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MICROALGAL COMMUNITIES IN THE RIPARIAN SYSTEMS ASSOCIATED WITH LAGOS LAGOON, NIGERIA II. ECOLOGICAL STUDY OF PHYTOPLANKTON FROM ITO-IWOLO CREEK, SOUTH-WEST, NIGERIA

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Abstract

A study on indigenous microalgae from sluggish tidal freshwater/brackish mangrove dominated creeks(Ito-Iwolo) emptying into Lagos Lagoon was carried out for twelve months (February 2010 - January 2011).Samples were obtained using a 55 µm plankton net towed at low speed for 10 minutes. Various physico-chemical parameters were monitored; surface water temperature, PO_4-P, transparency, NO_3-N, SO_4^{2-} and silica concentrations. All measured chemical parameters were lower in the rainy season while surface water pH ranged from slightly acidic to alkaline (6.42–8.70), chlorophyll 'a' showed its highest value 0.013µg/l in the dry season. There was a remarkable change in seasonal salinity values (14.90‰ and 0.10‰) while conductivity values ranged between 0.01 and 20.00 (mS/cm) in raining and dry seasons, respectively. Microalgal flora was dominated by diatoms, which comprised of 85% of the total phytoplankton population with 75 species from 32 genera. Chlorophyta, recorded 9% and was represented by 31 species from 12 genera, while Cyanobacteria (4%) comprising of 17 species from 8 genera, and Euglenophyta, represented by one genus with 4 species recorded 2% of the total phytoplankton population.

Key Words: *Creeks, Microalgae, Ito-Iwolo, Lagos lagoon, Water chemistry*

Introduction

The productivity of any water body is determined by the amount of plankton it contains as they are the major primary and secondary producers (Davies *et al*., 2009). Davies et al. (2009) also reported that phytoplankton communities are major producers of organic carbon in large rivers, a food source for planktonic consumers and may represent the primary oxygen source in low-gradient rivers. The distributions, abundance, species diversity, species composition of the phytoplankton are used to assess the biological integrity of the water body (Townsend *et al*., 2000) as cited by Ezekiel *et al.* (2011).

Phytoplankton are limited to the uppermost layers of the aquatic ecosystem where light intensity is sufficient for photosynthesis to occur. Other limitations to growth are nutrients such as nitrates and phosphate, which are prevalent in aquatic ecosystem.

Temperature acts along with other factors in influencing the variation of photosynthetic production. Generally, the rate of photosynthesis increases with an increase in temperature, but diminishes sharply after a point is reached. Each species of phytoplankton is adapted to temperature. Phytoplankton serves as very good conductors of environmental condition within the aquatic environment in that they are simple, capable of quantifying changes in water quality, applicable over a large geographical area, can furnish data on background conditions and natural variability and especially sensitive to changes in nutrient levels and other water quality conditions (Adesalu *et al*., 2008).

The Nigerian coastline is inundated with bays, creeks, estuaries and lagoons. The bays and lagoons are confined to the southern part of the country, while the estuaries form prominent features of the Niger Delta and the southern parts. The lagoons and creeks of southwestern Nigeria are linked to the sea through the Lagos harbor (Nwankwo and Akinsoji, 1992). The vegetation of the Nigerian coastal area is also characterized by mangrove forests, brackish swamp forests and rain forests. The Nigerian coastal zone experiences a tropical climate consisting of raining season (May-November) and dry season (December- April). The lagoon system and creeks experience seasonal flooding that introduces many detritus; nutrients as well as land based potential environmental pollutants due to the seasonal distribution of rainfall. They are also linked to the sea via the Lagos harbor that remains open all year long (Nwankwo and Akinsoji, 1992). Ecological studies in the Lagos lagoon, which is part of the largest lagoon system of South- western Nigeria, stretching from Cotonou to the Niger Delta (Hill and Webb, 1958) started over seven decades ago. Recent phytoplankton studies of some creeks in South-west Nigeria include; Adesalu and Nwankwo (2005, 2008) on Olero and Abule-Eledu creeks respectively; Adesalu *et al*. (2008) on Ogbe creek; Emmanuel and Onyema (2007) on the Abule-Agege creek; Adesalu *et al*. (2014) on Ipa-Itako creek, Adesalu and Olayokun (2011) on Agboyi creek, Adesalu and Kunrunmi (2012, 2016) on Majidun creek. Two prominent factors, fresh water discharge from rivers, creeks and storm water channels and tidal sea water incursion influence the physical, chemical and biological characteristics of the lagoon. At higher tide, sea water enters the lagoon from the Atlantic Ocean via the Harbor and Five Cowries creek, while at low tide, the water recedes (Nwankwo *et al*., 2012). Creeks are common hydrological features in South-Western Nigeria and are essentially of two types. The tidal freshwater/brackish creeks surrounded partly by mangrove swamps and partly by freshwater swamps from points beyond the reach of tidal influence and the non-tidal freshwater creeks, surrounded by freshwater swamps and usually infested with aquatic macrophytes all through the year (Adesalu and Nwankwo, 2005).

Materials and Methods

Description of Study Site

Ito-Iwolo creek (Figure 1) is in the South eastern part of the Lagos lagoon, in the Ikorodu area of Lagos state. The creek is an adjoining creek to the Lagos lagoon and receives the influence of tides semi-diurnally; hence it is tidal creek with the shore characterized by aquatic vegetation which is mostly mangrove and freshwater types. Three stations, A (N06° 35 604'; E003° 27 623'), B (N06° 35 910'; E003° 27 446') and C (N06° 36 135'; E003° 27 113') were studied. The dominating plant is *Rhizophora racemosa* L. with other plants like *Acrostichum aureum* L., *Paspalum vaginatum Sw.*, *Panicum maximum* Jacq., *Cyperus papyrus* L., *Eichhornia crassipes* (Mart.) Solms as well as *Raphia hookeri* P. Beauv., towards the interland. Fishing and *Rhizophora* wood logging for making charcoal are the common human activities at these sites even though the creek is far from human inhabitation.

Collection of Sample

Samples were collected monthly for twelve months (February 2010 - January 2011). All samples were collected between 09:00hr and 12:00hr to minimize the variations of phytoplankton distribution that could occur due to diurnal migration. Biological samples were collected using 55µm mesh size standard plankton net tied unto a motorized boat and towed horizontally at low speed (< 4 knots) for 10 minutes. The samples were transferred into well labeled 500ml plastic containers with screw caps and preserved with 4% unbuffered formalin. For physico-chemical analysis, surface water samples were collected in plastic containers of 1.5 litre. Some analyses were done *in-situ* while the plastic containers were well corked, labeled, and carried to the laboratory for further analysis. Taxanomic keys employed in the identification included Hustedt (1930, 1937, 1942 and 1971); Prescott (1964, 1973 and 1982; Wimpenny (1966), Whitford and Shumacher (1973).

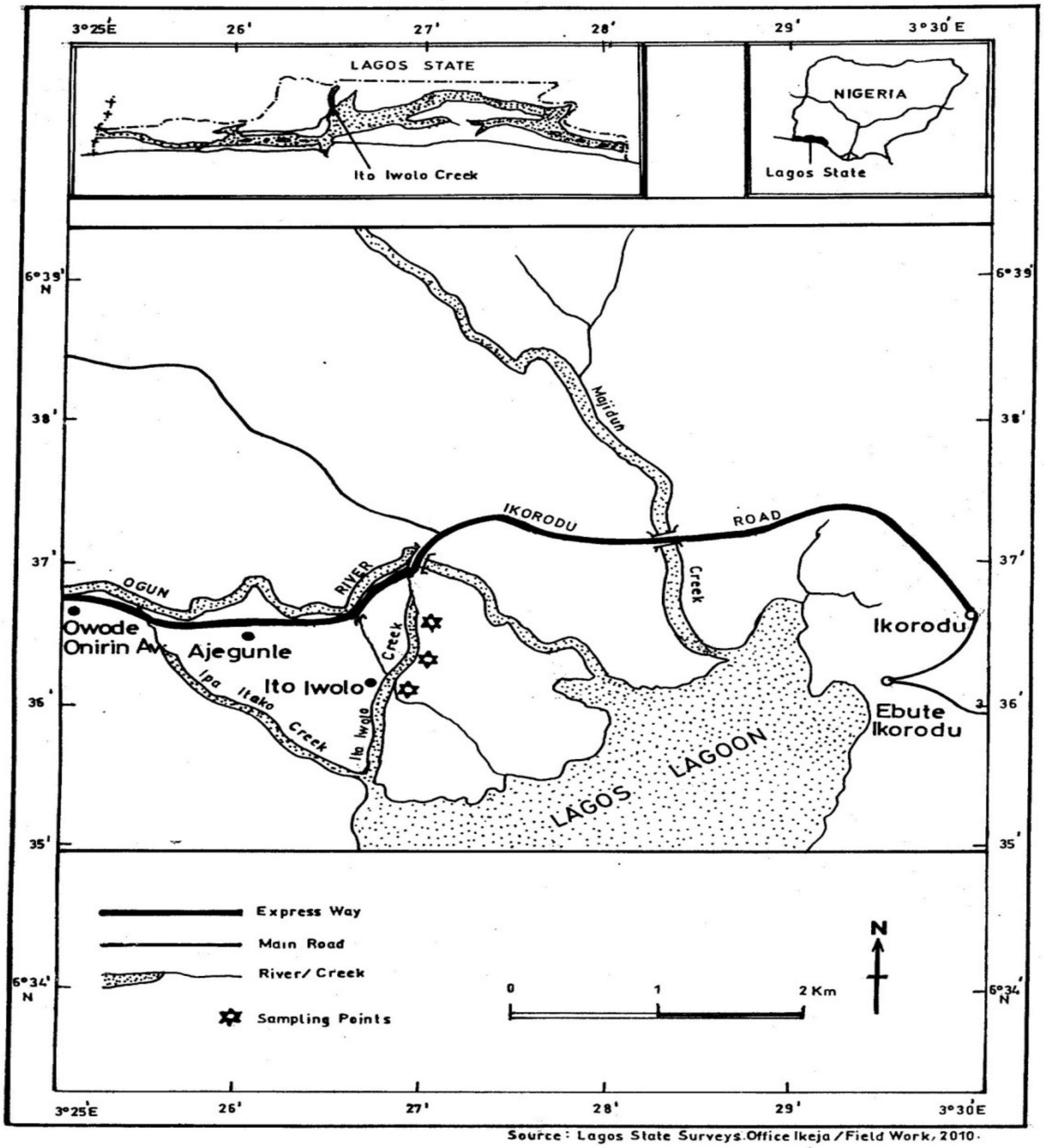

Figure 1: Sampling stations at Ito-Iwolo creek, Lagos

Analysis of Physico-chemical Parameters

Measurement of the surface water temperature was made *in-situ* with the aid of mercury-in-glass thermometer while water depth was measured by using a pole and measuring tape. Transparency of water body was measured using a 20cm diameter black and white Secchi disc attached to a rope. Surface water salinity was determined by using handheld refractometer; conductivity was determined by the use of Philips PW9505 Conductivity Meter (Range: 3-100,000µS/cm and Automatic Temperature Compensation Unit) and the hydrogen ion concentration (pH) was analyzed using the Cole Parmer Tester3 (an electronic pH meter). Total suspended solid and total dissolved solids were determined using the Gravimetric method (2540D APHA, 1998). Dissolved oxygen was determined using Titrimetric (Iodometric) method (Azide modification procedure APHA, 1988). The Wrinkler's method was used for Biological Oxygen Demand while Chemical Oxygen Demand was done by Titrimetric Closed Reflux Method (APHA, 1998). Nitrate-Nitrogen was determined by the Colorimetric Cadmium Reduction method. Phosphate content was analyzed by Colometric Method 4500-PD (APHA, 1998) while Sulphate content of water samples were determined using the Turbidimetric method (APHA, 1998). Silica was determined at 600nm using a colorimeter (DR2010). Chlorophyll content was determined using a Fluorometer equipped with filters for light emission and excitation. The Atomic Absorption Spectrometry (The Perkin Elmer 5000 AAS) was used to determine the quantity of heavy metals present in the water samples. Metal standards were according to Instrument marker's procedure for Copper, Mercury, and Lead.

Data Analysis

Three indices; species richness index (d) (Margalef, 1970), Shannon-Weiner index (H^1)(1963) and Species evenness 'j' (Pielou, 1975) were used to obtain the estimate of species diversity of the collected samples while Pearson's correlation (r), and Principal Component (PCA) were used for the physico-chemical data (PAST software).

Results

Physico-chemical Parameters

Surface water temperatures ranged between 26.70°C and 32.50°C with highest value (32.50°C) recorded in February 2010 at Station B. Depth ranged from 5.48m to 9.50m with lowest and highest values (5.48m and 9.50m) recorded at Stations C and A respectively in November and August 2010 (Table 1). Transparency ranged from 0.11m to 1.69m at the three Stations during the study. The highest transparency value (1.69m) was recorded in March 2010 at Station C while the lowest value (0.11m) was recorded in July 2010 at Station A which corresponded to dry and rain season. Salinity value was 0‰ during the raining season (August 2010) while 14.90‰ was recorded in January the peak of dry season; conductivity values (0.01µS/cm and 20.00µS/cm) were recorded in November and February 2010 respectively. The surface water hydrogen ion concentration varies between slightly acidic (6.42) to alkaline (8.70) (Table 1). The lowest number (9) of phytoplankton count (cells/ml) was recorded in July which corresponded to the highest rainfall value (560.3mm) and 0.13m transparency (Figure 2). Relationship between rainfall pattern, total phytoplankton and nutrients were presented on Figures 3 and 4.Pearson correlation (Table 2) analysis showed a strong positive correlation between Rainfall and depth (0.765), salinity and surface water temperature (0.805) phosphate and rainfall (0.492) (Table 2) while salinity and rainfall (-0.358), transparency and rainfall (-0.520) showed negative correlation indicating that as rainfall increases, salinity and transparency decreases. Principal component analysis (Figure 5) showed the controlling tendency of rainfall during the wet seasons while nutrients, Phosphate-phosphorus and Nitrate-nitrogen were the limiting factors during the dry season.

Biological Samples

Phytoplankton taxa belonging to four classes; Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae were recorded for Ito-Iwolo. Total of 127 species spread across the four classes with bacillariophyceae dominating the phytoplankton spectrum with 75 species from 32 genera with the order Naviculales recording the highest number followed by the green algae with 31 species from 12 genera with the order desmidiales recording the highest number of individual. Blue green algae and Euglenoids recorded 17 and 4 species each from 8 genera and I genus respectively (Table 3). Figure 6 showed the influence of the rainfall pattern as it depicted the phytoplankton group concentration while Figure 7 revealed the percentage composition of different microalgal group at the study site. Community structure analysis indicated a diverse ecosystem with Margalef index (d) and Shannon-Weiner following almost the same pattern (Figure 8).

Table 1: Physico-chemical parameters results obtained at the Ito-Iwolo Creek (February 2010-January 2011)

PARAMETERS	Feb. 2010			Mar. 2010			Apr. 2010			May. 2010			June 2010			July 2010			Aug. 2010			Sept. 2010			Oct. 2010			Nov. 2010			Dec. 2010			Jan.2011			Mean	STDV	Standard Error
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C			
Water Temperature (˚c)	32.2	32.5	31.9	30.4	30.4	30.4	30.1	30.1	30.2	31.8	31.1	31.2	28.9	29.5	27.5	26.7	26.6	26.6	26.7	27.1	27.2	27.5	27.7	27.7	28.5	28.3	28.2	27.7	27.9	27.9	28.5	28.2	28.5	26.9	26.8	26.8	28.8	1.778	0.296
pH	7.00	7.00	7.00	7.20	7.20	7.20	7.00	7.20	7.20	7.80	7.60	7.50	7.60	7.60	7.60	8.40	8.50	8.50	8.70	8.50	8.60	8.00	8.10	8.60	6.62	6.64	6.65	7.00	6.98	6.92	6.83	6.42	6.65	7.10	7.20	7.30	7.4	0.655	0.109
Total Dissolved Solid (mg/l)	10	9.74	8.68	8.72	7.97	7.23	8.04	7.23	6.2	7.2	3.81	2.13	0.08	0.01	0.08	0.06	0.05	0.05	0.04	0.02	0.04	0.03	0.04	0.04	0.04	0.04	0.04	0.00	0.00	0.04	0.05	0.05	0.05	3.55	2.53	0.28	2.6	3.579	0.596
Total Suspended Solid (mg/l)	1.20	2.30	1.50	ND	ND	ND	1.00	ND	1.20	1.20	1.00	1.40	2.20	1.70	1.50	2.50	2.20	2.00	2.50	2.30	2.20	2.10	2.00	3.00	1.20	1.10	1.20	1.20	1.10	1.30	1.10	1.30	1.00	1.00	1.10	1.00	1.4	0.565	0.094
Rainfall (mm)	40.8	40.8	40.8	45.6	45.6	45.6	172	171.6	171.6	233.2	233.2	233.2	444.1	444.1	444.1	560.3	560.3	560.3	161.7	161.7	161.7	240.3	240.3	240.3	134.3	134.3	134.3	65.7	65.7	65.7	0.0	0.0	0.0	0.0	0.0	0.0	174.8	167.908	27.984
Depth (m)	7.72	7.06	6.87	7.96	7.88	8.27	7.82	7.85	6.87	7.92	7.93	6.43	6.87	7.15	6.95	7.90	6.99	6.85	9.50	7.17	6.28	6.38	6.42	6.37	7.25	8.10	7.50	6.76	6.65	5.48	8.95	6.55	7.24	6.90	6.68	6.35	7.2	0.799	0.135
Transparency (m)	1.40	1.65	1.54	1.59	1.20	1.69	0.82	0.93	0.90	0.82	0.70	0.45	0.33	0.30	0.37	0.11	0.13	0.12	0.19	0.20	0.22	0.32	0.36	0.25	0.35	0.41	0.40	0.41	0.42	0.32	0.40	0.35	0.33	1.06	0.82	0.89	0.6	0.468	0.079
Salinity (‰)	14.9	11.2	10.3	11.4	11.1	10.2	10.4	10.6	6.8	10.4	5.8	3.6	0.9	0.7	0.6	0.1	0.1	0.1	0.00	0.10	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	5.00	4.00	4.00	3.9	4.550	0.769
Dissolved Oxygen (mg/L)	5.20	5.00	5.30	5.30	5.40	5.20	5.30	5.00	5.10	5.00	5.20	5.00	5.20	5.00	5.10	5.00	5.20	5.00	5.20	5.40	5.30	5.00	5.10	5.00	5.10	5.20	5.30	5.30	5.20	5.10	5.10	5.00	5.00	5.20	5.40	5.30	5.2	0.132	0.022
Chemical Oxygen Demand (mg/L)	12.00	10.00	11.00	11.00	10.00	12.00	10.00	14.00	16.00	11.00	13.00	14.00	13.00	12.00	15.00	13.00	12.00	14.00	14.00	11.00	12.00	12.00	10.00	11.00	11.00	12.00	10.00	13.00	12.00	11.00	12.00	13.00	14.00	13.00	14.00	15.00	12.3	1.560	0.264
Biological Oxygen Demand (mg/L)	7.00	9.00	8.00	9.00	6.00	8.00	8.00	10.00	11.00	9.00	9.00	10.00	8.00	7.00	9.00	8.00	7.00	9.00	10.00	9.00	8.00	9.00	8.00	7.00	8.00	7.00	8.00	10.00	9.00	8.00	9.00	10.00	9.00	10.00	11.00	13.00	8.8	1.362	0.230
Conductivity (µS/cm)	20.00	19.47	17.35	17.44	15.93	14.47	15.80	14.48	12.56	13.95	7.68	4.29	0.19	0.03	0.16	0.12	0.12	0.01	0.09	0.04	0.09	0.07	0.08	0.08	0.09	0.08	0.08	0.01	0.01	0.09	0.11	0.09	0.10	7.10	4.77	0.59	5.2	7.134	1.206
Nitrate-Nitrogen (mg/L)	10.20	11.32	11.11	9.43	8.87	7.92	9.20	10.10	10.40	9.90	11.20	10.60	6.50	5.70	4.20	4.30	5.10	7.20	2.27	3.10	2.90	2.10	2.20	1.70	1.90	1.70	1.40	1.20	1.10	1.30	1.22	1.10	1.50	0.90	0.70	0.80	5.1	3.861	0.653
Phosphate-Phosphorus (mg/L)	0.09	1.40	1.10	1.35	1.27	1.14	0.07	1.00	1.20	1.10	1.40	1.50	1.10	1.40	0.09	1.10	1.70	2.10	0.06	0.09	0.04	0.04	0.10	0.06	0.06	0.30	0.20	0.01	0.08	0.03	0.04	0.06	0.02	0.03	0.05	0.04	0.6	0.643	0.109
Sulphate (mg/L)	11.20	13.20	12.00	11.12	10.46	9.34	10.00	12.00	10.70	11.10	9.50	10.40	8.20	6.60	5.70	6.20	7.70	8.90	10.2	13.4	12.2	0.15	0.18	0.23	0.09	0.08	0.13	0.11	0.13	0.15	0.14	0.15	0.13	0.18	0.21	0.23	5.9	5.120	0.866
Lead (mg/L)	0.04	0.03	0.04	0.05	0.03	0.04	0.03	0.04	0.05	0.04	0.11	0.06	ND	ND	ND	0.001	0.001	0.002	0.02	0.03	0.01	ND	ND	ND	0.001	0.001	0.002	ND	ND	2.2	ND	ND	ND	ND	ND	ND	0.1	0.453	0.061
Mercury (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0	0.000	0.000
Copper (mg/L)	1.40	2.10	1.70	2.27	2.13	1.91	1.20	2.20	1.60	2.30	3.10	2.60	1.60	1.40	1.90	2.70	3.20	3.70	1.70	1.40	1.30	1.44	1.60	1.90	1.30	1.40	1.60	1.00	1.90	ND	1.20	2.20	1.30	1.70	1.40	1.80	1.8	0.606	0.113
Silicate (mg/L)	0.00	0.00	0.01	0.17	0.16	0.14	0.00	0.00	0.05	0.11	0.14	0.09	0.10	0.12	0.01	0.24	0.14	0.22	0.003	0.001	0.002	0.002	0.008	0.003	0.003	0.002	0.002	0.001	0.003	0.001	0.002	0.006	0.004	0.002	0.001	0.002	0.0	0.071	0.120
Chlorophyll a (µg/L)	0.00	0.00	0.01	0.005	0.003	0.002	0.00	0.004	0.002	0.005	0.002	0.004	0.005	0.004	0.001	0.001	0.009	0.003	0.005	0.004	0.002	0.003	0.012	0.007	0.002	0.009	0.004	0.001	0.009	0.008	0.004	0.01	0.013	0.002	0.011	0.01	0.0	0.003	0.001

Table 2: Pearson Correlation coefficient

	WaterTemp	pH	TDS	TSS	Rainfall	Depth	Transparency	Salinity	DO	COD	BOD	Conductivity	Nitrate	Phosphate	Sulphate	Lead	Copper	Silica	Chlorophyll 'a'
WaterTemp	0	0.021	0.000	0.018	0.134	0.168	0.000	0.000	0.571	0.115	0.276	0.000	0.000	0.010	0.000	0.838	0.644	0.535	0.033
pH	-0.385	0	0.099	0.000	0.000	0.865	0.012	0.078	0.651	0.669	0.530	0.098	0.972	0.202	0.048	0.428	0.021	0.038	0.651
TDS	0.818	-0.279	0	0.002	0.046	0.080	0.000	0.000	0.365	0.164	0.659	0.000	0.000	0.027	0.000	0.650	0.485	0.459	0.014
TSS	-0.391	0.665	-0.489	0	0.001	0.115	0.000	0.001	0.112	0.836	0.430	0.002	0.145	0.676	0.931	0.781	0.709	0.708	0.938
Rainfall	-0.254	0.640	-0.334	0.516	0	0.765	0.001	0.032	0.033	0.365	0.081	0.046	0.395	0.002	0.221	0.491	0.002	0.000	0.321
Depth	0.235	-0.029	0.296	-0.267	-0.052	0	0.224	0.103	0.547	0.759	0.413	0.081	0.154	0.425	0.068	0.037	0.316	0.187	0.097
Transparency	0.706	-0.414	0.901	-0.572	-0.520	0.208	0	0.000	0.123	0.280	0.732	0.000	0.000	0.135	0.014	0.649	0.887	0.824	0.106
Salinity	0.805	-0.297	0.982	-0.545	-0.358	0.276	0.906	0	0.285	0.188	0.766	0.000	0.000	0.057	0.000	0.702	0.554	0.520	0.025
DO	-0.098	-0.078	0.155	-0.269	-0.357	0.104	0.262	0.183	0	0.256	0.982	0.367	0.638	0.211	0.514	0.692	0.173	0.465	0.925
COD	-0.267	0.074	-0.237	-0.036	0.155	-0.053	-0.185	-0.224	-0.194	0	0.000	0.169	0.716	0.756	0.804	0.411	0.241	0.784	0.647
BOD	-0.186	-0.108	-0.076	-0.136	-0.295	-0.141	0.059	-0.051	0.004	0.664	0	0.657	0.407	0.339	0.450	0.605	0.862	0.143	0.370
Conductivity	0.820	-0.280	1.000	-0.489	-0.335	0.295	0.903	0.982	0.155	-0.234	-0.077	0	0.000	0.026	0.000	0.652	0.485	0.460	0.013
Nitrate	0.833	0.006	0.800	-0.248	0.146	0.243	0.596	0.764	-0.081	-0.063	-0.143	0.801	0	0.000	0.000	0.518	0.009	0.008	0.002
Phosphate	0.425	0.218	0.368	-0.072	0.492	0.137	0.254	0.320	-0.213	0.054	-0.164	0.370	0.732	0	0.000	0.497	0.000	0.000	0.159
Sulphate	0.558	0.331	0.627	-0.015	0.209	0.308	0.407	0.569	0.112	-0.043	-0.130	0.628	0.831	0.605	0	0.399	0.028	0.023	0.001
Lead	-0.035	-0.136	-0.078	-0.048	-0.119	-0.348	-0.078	-0.066	-0.068	-0.141	-0.089	-0.078	-0.111	-0.117	-0.145	0	0.008	0.582	0.449
Copper	0.080	0.383	0.120	0.064	0.507	0.172	0.025	0.102	-0.232	0.201	0.030	0.120	0.431	0.718	0.365	-0.435	0	0.000	0.612
Silica	0.107	0.346	0.127	-0.065	0.577	0.225	0.039	0.111	-0.126	0.047	-0.249	0.127	0.436	0.803	0.379	-0.095	0.688	0	0.237
Chlorophyll 'a'	-0.357	-0.078	-0.407	0.013	-0.170	-0.281	-0.274	-0.372	-0.016	0.079	0.154	-0.409	-0.489	-0.240	-0.515	0.130	-0.087	-0.202	0

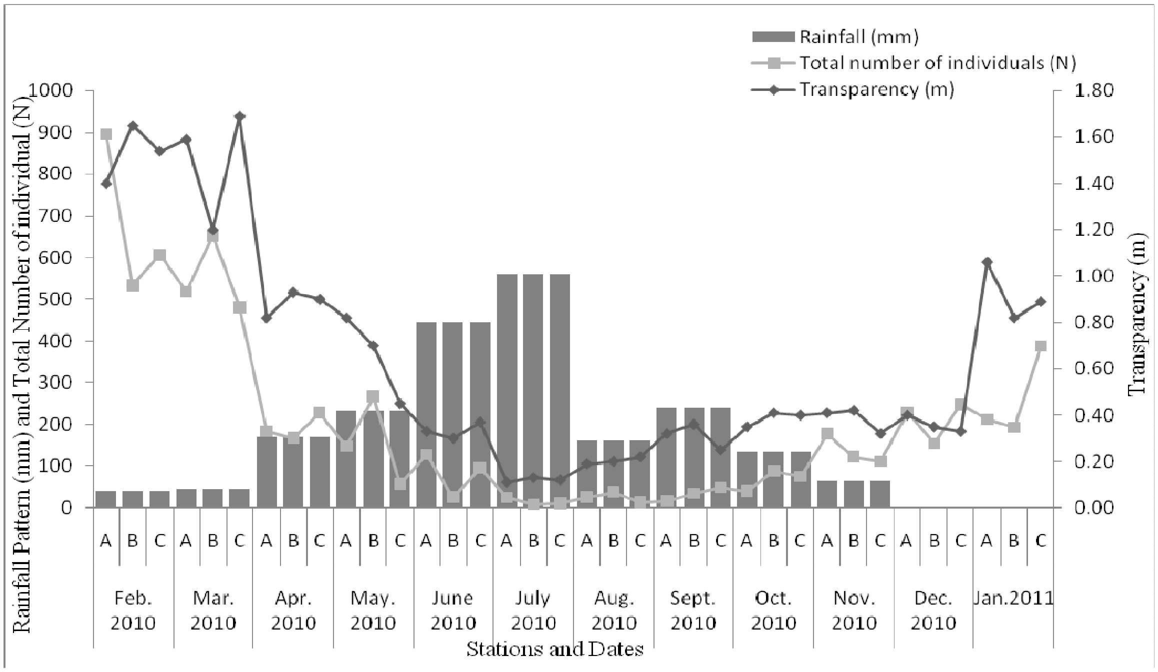

Fig. 2: Relationship between rainfall pattern, transparency and total phytoplankton abundance at Ito-Iwolo during the sampling period

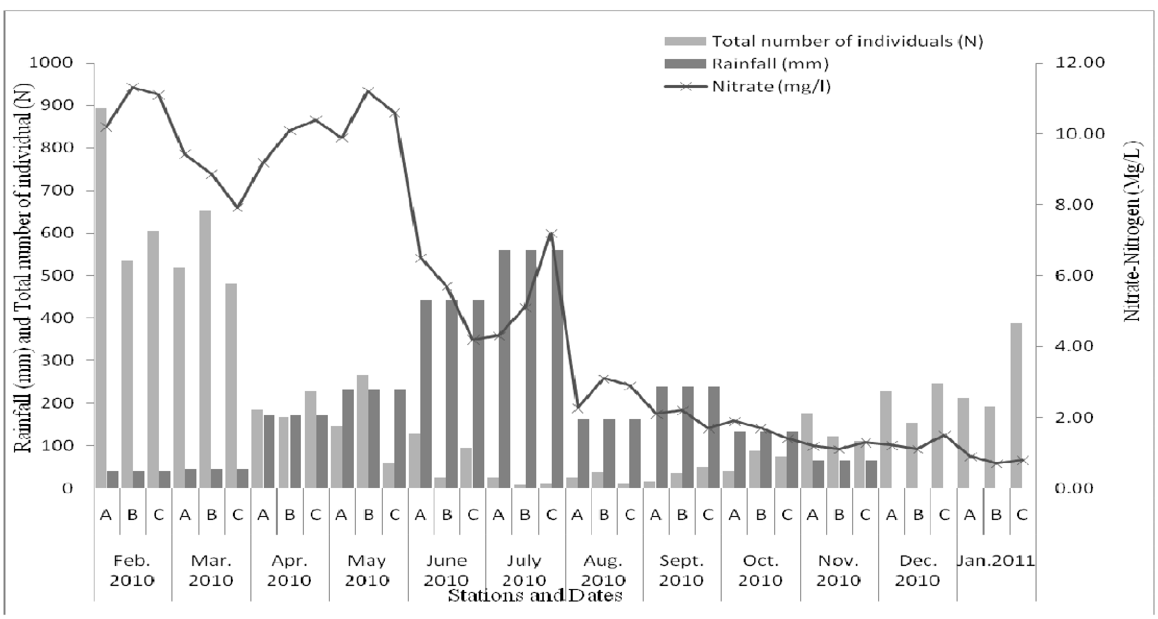

Fig. 3: Relationship between rainfall pattern, Nitrate-Nitrogen and total number of individuals at Ito-Iwolo creek during the sampling period

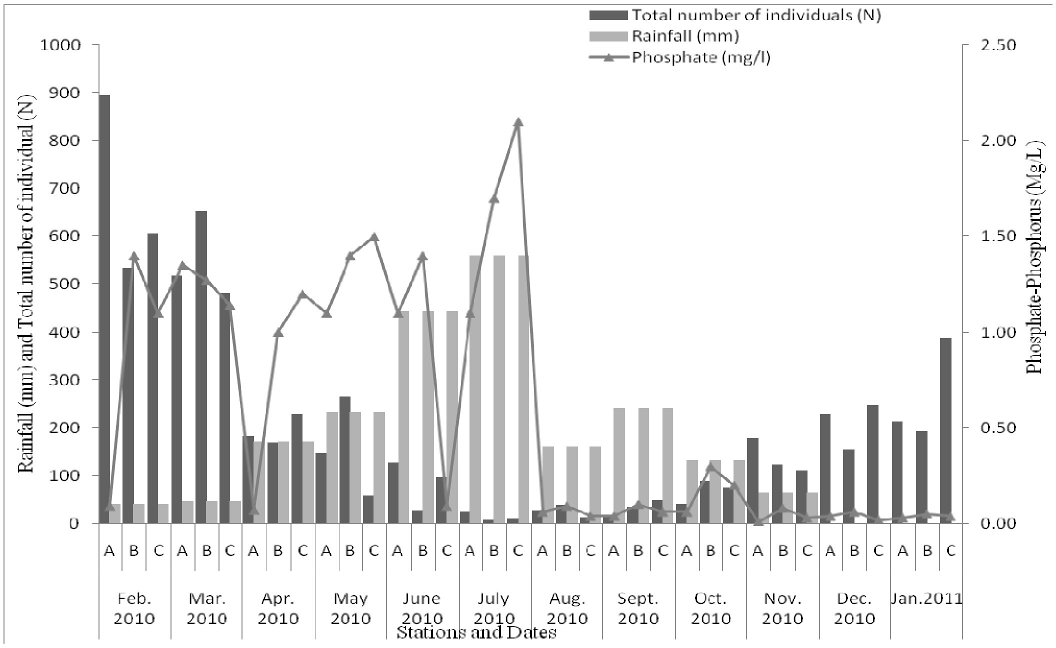

Fig. 4: Relationship between rainfall pattern, Phospahte-phosphorus and total number of individuals at Ito-Iwolo creek during the sampling period

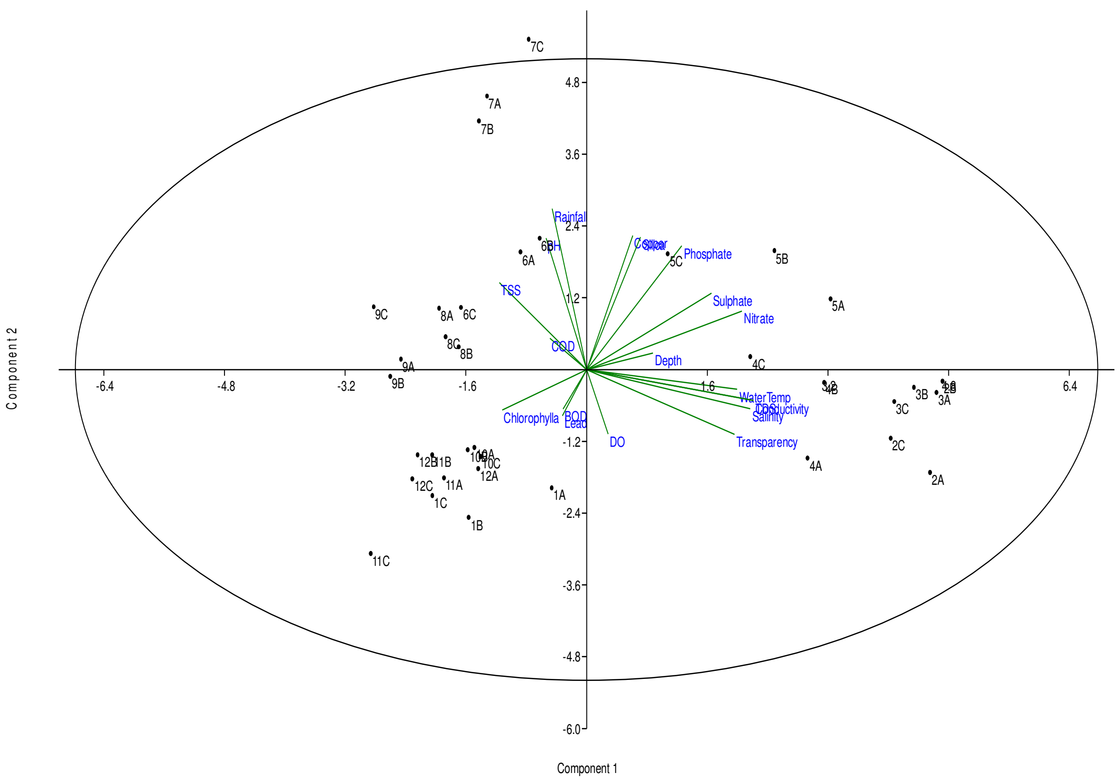

Figure 5: Principal Component Analysis of the physico-chemical parameters at Ito-Iwolo showing the controlling factor as Rainfall, pH and Phosphate for the wet months and Water temperature, Salinity and transparency for the dry months. Note: 1= January, 2 = February, 3 = March, 4 =April, 5=May, June=6, July=7, 8 = August, 9=September, 10=October, 11=November and 12=December

Table 3: Phytoplankton composition and diversity at Ito-Iwolo creek, Lagos (February 2010-January 2011)

		Feb. 2010			Mar. 2010			Apr. 2010			May 2010			June 2010			July 2010			Aug. 2010			Sept. 2010			Oct. 2010			Nov. 2010			Dec. 2010			Jan.2011		
		A	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
	Division: Bacillariophyta																																				
	Class: Bacillariophyceae																																				
	Order : Achnanthales																																				
	Family: Achnanthaceae																																				
1	*Achnanthes brevipes* Agardh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	1	-	-	-	-	-	
2	*Achnanthes* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	-	3	-	-	
	Family: Catenulaceae																																				
3	*Amphipleura pellucida* Kutzing	4	-	-	9	3	11	7	-	3	9	3	-	3	4	19	-	-	-	-	1		-		-	-	-	-	-	-	-	-	-	-	8	-	
4	*Amphiprora* sp.	34	5	-	11	5	2	-	-	-	4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Order : Aulacoseirales																																				
	Family : Aulacoseiraceae																																				
5	*Aulacoseira granulata* (Ehrenberg)	-	-	-	-	-	-	1	-	4	-	12	-	-	2	-	-	-	-	-			-		1	-	1	-	9	6	21	4	11	28	69	108	257
	Order : Biddulphiales																																				
	Family : Biddulphiaceae																																				
6	*Biddulphia laevis* Ehrenberg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1		-		-	-	-	-	-	-	-	-	-	-	-	-	
7	*Terpsinoe americana* (Bailey) Ralfs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	1	-	-	-	-	-	
	Order : Fragilariales																																				
	Family: Fragilariaceae																																				
8	*Asterionella formosa* Hassal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	2	-	-	-	-	-	-	
9	*Fragilaria crotonensis* Kitton	78	41	79	53	17		23	57	95	-	79	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	*F. virescens* Ralfs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	7	9	-			-		-	-	-	-	-	-	2	-	-	-	13	4	59
11	*Fragilaria* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		2	-	1	-	1	2	7	2	3	2	-	-	
12	*Synedra ulna* var. *contracta* Oestrup	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	-	30	17	-	
13	*S. utermohlii* Hustedt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	1	-	-	-	-	-	-	-	-	-	-	
14	*Synedra* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	2	5	-	1	2	20	13	23	16	-	2	-	-	20
	Order: Bacillariales																																				
15	*Bacillaria paradoxa* Gmelin	-	-	29	-	15	-	23	-	-	-	-	-	-	-	-	-	-	-	-																	
16	*Nitzschia gracilis* Heintzsch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	-	-	3	-	
17	*N. obtusa* W.Smith	23	7	9		5		2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	*N. subtilis* Grunow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	-	-	28	-	
19	*N. vermicularis* (Kutz.) Grunow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2		-		-	-	-	-	-	-	-	-	-	-	4	-	
	Family: Cocconeidaceae																																				
20	*Cocconeis disculus* (Schum) Cleven	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	-	2	-	-	
	Family: Cymbellaceae																																				
21	*Cymbella affinis* Kutzing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		1	-	-	-	1	-	-	-	-	-	-	-	
22	*Cymbella aspersa* (Ehr.) Cleve.	240	170	197	119	179	156	13	-	9	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	1	1	-	-	-	-	-	-	
23	*Cymbella gracilis* (Rabh.) Cleve.	200	190	205	115	225	197	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	2	1	-	-	3	2	-	
24	*Cymbella tumida* (Breb) van Heurck	19	20	-	-	-	-	9	3	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	*C. ventricosa* (Ehr.) Meister	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	1	-	-	-	1	-	-	1	-	-	-	-	-	
	Family: Gomphonemataceae																																				
26	*Gomphonema augur* Ehrenberg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	4	-	-	-	-	-	-	-	-	
27	*G. hebridense* Typenmaterial	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	7	-	-	-	
28	*G. rhombicum* Facke	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	2	-	-	-	-	-	-	-	-	-	
29	*Gomphonema* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	1	-	-	-	-	-	-	-	
	Order: Naviculales																																				
	Family: Naviculaceae																																				
30	*Caloneis schumannians* Grunow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	-	-	-	-	
31	*Caloneis* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	4	-	-	2	-	-	-	-	
32	*Gyrosigma acuminatum* Kutz.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	2	-	-	-	
33	*G. obtusatum* (Sulliv.) Boyer	15	3	4	-	39	-	2	7	11	0	4	-	9	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	-	-	-	1	
34	*Gyrosigma* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	-	-	-	-	6
35	*Navicula angusta* Grunow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		2	-	-	-	-	-	-	-	-	-	-	-	
36	*N. cuspidata* Kutzing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	2	-	-	-	-	-	-	-	
37	*N. decussis* Oestrup	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	1	-	-	-	-	-	-	-	-	-	
38	*N. mutica* Kutzing	4		7	-	-	-	11	-	2	5	7	-	9	-	7	-	-	-	-			-		-	-	-	-	-	5	-	1	2	-	-	-	
39	*N. radiosa* Kutz	8	9		4		2	5	-	1	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	1	-	-	-	-	-	-	-	

40	*N. radiosa* var. *tenella* (Breb.) Cleve	92	20	11	27	8	5	10	9	4	-	7	-	7	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	-	-	-	8	
41	*Neidium* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	2	-	-	-	-	-	-	-	
42	*Pinnularia ignobilis* Krasske	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		1	-	-	-	-	-	-	-	-	-	-	-	
43	*P. macilenta* (Ehrenberg) Ehrenberg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	1	-	-	-	-	
44	*P. major* Kutzing	32	-	-	12	-	-	-	-	-	-	-	-	-	7		-	-	-	-			-	1	-	-	-	-	-	-	-	-	-	-	-	-	
45	*P. streptoraphe* Cleve	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	1	-	-	-	-	-	-	-	
46	*Pinnularia* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	2	-	8	-	8	2	-	3	-	-	-	-	-	
47	*Ulnaria ulna* (Nitzsch.) Ehrenberg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	1	-	-	4	1	-	-	-	-	22	20
	Family : Surirellaceae																																				
48	*Surirella angustata* Kutzing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1			-		-	-	-	-	3	-	-	-	-	1	-	-	
49	*S. arctissima* A. Schmidt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	1	-	-	-	-	-	-	-	
50	*S. ovalis (Grunow) Cleve*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	1	-	-	-	
51	*S. ovalis* var. *pyriformis* (Pant) A. Cleve	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		1	-	-	-	-	-	-	-	-	-	-	-	
52	*S. tenera* var.*nervosa* A. Schmidt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		1	-	1	1	-	-	-	-	-	-	-	-	
53	*Surirella* sp.	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	1	-	-	-	-	
	Order: Tabellariales																																				
	Family :Tabellariaceae																																				
54	*Meridion circulare* (Grev.) Agardh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	1	-	-	-	-	-	-	-	
55	*Tabellaria fenestrata* (Lyng.) Kutzing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	1	-	-	-	2	-	27	2
56	*Tabellaria* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	-	-	14	-	
	Family: Stephanodiscaceae																																				
57	*Coscinodiscus centalis* Ehrenberg	27	15	-	17	20	11	13	15	-	17	32	-	27	-	29	-	-	-	-			-		-	-	-	-	-	-	-	-	-	-	-	-	-
58	*Coscinodiscus eccentricus* Ehrenberg	17	9	-	11	12	7	9	9	25	12	25	-	17	-	15	-	-	-	-			-		-	-	-	-	-	-	-	-	-	-	-	-	-
59	*Coscinodiscus lineatus* Grunow	9	4	-	7	6	3	3	4	15	5	19	-	9	-	7	-	-	-	-			-		-	-	-	-	-	-	-	-	-	-	-	-	-
60	*Cyclotella meneghiniana* Kutzing	9	4	-	35	26	13	7	10	37	11	0	-	5	-	19	-	-	-	-			-		-	-	-	-	-	-	-	30	-	-	1	-	
61	*C. stelligera* Cleve and Grun.	3	2	-	15	10	7	2	5	-	-	-	-	-	-	-	-	-	-	-			-	1	-	2	-	2	4	7	-	10	67	31	-	-	2
62	*Diatoma anceps* (Ehr.) Kirchner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	15	64	44	109	53	41	-	4	-	-	-	
63	*D. hiemale* var. *mesodon* (Ehr.) Grun.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		1	-	-	-	-	-	-	-	-	-	-	-	
64	*D. tenue* var. *elongatum* Lyngbya	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	2	-	2	-	-	-	-	-	
65	*Diatoma* sp.	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-	-	-			-		7	-	-	-	-	-	-	-	-	-	-	-	
66	*Diatomella balfouriana* Gurtelseiten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		1	-		-	-	-	-	-	-	-	-	-	-	-	-	
	Family: Diploidaceae																																				
67	*Diploneis* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	1	-	-	-	-	
	Family: Melosiraceae																																				
68	*Melosira moniliformis* Agardh.	-	4	6	-	-	-	5	5	5	6	28	-	-	4	-	-	-	-	-			-		-	-	-	-	-	17	-	70	26	-	-	-	
69	*M. varians* C. A. Agardh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			2	4	3	-		1	3	-	1	21	23	98	50	1	9
70	*Melosira* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	1	-	1		-	-	-	-	-	-	-	-	-	
	Family: Stauroneidaceae																																				
71	*Stauroneis anceps* Cleve	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	-	-	-	-	1
72	*Stauroneis* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	3	-	-	-	-	-	-	-	-	-	
	Order: Ropalodiales																																				
	Family: Ropalodiaceae																																				
73	*Epithemia zebra* (Grunow) A. Mayer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	1	-	-	-	-	-	-	-	-	-	-	
74	*E. zebra* var. *saxonica* (Kutz.) Grun.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	-	1	-	-	
	Order:Mastogloiales																																				
	Family: Mastogloiaceae																																				
75	*Mastogloia braunii* Grunow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	2	-	1	-	-	-	-	-	2	-	-	-	-	
	Division: Chlorophyta																																				
	Class: Chlorophyceae																																				
	Order: Chlorococcales																																				
	Family: Chlorellaleceae																																				
76	*Akistrodesmus falcatus* (Corda) Ralfs	5	9	13	-	25	-	-	-	-	-	-	-	-	-	-	-	-	-	2			-		-	-	-	-	-	-	-	-	-	-	-	-	
77	*Chlorella vulgaris* Beyerinck	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		1	-		-	-	-	-	-	-	-	-	-	-	-	-	

	Order: Desmidiales																																				
78	*Cosmarium subulatum* (Kutz.) Breb	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	-			-	1	-	-	-	-	-	-	-	-	-	-	-	-	
79	*C. toxon* West	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	3		-		-	-	-	-	-	-	-	-	-	-	-	-	
80	*C. tumidum* Johnson	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	-			-		-		-	-	-	-	-	-	3	-	-	-	
81	*Cosmarium* sp.	23			37	39	53	-	-	-	-	-	-	9	7	-	-		-	-			-		-	-	-	-	1	-	-	-	-	-	4	22	
82	*Euastrum* sp.		4	2		3		2	1	1	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	-	1	-	-	
83	*Gonatozygon montaenium* DeBary	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13		-		-	-	-	-	-	-	-	-	-	-	-	-	
84	*G. pilosum* Wolle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2		-		-	-	-	-	-	-	-	-	-	-	-	-	
85	*Gonatozygon sp.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		2	-	12	5	8		9	2	-	-	-	-	-	-	-	
86	*Pleurotaenium minutum* f. major Lund	-	-	-	-	5	-	1	-	-	-	-	-	3	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	-	1	-	-	
87	*Pleurotaenium* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1		-		10	-	1	-	-	-	-	-	-	-	-	-	
	Family: Closteriaceae																																				
88	*Closterium cornu* Ehrenberg	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	2		-		-	-	-	-	-	-	-	-	-	1	-	-	
89	*C. macilentum* Breb	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	3			-		-	-	-	-	-	-	-	-	-	-	-	-	
90	*C. abruptum* W. and G. S. West	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	-			-		-	-	-	-	-	-	-	-	-	-	-	-	2
91	*C. biclavatum* Borgesen	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	-			1		-	-	1	3	-	-	-	-	1	-	-	-	
92	*C. ehrenbergii* Menegh.	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	-			-		-	-	2	-	-	-	-	-	-	-	-	-	
93	*C. gracile* W. and G. S. West	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	3			-		-	-	-	-	-	-	-	-	-	-	-	-	
94	*C. navicula* (Breb) Lutkem	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	-			-		-	-	-	-	1	-	-	-	-	-	-	-	
95	*C. peracerosum* Gay	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	-			-		-	-	4	-	-	-	-	-	-	-	-	-	
96	*C. praelongum* f. *brevior* West	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	-			-		-	-	-	-	2	-	-	-	-	-	-	-	10
97	*C. pronum* Breb	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	3	6	5	-		-	-	-	-	-	-	-	-	-	-	-	-	
98	*C. sigmoideum* (Lagerh.) Nordst.	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	-			-		-	1	-	-	-	-	-	-	-	-	-	-	
99	*Closterium* sp.	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	-			-		-	-	-	-	-	-	-	-	1	-	-	-	
	Family: Scenedesmaceae																																				
100	*Scenedesmus quadricauda* var. *maxima* W.G.S. West	-	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	-	-	-	-	
	Order : Microsporales																																				
	Family: Microsporaceae																																				
101	*Microspora quadrata* Hazen	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	3	-	-	-	-	-	-	-	-	-	-	
102	*M. tumidula* Hazen	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4		-		-	-	-	-	-	-	-	-	-	-	-	-	
	Order : Conjugales																																				
103	*Spirogyra* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	4	2	-	-	-	-	-	-	-	-	-	-	-	
	Order: Volvocales																																				
	Family: Volvocaceae																																				
104	*Volvox* sp.	19	9	7	21	-	-	19	13	-	-	5	-	-	-	-	-	-	-	-			-		-	-		1	-	-	7	51	4	42	-	-	
	Family: Chlamydomonaceae																																				
105	*Chlamydomonas* sp.I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-		-	2	-	-	-	-	-	-	-	
106	*Chlamydomonas* sp.II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-		-	-		-	-	10	-	17	-	-	-	-	
	Division: Cyanophyta																																				
	Class: Cyanophyceae																																				
	Order: Oscillatoriales																																				
	Family: Oscillatoriaceae																																				
107	*Oscillatoria acuminata* Gomont	15	7	11	10	3	3	4	8	-	-	-	-	7	-	-	21	-	-	-			-		5	-		-	-	-	-	-	-	-	-	-	
108	*O. agardhi* Gomont		-			-				-	-	-	-	-	-	-	-		-	-			-		-	-	4	-	-	-	-	-	-	-	-	-	
109	*Oscillatoria formosa* Bory	4	-	2	5	-		2	3	-	-	-	-	-	3	-	-	-	-	-	1		-	1	-	-		-	-	-	-	-	-	-	-	-	
110	*Oscillatoria sancta* (Kutz.) Gomont	9	-	11	7	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-			-		1	-		-	-	-	-	-	-	-	-	-	
	Family: Phormidiaceae																																				
111	*Phormidium ambiguum* Gomont	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-			-		1	-	2	-	2	-	-	-	-	-	-	-	
112	*P. crouani* Gomont	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	1			-		1			-	-	-	-	-	-	-	-	-	
113	*P. interruptum* Kutzing	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	1	1		-		-	-		-	-	-	-	-	-	-	-	-	
114	*P. willei* Gardner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			1		-	-		-	-	-	-	-	-	-	-	-	
115	*Phormidium* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-		2	-		-	-		-	-	-	-	-	-	-	-	-	

	Order: Chlorococcales																																				
	Family : Microscystaceae																																				
116	*Microcystis* sp	6	2	13	3	7	9	11	15	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Family:Schizotrichaceae																																				
117	*Schizothrix lamyi* Gomont	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1			-		-	-	-	-	-	-	-	-	-	-	-	-	
	Family :Pseudanabaenaceae																																				
118	*Spirulina laxa* G. M. Smith	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-		1	-		-	-	-	-	-	-	-	-	-	-	-	-	
119	*S. subsalsa* Oersted	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10			7	3	-	-	-	-	-	-	-	-	-	-	-	-	
	Family: Merismopediaceae																																				
120	*Aphanocapsa delicatissima* West and West	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-		1	-		-	-	-	-	-	-	-	-	-	-	-	-	
121	*Aphanocapsa* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		1	5		-	-	-	-	-	-	-	-	-	-	-	-	
	Order: Nostocales																																				
	Family: Rivulariaceae																																				
122	*Calothrix* sp	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	2		-		-	-	-	-	-	-	-	-	-	-	-	-	
	Order: Stigonematales																																				
	Family:Stigonemataceae																																				
123	*Stigonema mamillosun* (Lyng) Agardh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			1		-	-	-	-	-	-	-	-	-	-	-	-	
	Division: Euglenophyta																																				
	Class:Euglenophyceae																																				
	Order: Euglenales																																				
124	*Euglena caudata* Hubner	-	-	-	-	-	-	-	-	-	17	19	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
125	*E. ehrenbergii* Klebs	-	-	-	-	-	-	-	-	-	26	7	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
126	*E. proxima* Dang.	-	-	-	-	-	-	-	-	-	16	3	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
127	*E.spiroides* var. *annulata* Gojdics	-	-	-	-	-	-	-	-	-	19	15	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total number of species	24	20	16	19	20	15	23	17	16	14	17	4	14	6	6	2	2	2	10	13	8	6	13	18	10	15	11	25	13	14	15	14	16	12	8	11
	Total number of individuals	895	534	606	518	652	481	184	168	228	148	267	58	128	27	96	26	9	12	27	39	14	17	35	50	41	89	76	178	123	112	229	155	248	213	193	388
	Margalef (d)	3.38	3.03	2.34	2.88	2.93	2.27	4.22	3.12	2.76	2.60	2.86	0.74	2.68	1.52	1.10	0.31	0.46	0.40	2.73	3.28	2.65	1.76	3.38	4.35	2.42	3.12	2.31	4.63	2.49	2.76	2.58	2.58	2.72	2.05	1.33	1.68
	Shannon-Weiner (H^1)	2.38	1.93	1.81	2.40	2.07	1.62	2.82	2.33	1.96	2.36	2.31	1.36	2.46	1.70	1.67	0.49	0.53	0.56	1.97	2.16	1.87	1.48	2.17	2.55	1.80	1.28	1.51	1.70	1.91	1.85	1.99	1.82	1.80	1.93	1.36	1.21
	Species evenness (j)	0.75	0.64	0.65	0.82	0.69	0.60	0.90	0.82	0.71	0.89	0.82	0.98	0.93	0.95	0.93	0.71	0.76	0.81	0.86	0.84	0.90	0.83	0.85	0.88	0.78	0.47	0.63	0.53	0.74	0.70	0.73	0.69	0.65	0.78	0.65	0.50

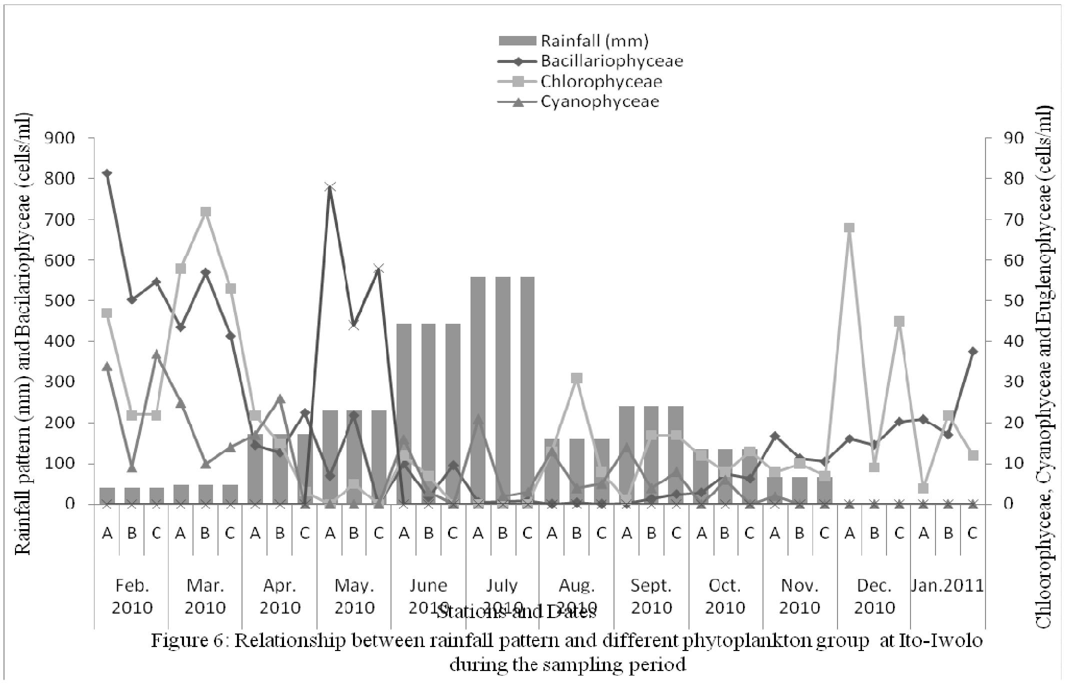

Fig. 6: Relationship between rainfall pattern and different phytoplankton group at Ito-Iwolo during the sampling period

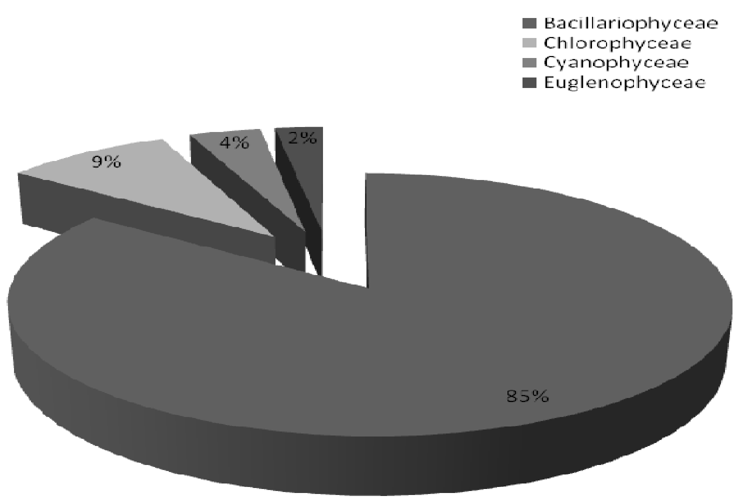

Fig. 7: Percentage composition of different microalgal groups at Ito-Iwolo during the sampling period

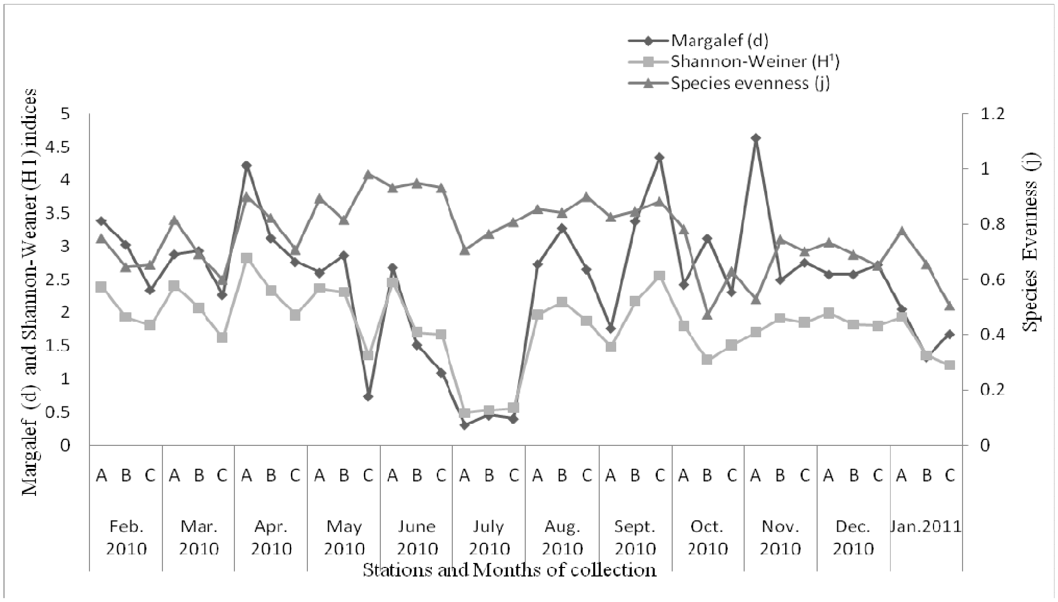

Fig. 8: Comparison of community structure of Ito-Iwolo creek

Discussion

Phytoplankton satisfy conditions to qualify as suitable indicators in that they are simple, capable of quantifying changes in water quality, applicable over large geographic areas and can also furnish data on background conditions and natural variability (Lee, 1999). The variation in the physicochemical parameters of Ito Iwolo creek was distinctive and according to Nwankwo and Amuda (1993), this may have been a reflection of the influence of seasonal effect and persisting environmental conditions. The ecological factor influencing the abundance and composition of phytoplankton in coastal water of south-western Nigeria are known to be limited with rainfall pattern (Hill and Webb, 1958; Nwankwo, 1988; Nwankwo and Akinsoji, 1992, Adesalu *et al.,* 2008). At reduced rainfall, nutrient level of water generally seemed high but tends to reduce as rainfall increases which could be due to dilution by rain water. The decrease in nutrients due to high rainfall therefore may account for reduction in dissolved oxygen levels, which could bring about a reduction in phytoplankton taxa. During this study, dissolved oxygen was however observed to have a direct relationship with chemical oxygen demand and biological oxygen demand. Rainfall possible initiated floods which increased suspended solids diluted the water thereby lowering total dissolved solids, salinity and conductivity and broke down any stratification.

The high total suspended solids may have accounted for the low light penetration level and limited phytoplankton production as reported by Karlman (1982) that transparency regulates primary production in accordance with flood condition and also by Nwankwo (1991) who stated that turbidity and dilution by fresh water were the major factors limiting growth of periphytic algae on fish fences in the Lagos Lagoon. The reduced transparency value recorded especially during the rainy season may be due to the mixing of the creek by more turbid floodwater inputs and re-suspension of bottom materials as suggested by Adesalu *et al*. (2010).The uniformity of water temperature readings recorded in both seasons may be linked to the shallowness of the Lagos lagoon and regular tidal motions, which ensured the complete mixing of the water. This observation agrees with Ajao (1990) on the temperature of Lagos Lagoon. There is no significant difference in the temperature of the two seasons. However, the relatively small range of variation in water temperature observed in this study area is in line with the observations of Hill and Webb (1958), Longhurst (1958) and Olaniyan (1969). They agreed that temperature is a stable environmental factor in the shallow brackish environments of West Africa, and it is most unlikely that this variation in temperature constitutes an important ecological factor in this area.

There was an increase in the conductivity as salinity increased, which is in accordance to Odum (1971) who reported that conductivity increased as salinity in the surrounding water increased, therefore conductivity increased as inflow of sea water to the lagoon from harbour rose. Nwankwo (1996) also pointed out that with a cessation of flood waters in the dry season and increased brackish water gives rise to these conditions in the Lagos Lagoon. The variation in pH is in line with Ayoola and Kuton (2009) who reported that high seawater influx and strong tidal currents due to high buffering capacity of the system and effective flushing cause the relatively stable pH observed in this environment. The level of total dissolved solids was generally low but higher in the sampling stations during the wet seasons compared to the dry seasons, this may be linked to the observation of Ajao (1990) that effluents can introduce some reaction which precipitates more solids in the solution, leading to high total dissolved solids but due to natural filtration total dissolved solids can decrease down the stream, with increasing distance away from the source of effluent discharge.

According to Suthers and Rissik (2009) as cited by Dogiparti *et al*. (2013), nitrogen tends to be the limiting nutrients in marine systems, while phosphate is the limiting nutrient in the freshwater systems; these two nutrients are needed for construction of cell membranes and for proteins such as enzymes.

Usually, the nitrate content of the surface water occurs in trace amount but the value is enhanced by the inputs from other sources (Bilger and Atkinson, 1997). The phosphate is also of great importance as an essential nutrient in aquatic system. The nutrients values were higher in the dry months and coincidentally, the highest phytoplankton species composition hence an increase in nutrient levels probably affects phytoplankton composition (Adesalu *et al.,* 2010). According to Onyema and Nwankwo (2009), reduced phytoplankton densities as reflected in chlorophyll '*a*' values in the wet season may be linked to the low water clarity which reduces the amount of light getting to planktonic algal component for photosynthesis. Higher plankton diversity was recorded in the dry season as against the wet periods. The phytoplankton of the Ito Iwolo creek was dominated by diatoms throughout the study. Similar findings have been reported by Nwankwo (1988, 1996), Nwankwo and Akinsoji (1988), Adesalu *et al*. (2008, 2012, 2014) for the Lagos lagoon and environs. According to Adesalu and Nwankwo (2008) frequently occurring pennate forms in the plankton samples from the Lagos lagoon was a likely reflection of the mixing of the shallow lagoon and phytobenthic community by tides and flood waters at different seasons. Nwankwo and Akinsoji (1988) and Onyema and Nwankwo (2006) are also of similar views in their study of shallow coastal water bodies in south-western Nigeria. Recent phytoplankton studies of some creeks in South-West Nigeria include: Adesalu and Nwankwo (2005, 2008) on Olero and Abule-Eledu creeks respectively; Adesalu *et al*. (2008) on Ogbe creek and Emmanuel and Onyema (2007) on the Abule-Agege creek. The heavy metal concentration in the sampling stations were relatively low, however the values could be linked to the indiscriminating discharge and human activities around the creek. The report however is in conformity with thestudies by Nwankwo (1996), Nwankwo and Akinsoji (1992), Adesalu *et al*. (2014), Adesalu and Kunrunmi (2012) who reported that diatoms are the most abundant algal groups in the Majidun creek that empties into Lagos Lagoon.

Conclusion

Observations from this study clearly pointed out that phytoplankton diversity, distribution and succession in the Lagos Lagoon depends greatly on seasonality rainfall which tends to either simulate or inhibit their growth and human activities such as dredging and release of pollutants into the system which impose lot of stress on water quality and phytoplankton diversity which probably would affect food webs in the environment and consequently the whole community structure in the study area, alternation in community structure may be the most serious consequence of water pollution because it could have profound impact on food webs and the entire ecosystem.

Declaration: The experiments have complied with the current laws of the country in which the experiments were performed.

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