, I. C. (2008). A checklist of phytoplankton species of the Iyagbe lagoon, Lagos. *Journal of Fisheries and Aquatic Science*, *3*(3), 167-175.

Palmer, C. M. (1969). A composite rating of algae tolerating pollution. *Journal of Phycolog*, *5*, 8-82. http://dx.doi.org/10.1111/j.1529-8817.1969.tb02581.x

Pauly, D. (1975). On the ecology of a small West African lagoon. *Berichte der Deutschen Wissenschaflichen Kommmission fur Meeresforschung*, *24*(1), 46- 62.

Pielou, E. C. (1975). The measurement of diversity types of biological collections. *Journal of Theoretical Biology*, *13*, 131-144.

Saliu, J. K., & Ekpo, M. P. (2006). Preliminary chemical and biological assessment of Ogbe creek, Lagos, Nigeria. *West Africa Journal of Applied Ecology*, *9*, 14-22. http://dx.doi.org/10.4314/wajae.v9i1.45685

Shannon, C. E., & Weiner, W. (1963). *The mathematical theory of communication*. University of lllinois Press, Urbans. 125p.

Suthers, I. M., & Rissik, D. (2009). *A Guide to their Ecology and Monitoring for Water Quality*. 2nd edition. CSIRO Publishing, Collingwood Victoria. 272p.

Webb, J. E. (1958). The Ecology of Lagos lagoon I. The lagoons of the Guinea Coast. *Philosophical Transactions of the Royal Society B:Biological Sciences*, *241*, 307-317. http://dx.doi.org/10.10982/rstb.1958.0005

Whitford, L. A., & Schumacher, G. J. (1973). *A manual of fresh water algae*. Sparks Press, Raleigh. 574p.

Glossary

Biological Oxygen Demand (BOD): a measure of the quantity of oxygen used by microorganisms in the oxidation of organic matter.

Chemical Oxygen Demand (COD): used as a measure of oxygen requirement of a sample that is susceptible to oxidation by strong chemical oxidant.

Creek: narrow inlet in a coastline.

Euphotic zone: the depth of the water in a lake or ocean that is exposed to sufficient sunlight for photosynthesis to occur.

Hypereuthrophic: very nutrient-rich lakes characterized by frequent and severe nuisance algal bloom and low transparency.

Macrophytes: conspicuous plants that dominate wetlands, shallow lakes and streams.

Phytoplankton: microscopic plants that live in moist environment, both marine and fresh.

Plankton net: a device used in the collection of plankton.

Secchi disc: a circular disk, painted alternately black and white, used to measure water transparency in oceans and lakes.

Zooplankton: microscopic animals that live in moist environment, both marine and fresh.