PHYTOPLANKTON DIVERSITY INDICES OF OSSE RIVER, EDO STATE, NIGERIA.

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ABSTRACT

The phytoplankton diversity indices of Osse River, Edo State, Nigeria, were investigated monthly from January 2003 to April 2004. The plankton samples were collected from five sampling stations in the open water of the river using a plankton net of 55µm mesh net tied to a motorized boat and towed at low speed for five minutes at each station. The samples were transferred into 200ml capacity properly labeled plastic containers and immediately preserved with 4% formalin solution. Each sample was concentrated to 10ml volume in the laboratory by centrifugation and two drops from this 10ml were used for slide mount for microscopic examination using a Leitz Orthoplan Research Microscope at the phycology laboratory, Department of Plant Biology and Biotechnology, University of Benin, Benin City. Ten slide mounts were examined and phytoplankton organisms recorded in each mount. Identification of phytoplankton organisms was done by reference to standard texts and monographs in the phycology laboratory, University of Benin. A total of 154 species belonging to 4 divisions of algae (Bacillariophyta, Chlorophyta, Euglenophyta and Cyanophyta) were recorded. In terms of abundance, Bacillariophyceae had the highest distribution of phytoplankton (79.00%), Chlorophyceae, Cyanophyceae and Euglenophyceae presented 19.77%, 1.00% and 0.23% respectively. Species richness was highest in station 1 (11.43) and lowest in station 5 (6.25). Species diversity was lowest in station 5 (1.83) and highest in station 1 (3.43), while Simpson index and evenness were low in all the five sampling stations studied. The heterogeneity and abundance of phytoplankton observed in this study shows the river to be eutrophic and can support fish production. This is the first documented report on the phytoplankton community structure of Osse River.

Key words: Phytoplankton, species and diversity

INTRODUCTION

Phytoplankton are free-floating unicells and colonies that grow photoautotrophically in aquatic environments and play a key role in biological primary production and global elemental cycles of the earth (Vaulot, 2001).They are of great importance in bio-monitoring of aquatic pollution as their distribution, abundance, species diversity, species composition are used to assess the biological integrity of the water body (Townsend *et al.*, 2000).Phytoplankton are important water quality indicators because of their short life cycles and ability to respond to environmental change. Diversity is an important attribute of a natural community and it has been widely used to characterize community structure. From ecological view point, it has been studied in relation to ecosystem characteristics such as development, stability, primary production and heterogeneity (Ogawa and Ichimura 1984). Species diversity has two basic components; richness or number of species in a given area and evenness or how relative abundance or biomass is distributed among species (Wiley and Stirling, 2007).The diversity of a community depends on the species richness and species evenness. Species richness is the number of species present in the community, whereas, species evenness is the evenness with which the individuals are apportioned among the species. Influence of richness or evenness on diversity and how they might be related to each other depends on whether species assemblages are structured more by interactions such as competition or regulated by dispersal and migration. When communities are regulated by dispersal and migration, evenness is reduced with each new species detected as long as it remains rare (Wiley and Stirling, 2007).

Previous investigations on phytoplankton diversity indices in Nigeria, include the investigations of Uttah *et al.* (2008), Davies *et al.* (2009), Onuoha and Wim (2010), Adesalu and Nwankwo (2010), Onyema *et al.* (2010), Onyema (2010), Adesalu *et al.* (2010) and Zakariya *et al.* (2013). Information on the diversity of phytoplankton species of Osse River had not been documented before this investigation.

The aim of this study is to assess the phytoplankton community structure of Osse River and to give baseline ecological information on the phytoplankton status.

Study Area

The Osse River originates in the Akpata hills in Ekiti State, Southwest Nigeria. It flows through Ovia North-East Local Government Area in Edo State and empties into the Benin River (in the Niger-Delta region), which is one of the major rivers that drains into the Bight of Benin. Other rivers being Ramos, Forcados and Escravos Rivers (Fig 1). The climate is the tropical type with alternating wet and dry season. The wet season occured from May to October while the dry season was from November to April. Relative humidity of the study area ranged between 73% to 84% in the dry season while it was between 83% to 91% in the wet season. Rainfall values ranged from 227.1mm to 338.1mm in the wet season and 94.3mm to 169.8mm in the dry season. Cloud cover ranged from 7.0 oktas to 7.3 oktas in the wet season and 7.0 oktas to 7.1 oktas in the dry season. These stations have similar and peculiar human activities taking place in them.

Station 1 (Nikorogha, which lies on latitude 06^{0}14'02"N and longitude 05^{0}22'00"E.) has a lot of anthropogenic activities around it with a slow flow rate of water. The tall and large vegetation in this station provides a cool environment for the activities around it. Station 2 (Ekenhuan, which lies on latitude 06^{0}10'55"N and longitude 05^{0}20'34"E.) is characterized by commercial and anthropogenic activities like construction of boats, production of local gin and washing of cloths, hence the water at this station is sometimes muddy. Station 3 (Tolofa, lies on latitude 06^{0} 3'05"N and longitude 05^{0}15'22"E.) is the third point of study. The inhabitants of this zone are not as many as that in station 1. Activity here is low. Station 4 (Ogeba, which on between latitude 05^{0}55'47"N and longitude 05^{0}13'43"E.) is close to the mouth of Benin River. *Eicchornia crassipes* dominated the water surface and houses made of palm fronds are abundant. Mangrove trees are the dominant vegetation here. Station 5 (Ureju, lies on latitude 05^{0}51'38"N and longitude 05^{0}15' 10"E.) is the last station at the mouth of Benin river, close to the sea. Mangrove trees (*Rhizophora racemosa*) are the dominant vegetation. *Eicchornia crassipes* are also abundant.

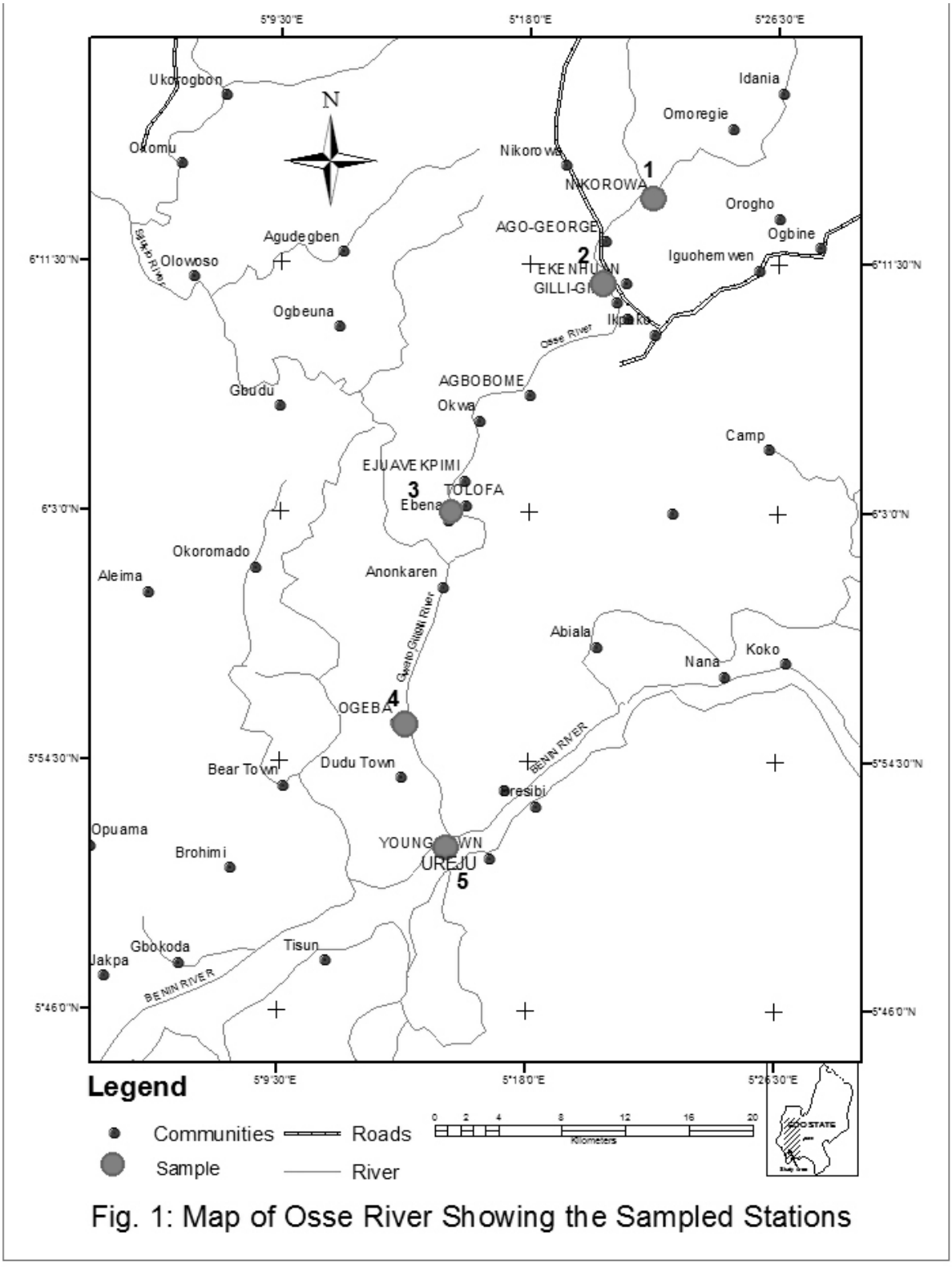

Fig. 1: Map of Osse River Showing the Sampled Stations

MATERIALS AND METHODS

Phytoplankton collection was carried out from January 2003 to April 2004, covering the wet and dry seasons. Phytoplankton samples were collected monthly in the open water using plankton net of 55 μm mesh size tied into a motorized boat and towed at low speed in all stations each time for 5 minutes. The samples were transferred into 200 ml capacity properly labeled plastic containers and immediately preserved with 4% formalin solution. Samples were examined with a Leitz Orthoplan Research Microscope at the phycology laboratory, Department of Plant Biology and Biotechnology, University of Benin, Benin City. Each sample was concentrated to 10ml volume in the laboratory by centrifugation. Two drops from this 10ml were used for slide mount for microscopic examination. Ten slide mounts were examined and phytoplankton organisms recorded in each mount as described by Lackey (1938). The average count was taken to get the relative number of organisms per ml of original water sample. Identification of phytoplankton organisms was done by reference to published works of Opute (1991, 2000 and 2003), Kadiri (1987), Prescott (1975),Yungfang and Maosen (1995) and Botes (2001). The following diversity indices were used for the ecological data analysis (Ogbeibu, 2005).

(i) For Margelef species richness index (d);

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

where, S = Total number of species
N = Total number of individuals
In = The natural or Naperian logarithm ($\log_e$)

(ii) Shannon-Weiner Diversity index (H)

$$H = \frac{N\log N - \sum_{i=1}^{s} fi \log fi}{N}$$

Where, H = Species diversity
fi = No. of individuals of the ith species
N = Total no. of the individuals in the collection and
Σ = Sum

iii. Evenness index (E)

$$E = \frac{H}{Hmax} = \frac{H}{\log S}$$

Where, S = Total number of species
H = Species diversity

(iv) Simpson's Dominance index (C)

$$C = \sum \left({}^{ni}/_{N}\right)^2$$

RESULTS

One hundred and fifty four (154) species of phytoplankton were recorded. Phytoplankton abundance ranged between 6300 orgs/ml (station 1) and 53496 orgs/ml (station 5).

Table 1: Relative Phytoplankton Abundance in Osse River, January 2003-April 2004.

Phytoplankton	Phytoplankton Abundance (counts/ml)	Percentage Abundance (%)	No of Species	Station	Phytoplankton Abundance (counts/ml)
Bacillariophyceae	97333	79.00	53	1	6300
Chlorophyceae	24366	19.77	75	2	16167
Euglenophyceae	287	0.23	15	3	9994
Cyanophyceae	1235	1.00	11	4	37264
	123221	100.00	154	5	53496
Total				5	123221

A total of 53 species of diatoms were recorded in the study. *Coscinodiscus centralis* (30376 orgs/ml) was the most dominant followed by *Actinoptychus splendens* (13458 orgs/ml), *Aulacoseira granulata* var. *angustissima* Muller (11446 orgs/ml) and *Surirella robusta* (9054 orgs/ml). Thirty five (35) diatom species were recorded in station 5 and the minimum of 20 species was recorded in station 3.

Blue-green algae species ranged between 5 species in station 4 and 10 species in station 1. *Tychonema bornettia* (494 orgs/ml) was the most abundant while other prominent species were: *Oscillatoria princeps* (230orgs/ml), *Merismepodia smithii* (186 orgs/ml) and *Oscillatoria proboscidea* (180 orgs/ml).

The maximum number of Euglenophyceae species (7species) was recorded in Station 3 and the minimum (2species) was recorded in Station 4. *Lepocinclis oxyuris* (134 orgs/ml) was the most abundant euglenoid. Generally, *Lepocinclis* species had the highest abundance of the Euglenophyceae.

The number of green algae ranged from 23 species (Station 5) to 55 in Stations 1 and 2 respectively. *Volvox aureus* (9181orgs/ml) was the most abundant species. Others were: *Volvox africana* (8707 orgs/ml) and *Spirogyra dubia* (1896 orgs/ml).

Table 2 :Phytoplankton ecological indices in study stations

Bacillariophyceae							
S/N		Station 1	Station 2	Station 3	Station 4	Station 5	Total
1.	Actinoptychus splendens (Shadbolt) Ralfs ex Pritchard			2	8934	4522	13458
2.	Aulacoseira ambigua (Grunow) Simonsen	70			24		94
3.	Aulacoseira granulata (Ehrenberg) Simonsen	6	10				16
4.	Aulacoseira granulata F. spiralis (Hustedt) D.B.Czarnecki & D.C. Reinke	28		44	4054	292	4418
5.	Aulacoseira granulata var. angustissima (O.F. Müller) Simonsen	74	6840	1566		2966	11446
6.	Coscinodiscus centralis Ehrenberg	2		2	4192	26180	30376
7.	Cyclotella sp				158	860	1018
8.	Cymbella sp	6	4		6		16
9.	Ditylum brightwelli (T.West) Grunow				104	198	302
10.	Ditylum sol (Grunow) De Toni					2	2
11.	Eunotia asterionelloides Hustedt	16	24	2	38	4	84
12.	Eunotia flexuosa (Brébisson ex Kützing) Kützing	10	8		12		30
13.	Eunotia monodon var. tropica (Hustedt) Hustedt	2	2				4
14.	Eunotia pectinalis (Dillw and Kutz) Rabh.	4	4	4			12
15.	Eunotioforma elongata (R.Patrick) J.P.Kociolek & A.L.Burliga		4	4	90	72	170
16.	Fragilariforma javanica (Hustedt) C.E.Wetzel, E.Morales & L.Ector	234	122	180	100	78	714
17.	Fragillaria sp	248	565	236	372	1176	2597
18.	Frustulia rhomboides (Ehrenberg) De Toni	28	40	28	20	18	134
19.	Gyrosigma balticum (Ehrenberg) Rabenhorst				2	4	6
20.	Hydrosera sp	30	6	14	12		62
21.	Melosira moniliformis (O.F.Müller) C.Agardh				86	76	162
22.	Melosira nyassensis var. victoriae Otto Müller				70	56	126
23.	Navicula gastrum (Ehrenberg) Kützing					2	2
24.	Navicula sp	2					2
25.	Naviculadicta vaucheriae (J.B.Petersen) Lange-Bertalot					2	2
26.	Nitzschia palacea Grunow	6					6
27.	Odontella longicruris (Greville) M.A.Hoban					6	6
28.	Pinnularia cardinaliculus Cleve	38	68	16	16	12	150
29.	Pinnularia divergens W. Smith f. capitata Cleve -Euler		6				6
30.	Pinnularia nobilis (Ehrenberg) Ehrenberg	4	2				6
31.	Pinnularia rivularis Hustedt	4					4
32.	Pinnularia subcapitata W.Grego ry		4				4
33.	Pinnularia viridis (Nitzsch) Ehrenberg	6	6	4	6	2	24
34.	Pleurosigma angulatum (Queckett) W. Smith					18	18
35.	Pleurosigma declicatulum W. Smith		4				4
36.	Pleurosigma decorum W. Smith				4	8	12
37.	Pleurosigma formosum W. Smith				52	60	112
38.	Stenopterobia rautenbachiae Cholnoky				2		2
39.	Surirella elegans Ehrenberg	416	326	24	326	32	1124
40.	Surirella engleri Muller f. genuina recta.	2	4			2	8
41.	Petrodictyon gemma (Ehrenberg) D.G.Mann	220	86	8	2		316
42.	Surirella robusta Ehrenberg	22	6		5506	3520	9054
43.	Surirella celebesiana Hustedt	8	36	4	12		60
44.	Fragilaria acus (Kützing) Lange-Bertalot	88	102	108	36	34	368
45.	Synedra superba Kützing	616	40	164	60	40	920

Table 2 :Continued

		Station 1	Station 2	Station 3	Station 4	Station 4	Total
46.	Synedra ulna (Nitzsch) Ehrenberg	82	182	134	34	24	456
47.	Tabellaria fenestrata (Lyngbye) Kützing	2		24	42	64	132
48.	Tabellaria flocculosa (Roth) Kützing					4	4
49.	Terpsinoë musica Ehrenberg	14	6		6		26
50.	Thalassionema frauenfeldii (Grunow) Tempère & Peragallo				286	2598	2884
51.	Triceratium favus Ehrenberg					2	2
52.	Trieres regia (M.Schultze) M.P.Ashworth & E.C.Theriot				2998	6024	9022
53.	Trieres chinensis (Greville) M.P.Ashworth & E.C.Theriot				3208	4142	7350
Cyanophyceae							
1.	Anabaena alatospora Gonzalvez & Kamat	4			4	4	12
2.	Lemmermanniella pallida (Lemmermann) Geitler					4	4
3.	Coelosphaerium sp	11	6	10		2	29
4.	Lyngbya majuscula Harvey ex Gomont	22	32	14		4	72
5.	Merismopedia smithii De Toni	42	64	72	8		186
6.	Microcystis aeruginosa (Kützing) Kützing	4		8			12
7.	Tychonema bornetii (Zukal) Anagnostidis & Komárek	250	102	74	54	14	494
8.	Oscillatoria curviceps C.Agardh ex Gomont	2	6	4		2	14
9.	Oscillatoria limosa C.Agardh ex Gomont	2					2
10.	Oscillatoria princeps Vaucher ex Gomont	46	54	54	54	22	230
11.	Oscillatoria proboscidea Gomont	70	4	82	18	6	180
Euglenophyceae							
1.	Lepocinclis acus (O.F.Müller) Marin & Melkonian	18					18
2.	Lepocinclis helicoidea (Bernard) M.S.Bennett & R.E. Triemer	4	6				10
3.	Lepocinclis oxyuris (Schmarda) Marin & Melkonian	60	52	16	4	2	134
4.	Lepocinclis spirogyroides Marin & Melkonian				8		8
5.	Euglena viridis (O.F.Müller) Ehrenberg	6					6
6.	Lepocinclis dextrosa Thom	2					2
7.	Lepocinclis playfairiana (Deflandre) Deflandre					16	16
8.	Phacus longicauda var. major Swirenko		4	2		2	8
9.	Strombomonas australica (Playfair) Deflandre			12			12
10.	Strombomonas ensifera (Daday) Deflandre			2			2
11.	Strombomonas ensifera var. javanica Huber-Pestalozzi			2			2
12.	Trachelomonas caudata (Ehrenberg) Stein		2				2
13.	Trachelomonas dastuguei Balech			3			3
14.	Trachelomonas eurystoma var. nuda Szabados			56			56
15.	Trachelomonas spinosa Stokes	8					8
Chlorophyceae							
1.	Actinotaenium mooreanum var. mooreanum (W.Archer) Teiling (P)				2		2
2.	Bambusina brebissonii var. major (Raciborski) Croasdale (P)				2		2
3.	Cladophora rivularis (Linnaeus) Hoek	48	16	8			72
4.	Closterium acerosum Ehrenberg ex Ralfs	66	40	24	8	10	148
5.	Closterium dianae var. arcuatum (Brebisson ex Ralfs) Rabenhorst	4					4
6.	Closterium ehrenbergii Meneghini ex Ralfs	50	34	12	6	2	104
7.	Closterium gracile Brébisson ex Ralfs		6	4	12	8	30
8.	Closterium kuetzingii Brébisson	24	12	10	12	4	62
9.	Closterium lineatum Ehrenberg ex Ralfs			2	6	26	34
10.	Closterium lunula var. maximum Borge	18	16	2			36
11.	Closterium lunula var. maximum f. crassimum H.T.Croasdale	328	132	50		2	512
12.	Closterium moniliferum Ehrenberg ex Ralfs	112	38	34	18	16	218
13.	Closterium ralfsii var. hybridum Rabenhorst	2	4	2		4	12
14.	Closterium setaceum Ehrenberg ex Ralfs	12		16	16		44
15.	Closterium turgidum var. borgei Deflandre		2				2
16.	Closterium lunula Ehrenberg & Hemprich ex Ralfs	258	114	28	4		404
17.	Coelastrum cambricum W.Archer		4			4	8
18.	Coelastrum microporum Nägeli		4				4
19.	Cosmarium askenasyi f. latum A.M.Scott & Prescott	6	78	8			92
20.	Cosmarium birectum var. floridenseWolle		2				2
21.	Cosmarium decoratum West & G.S.West	16	16	10			42

Table 2 :Continued

		Station 1	Station 2	Station 3	Station 4	Station 4	Total
22.	Cosmarium depressum (Nägeli) P.Lundell	2					2
23.	Cosmarium monodii Bourrelly	6	12	6			24
24.	Cosmarium pyramidatum Brébisson ex Ralfs		2	4			6
25.	Cosmarium sabbulteum Schmidle var. Maius Thom		2	2			4
26.	Cosmarium salisburyi F.E.Fritsch & M.F.Rich		2				2
27.	Cosmarium subauriculatum West & G.S.West	4	20				24
28.	Desmidium baileyi f. tetragonum Nordstedt	2	2	2			6
29.	Desmidium quadratum Nordstedt	18	8	2	2		30
30.	Desmidium swartzii C.Agardh ex Ralfs	2	4				6
31.	Euastrum didelta var. bengalicum Lagerheim	4	6				10
32.	Euastrum spinulosum var. lindae R.L.Grönblad & A.M.Scott	2		16			18
33.	Eudorina elegans Ehrenberg	98	32	120	218	32	500
34.	Gonatozygon aculeatum W.N.Hastings			2			2
35.	Gonatozygon kinahanii (W.Archer) Rabenhorst			8	2		10
36.	Gonatozygon monotaenium De Bary			6	4		10
37.	Hyalotheca dissiliens Brébisson ex Ralfs	8	2	4	6	4	24
38.	Micrasterias ambadiensis (R.L.Grönblad & A.M.Scott) K.Thomasson	4					4
39.	Micrasterias americana Ehrenberg ex Ralfs		6	12			18
40.	Micrasterias apiculata var. stuhlmannii (G.H.E.W.Hieronymus) P.Bourrelly (P)	12	10	4	4	2	32
41.	Micrasterias fimbriata Ralfs	12	10	2			24
42.	Micrasterias foliacea J.W.Bailey ex Ralfs	62	60	47			169
43.	Micrasterias mahabuleshwarensis var. dichotoma G.M.Smith	26	22	12	8		68
44.	Micrasterias radians var. bogoriensis (C.J.Bernard) Willi Krieger	2					2
45.	Micrasterias thomasiana var. notata (Nordstedt) Grönblad	48	24	6			78
46.	Micrasterias torreyi var. curvata Willi Krieger	6	6	6	2		20
47.	Mougeotia sphaerocarpa Wolle	319	98	66	14	14	511
48.	Oedogonium grande Kützing ex Hirn	46	14	22	24	6	112
49.	Oedogonium suecicum Wittrock ex Hirn	16	24	10	24	2	76
50.	Pandorina morum (O.F.Müller) Bory de Saint -Vincent	6	2	8	8	4	28
51.	Pandorina sp	2					2
52.	Pseudopediastrum boryanum (Turpin) E.Hegewald	2					2
53.	Pediastrum boryanum var. longicorne Reinsch		4				4
54.	Pediastrum duplex Meyen		10	46			56
55.	Pediastrum duplex var. subgranulatum Raciborski	4	14				18
56.	Stauridium tetras (Ehrenberg) E.Hegewald	2					2
57.	Pleodorina illinoisensis Kofoid	8	16	26	32	2	84
58.	Pleurotaenium nodulosum (Brébisson ex Ralfs) Rabenhorst		2				2
59.	Pleurotaenium coronatum var. fluctuatum West & G.S.West	4					4
60.	Pleurotaenium ehrenbergii (Ralfs) Delponte	16	2	2			20
61.	Pleurotaenium ovatum (Nordstedt) Nordstedt	36	6	6			48
62.	Pleurotaenium ovatum var. tumidum (Maskell) G.S.West	14	10		2		26
63.	Pleurotaenium subcoronulatum (W.B.Turner) West & G.S.West (P)	26	10	2			38
64.	Pleurotaenium subcoronulatum var. africanum (Schmidle) Willi Krieger (P)	24	4	2			30
65.	Scenedesmus quadricauda (Turpin) Brébisson			14			14
66.	Desmodesmus magnus (Meyen) Tsarenko	6		2			8

Table 2 :Continued

		Station 1	Station 2	Station 3	Station 4	Station 4	Total
67.	Spirogyra communis (Hassall) Kützing	128	38	26	8		200
68.	Spirogyra dubia Kützing	1028	570	270	16	12	1896
69.	Spirogyra insignis (Hassall) Kützing	6				16	22
70.	Spirogyra karnalae Randehawa		2	10	6	4	22
71.	Spirogyra majuscule Kützing	80	42	18	28	20	188
72.	Triplocerus gracile Bail var bidentum Nordst	2			2		4
73.	Ulothrix tenuissima Kützing	34	34	58	8		134
74.	Volvox africana G.S.West	128	2609	2908	2982	80	8707
75.	Volvox aureus Ehrenberg	262	3069	3048	2758	44	9181
		ST.1	**ST.2**	**ST.3**	**ST.4**	**ST.5**	
	Taxa_S	**101**	**93**	**86**	**73**	**69**	
	Individuals	**6300**	**16167**	**9994**	**37264**	**53496**	
	Shannon_H	**3.433**	**2.067**	**2.234**	**2.334**	**1.829**	
	Simpson_1-D	**0.9418**	**0.7554**	**0.7949**	**0.8701**	**0.7241**	
	Evenness_e^H/S	**0.3066**	**0.08499**	**0.1086**	**0.1414**	**0.09026**	
	Margalef	**11.43**	**9.494**	**9.229**	**6.84**	**6.246**	

Fig.2 below shows that station 5 accounts for the highest number of individuals (53496 orgs) throughout the study followed by station 4 with 3726 orgs. They are however lower in terms of the number of species present (73 for station 4 and 69 for station 5) compared to stations 1to 3 with lower number of individuals (station 1; 6300 orgs, station 2, 16167 and station 3, 9994) and higher number of species (station 1; 101, station 2; 93 and station 3; 86)

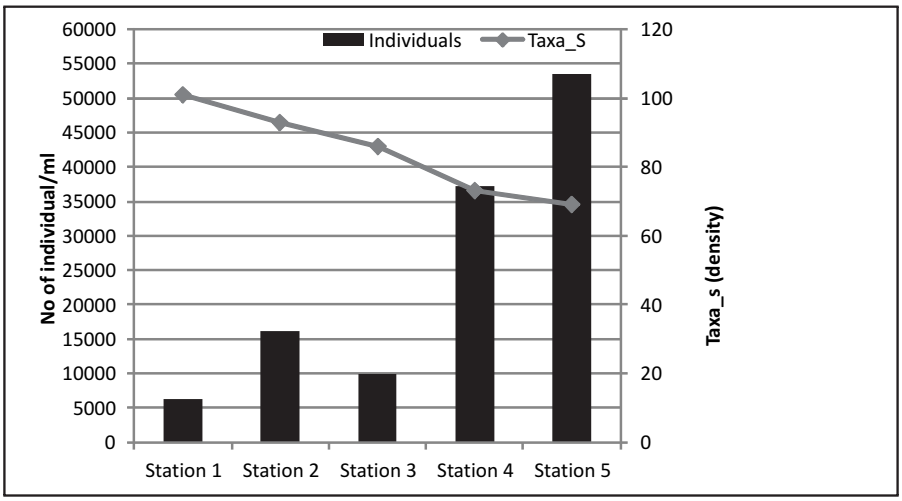

Fig 2: Individuals and Taxa Density of Phytoplankton Species in the Study Stations, January 2003-April 2004.

Phytoplankton of Osse River During the Wet and Dry Seasons

For each phytoplankton group, wet and dry season composition was studied. For Bacillariophyceae (Table 3), dry season count (85016 orgs/ml) was higher than wet season (12317 orgs/ml). The observed dominant species for the dry season was *Coscinodiscus centralis* (29442 orgs/ml) while the dominant species for the wet season was *Aulacoseira granulata* var.*angustissima* Muller (6166orgs/ml).

Table 3: Relative Phytoplankton Abundance (Bacillariophyceae) of Osse River During the Wet and Dry Seasons

S/N	Bacillariophyceae	Wet season	Dry season	Total
1.	Actinoptychus splendens (Shadbolt) Ralfs ex Pritchard	144	13314	13458
2.	Aulacoseira ambigua (Grunow) Simonsen	12	82	94
3.	Aulacoseira granulata (Ehrenberg) Simonsen	6	10	16
4.	Aulacoseira granulata var. angustissima (O.F. Müller) Simonsen	6166	5280	11446
5.	Aulacoseira granulata F. spiralis (Hustedt) D.B.Czar necki & D.C. Reinke	176	4242	4418
6.	Odontella longicruris (Greville) M.A.Hoban	2	4	6
7.	Coscinodiscus centralis Ehrenberg	934	29442	30376
8.	Cyclotella sp	216	800	1016
9.	Cymbella sp	6	10	16
10.	Fragilariforma javanica (Hustedt) C.E.Wetzel, E.Morales & L.Ector	82	88	170
11.	Ditylum brightwelli (T.West) Grunow	6	296	302
12.	Ditylum sol (Grunow) De Toni	-	2	2
13.	Eunotia asterionelloides Hustedt	8	76	84
14.	Eunotia flexuosa (Brébisson ex Kützing) Kützing	12	18	30
15.	Eunotia monodon var. tropica (Hustedt) Hustedt	4	-	4
16.	Eunotia pectinalis (Dillw and Kutz) Rabh.	12	-	12
17.	Fragillaria sp	1015	1582	2597
18.	Fragilariforma javanica (Hustedt) C.E.Wetzel, E.Morales & L.Ector	212	502	714
19.	Frustulia rhomboides (Ehrenberg) De Toni	72	72	144
20.	Gyrosigma balticum (Ehrenberg) Rabenhorst	-	6	6
21.	Hydrosera sp	38	24	62
22.	Melosira moniliformis (O.F.Müller) C.Agardh	78	84	162
23.	Melosira nyassensis var. victoriae Otto Müller	44	82	126
24.	Navicula gastrum (Ehrenberg) Kützing	-	2	2
25.	Navicula sp	2	-	2
26.	Naviculadicta vaucheriae (J.B.Pe tersen) Lange-Bertalot	-	2	2
27.	Nitzschia palacea Grunow	6	-	6
28.	Trieres regia (M.Schultze) M.P.Ashworth & E.C.Theriot	260	8762	9022
29.	Trieres chinensis (Greville) M.P.Ashworth & E.C.Theriot	258	7120	7378
30.	Pinnularia cardinaliculus Cleve	54	96	150
31.	Pinnularia divergens W. Smith f. capitata Cleve -Euler	-	6	6
32.	Pinnularia nobilis (Ehrenberg) Ehrenberg	-	6	6
33.	Pinnularia rivularis Hustedt	4	-	4
34.	Pinnularia subcapitata W.Gregory	-	4	4
35.	Pinnularia viridis (Nitzsch) Ehrenberg	6	18	24
36.	Pleurosigma angulatum (Queckett) W. Smith	-	18	18
37.	Pleurosigma declicatulum W. Smith	-	4	4
38.	Pleurosigma decorum W. Smith	12	-	12
39.	Pleurosigma formosum W. Smith	4	108	112
40.	Stenopterobia rautenbachiae Cholnoky	2	-	2
41.	Surirella celebesiana Hustedt	6	54	60
42.	Surirella elegans Ehrenberg	354	770	1124
43.	Surirella engleri Muller f. genuina recta.	-	-	8
44.	Petrodictyon gemma (Ehrenberg) D.G.Mann	80	236	316
45.	Surirella robusta Ehrenberg	976	8078	9054
46.	Fragilaria acus (Kützing) Lange-Bertalot	176	192	368
47.	Synedra superba Kützing	576	344	920
48.	Synedra ulna (Nitzsch) Ehrenberg	176	280	456
49.	Tabellaria fenestrata (Lyngbye) Kützing	52	52	104
50.	Tabellaria flocculosa (Roth) Kützing	4	-	4
51.	Terpsinoë musica Ehrenberg	10	16	26
52.	Thalassionema frauenfeldii (Grunow) Tempère & Peragallo	54	2830	2884
53.	Triceratium favus Ehrenberg	-	2	2

Wet season count for Cyanophyceae was higher than dry season count (654 orgs/ml to 581 orgs/ml). *Tychonema borneti* was more dominant in both the dry and wet seasons (264 orgs/ml and 230 orgs/ml) (Table 4).

Table 4: Relative Phytoplankton Abundance (Cyanophyceae) Of Osse River During the Wet and Dry Seasons

S/N	Cyanophyceae	Wet Season	Dry Season	Total
1	*Anabaena alatospora* Gonzalvez & Kamat	12	-	12
2	*Lemmermanniella pallida* (Lemmermann) Geitler		4	4
3	*Coelosphaerium* sp	6	23	29
4	*Lyngbya majuscula* Harvey ex Gomont	58	14	72
5	*Merismopedia smithii* De Toni	96	90	186
6	*Microcystis aeruginosa* (Kützing) Kützing	4	8	12
7	*Oscillatoria princeps* Vaucher ex Gomont	140	90	230
8	*Tychonema bornetii* (Zukal) Anagnostidis & Komárek	230	264	494
9	*Oscillatoria curviceps* C.Agardh ex Gomont	8	6	14
10	*Oscillatoria limosa* C.Agardh ex Gomont	2	-	2
11	*Oscillatoria proboscidea* Gomont	98	82	180
	Total	654	581	1235

Euglenophyceae count was higher in the wet season than in the dry season (173 orgs/ml against 114 orgs/ml) with *Lepocinclis oxyuris* being the highest in both seasons (76 orgs/ml wet season and 53 orgs/ml dry season), *Lepocinclis dextrosa* was least recorded in the dry season (2 orgs/ml) while *Phacus longicauda* and *Trachelomonas caudata* were among the least recorded in the wet season with 2 orgs/ml each (Table 5).

Table 5: Relative Phytoplankton Abundance (Euglenophyceae) of Osse River During the Wet and Dry Seasons

S/N	Euglenophyceae	Wet Season	Dry Season	Total
1.	*Lepocinclis acus* (O.F.Müller) Marin & Melkonian	-	18	18
2.	*Lepocinclis helicoidea* (Bernard) M.S.Bennett & R.E. Triemer	10	5	15
3.	*Lepocinclis oxyuris* (Schmarda) Marin & Melkonian	76	53	129
4.	*Lepocinclis spirogyroides* Marin & Melkonian	-	8	8
5.	*Euglena viridis* (O.F.Müller) Ehrenberg	-	6	6
6.	*Lepocinclis dextrosa* Thom	-	2	2
7.	*Lepocinclis playfairiana* (Deflandre) Deflandre	-	16	16
8.	*Phacus longicauda* var. major Swirenko	2	6	8
9.	*Strombomonas ensifera* (Daday) Deflandre	2	-	2
10.	*Strombomonas australica* (Playfair) Deflandre	12	-	12
11.	*Strombomonas ensifera* var. javanica Huber - Pestalozzi	2	-	2
12.	*Trachelomonas caudata* (Ehrenberg) Stein	2	-	2
13.	*Trachelomonas dastuguei* Balech	3	-	3
14.	*Trachelomonas eurystoma* var. nuda Szabados	56	-	56
15.	*Trachelomonas spinosa* Stokes	8	-	8
	Total	173	114	287

Chlorophyceae recorded a wet season count of 11702 orgs/ml while dry season count was higher with 12664 orgs/ml. Most dominant species for both seasons were *Volvox aureus* and *Volvox africana* (Table 6).

Table 6: Relative Phytoplankton Abundance (Chlorophyceae) of Osse River During the Wet and Dry Seasons

S/N	Chlorophyceae	Wet Season	Dry Season	Total
1.	Actinotaenium mooreanum var. mooreanum (W.Archer) Teiling (P)	-	2	2
2.	Bambusina brebissonii var. major (Raciborski) Croasdale (P)	2	-	2
3.	Cladophora rivularis (Linnaeus) Hoek	36	36	72
4.	Closterium acerosum Ehrenberg ex Ralfs	114	32	146
5.	Closterium gracile Brébisson ex Ralfs	20	10	30
6.	Closterium kuetzingii Brébisson	46	16	62
7.	Closterium lineatum Ehrenberg ex Ralfs	6	28	34
8.	Closterium lunula var. maximum Borge	22	14	36
9.	Closterium lunula var. maximum f. crassimum H.T.Croasdale	508	4	512
10.	Closterium moniliferum Ehrenberg ex Ralfs	142	74	216
11.	Closterium ralfsii var. hybridum Rabenhorst	2	10	12
12.	Closterium setaceum Ehrenberg ex Ralfs	20	24	44
13.	Closterium turgidum var. borgei Deflandre	-	2	2
14.	Closterium dianae var. arcuatum (Brebisson ex Ralfs) Rabenhorst	-	4	4
15.	Closterium ehrenbergii Meneghini ex Ralfs	84	20	104
16.	Closterium lunula Ehrenberg & Hemprich ex Ralfs	364	40	404
17.	Coelastrum cambricum W.Archer	-	8	8
18.	Coelastrum microporum Nägeli	-	4	4
19.	Cosmarium askenasyi f. latum A.M.Scott & Prescott	82	10	92
20.	Cosmarium birectum var. floridenseWolle	-	2	2
21.	Cosmarium decoratum West & G.S.West	2	42	44
22.	Cosmarium depressum (Nägeli) P.Lundell	-	2	2
23.	Cosmarium monodii Bourrelly	-	24	24
24.	Cosmarium pyramidatum Brébisson ex Ralfs	-	6	6
25.	Cosmarium sabbulteum Schmidle var. Maius Thom	4	-	4
26.	Cosmarium salisburyi F.E.Fritsch & M.F.Rich	2	-	2
27.	Cosmarium subauriculatum West & G.S.West	-	24	24
28.	Scenedesmus quadricauda (Turpin) Brébisson	10	4	14
29.	Desmidium baileyi f. tetragonum Nordstedt	-	6	6
30.	Desmidium quadratum Nordstedt	26	4	30
31.	Desmidium swartzii C.Agardh ex Ralfs	-	6	6

33.	Euastrum spinulosum var. lindae R.L.Grönblad & A.M.Scott	2	16	18
34.	Eudorina elegans Ehrenberg	256	244	500
35.	Gonatozygon aculeatum W.N.Hastings	-	2	2
36.	Gonatozygon kinahanii (W.Archer) Rabenhorst	-	10	10
37.	Gonatozygon monotaenium De Bary	4	6	10
38.	Hyalotheca dissiliens Brébisson ex Ralfs	18	6	24
39.	Micrasterias ambadiensis (R.L.Grönblad & A.M.Scott) K.Thomasson	4	-	4
40.	Micrasterias americana Ehrenberg ex Ralfs	14	4	18
41.	Micrasterias apiculata var. stuhlmannii (G.H.E.W.Hieronymus) P.Bourrelly (P)	12	20	32
42.	Micrasterias fimbriata Ralfs	18	6	24
43.	Micrasterias foliacea J.W.Bailey ex Ralfs	20	149	169
44.	Micrasterias mahabuleshwarensis var. dichotoma G.M.Smith	28	40	68
45.	Micrasterias radians var. bogoriensis (C.J.Bernard) Willi Krieger	-	2	2
46.	Micrasterias thomasiana var. notata (Nordstedt) Grönblad	66	12	78
47.	Micrasterias torreyi var. curvata Willi Krieger	8	12	20
48.	Mougeotia sphaerocarpa Wolle	146	365	511
49.	Oedogonium grande Kützing ex Hirn	62	50	112
50.	Oedogonium suecicum Wittrock ex Hirn	42	34	76
51.	Pandorina morum (O.F.Müller) Bory de Saint -Vincent	6	22	28
52.	Pandorina sp	-	2	2
53.	Pseudopediastrum boryanum (Turpin) E.Hegewald	-	2	2
54.	Pediastrum boryanum var. longicorne Reinsch	-	4	4
55.	Pediastrum duplex Meyen	46	10	56
56.	Pediastrum duplex var. subgranulatum Raciborski	16	2	18
57.	Stauridium tetras (Ehrenberg) E.Hegewald	-	2	2
58.	Pleodorina illinoisensis Kofoid	4	80	84
59.	Pleurotaenium coronatum var. fluctuatum West & G.S.West	2	2	4
60.	Pleurotaenium nodulosum (Brébisson ex Ralfs) Rabenhorst	2	-	2
61.	Pleurotaenium ehrenbergii (Ralfs) Delponte	14	6	20
62.	Pleurotaenium ovatum var. tumidum (Maskell) G.S.West	20	6	26
63.	Pleurotaenium subcoronulatum var. africanum (Schmidle) Willi Krieger (P)	28	2	30
64.	Pleurotaenium subcoronulatum (W.B.Turner) West & G.S.West (P)	36	2	38
65.	Pleurotaenium ovatum (Nordstedt) Nordstedt	40	8	48
66.	Desmodesmus magnus (Meyen) Tsarenko	2	6	8
67.	Spirogyra communis (Hassall) Kützing	70	130	200
68.	Spirogyra dubia Kützing	1068	828	1896
69.	Spirogyra insignis (Hassall) Kützing	22	-	22
70.	Spirogyra karnalae Randehawa	12	12	24
71.	Spirogyra majuscule Kützing	62	126	188

72.	Triplocerus gracile Bail var bidentum Nordst	4	-	4
73.	Ulothrix tenuissima Kützing	28	106	134
74.	Volvox africana G.S.West	3574	5133	8707
75.	Volvox aureus Ehrenberg	4454	4727	9181
	Total	11702	12664	24366

	Grand total (count/ml)	24846	98 375	123221
	Percentage abundance (%)	20.164%	79.836%	

Phytoplankton Distribution in Osse River

Bacillariophyceae contributed the highest number of phytoplankton 79.00% in Osse River followed by Chlorophyceae 19.77% and Cyanophyceae 1.00%. The lowest was Euglenophyceae 0.23% (Fig.3).

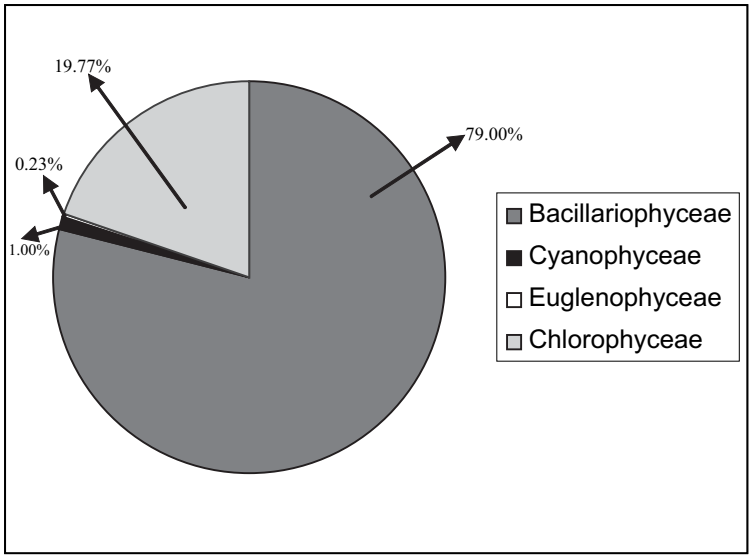

Fig. 3: Percentage Distribution of Phytoplankton Groups in Osse River, Jannuary 2003-April 2004.

Classes Species Diversity

Table 7 shows that Chlorophyceae was the most diversified phytoplankton in terms of Margelef species richness (d). The highest species richness of green algae, 6.63 was recorded in station 1 and the lowest in station 4 (3.55). For Bacillariophyceae (Table 2), Station 1 recorded the highest d.of 3.75 and station 3 the minimum with 2.42. In Table 3, Station 5 recorded the maximum for Cyanophyceae (1.72) and minimum 1.07 for station 2. The highest d for Euglenophyceae (Table 4) was observed in Station 3 with 1.32 and the lowest d of 0.40 in station 4. Shannon-Weiner index (H), ranged from 0.92 (Station 2) to 2.34 (Station 1) for Bacillariophyceae, 1.11 (Station 4) to 2.75 (Station 1) for Chlorophyceae, 0.64 (Stations 4 and 5) to 1.23 (Station 3) for Euglenophyceae and 1.27 (Station 4) to 1.73 (Stations 5) for Cyanophyceae. Generally, Dominance Index (C) and Evenness Index (E) were low (less than 1) for all taxa.

TABLE 7: Ecological indices of Osse River for Bacillariophyceae group, January 2003-April 2004.

Bacillariophyceae	Station 1	Station 2	Station 3	Station 4	Station 5
Taxa_S	30	27	20	34	35
Individuals	2288	8507	2568	30870	53100
Shannon_H	2.338	0.9174	1.512	2.009	1.777
Simpson_1-D	0.8573	0.3466	0.6055	0.8281	0.72
Evenness_e^H/S	0.3453	0.09269	0.2267	0.2194	0.1689
Margalef	3.749	2.873	2.42	3.192	3.125

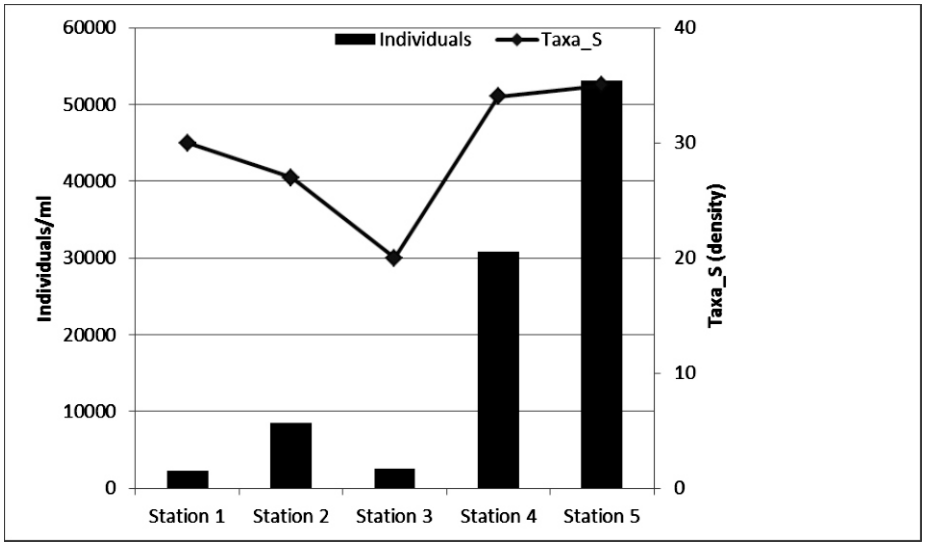

Fig 4 : Individuals and taxa density of Bacillariophyceae species in the study stations, January 2003-April 2004.

TABLE 8: Ecological indices of Osse River for Cyanophyceae group, January 2003-April 2004.

Cyanophyceae	Station 1	Station 2	Station 3	Station 4	Station 5
Taxa_S	10	7	8	5	8
Individuals	453	268	318	138	58
Shannon_H	1.438	1.519	1.72	1.268	1.731
Simpson_1-D	0.6495	0.742	0.7955	0.6725	0.7705
Evenness_e^H/S	0.4212	0.6526	0.6982	0.7105	0.7058
Margalef	1.472	1.073	1.215	0.8118	1.724

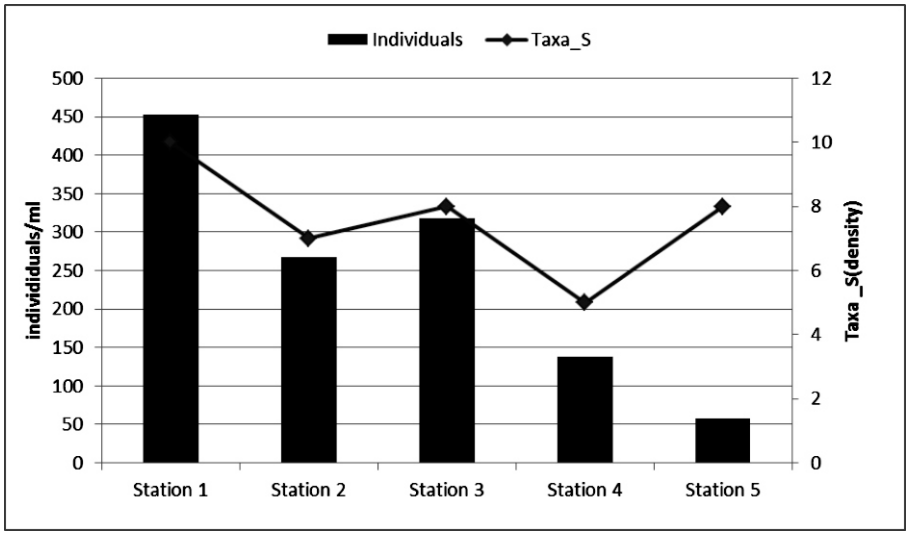

Fig 5: Individuals and taxa density of Cyanophyceae species in the study stations, January 2003-April 2004.

TABLE 9: Ecological indices of Osse River for Euglenophyceae group, January 2003-April 2004.

Euglenophyceae	Station 1	Station 2	Station 3	Station 4	Station 5
Taxa_S	6	4	7	2	3
Individuals	98	64	93	12	20
Shannon_H	1.197	0.6722	1.231	0.6365	0.639
Simpson_1-D	0.5789	0.3262	0.5887	0.4444	0.34
Evenness_e^H/S	0.5518	0.4896	0.4892	0.9449	0.6315
Margalef	1.091	0.7213	1.324	0.4024	0.6676

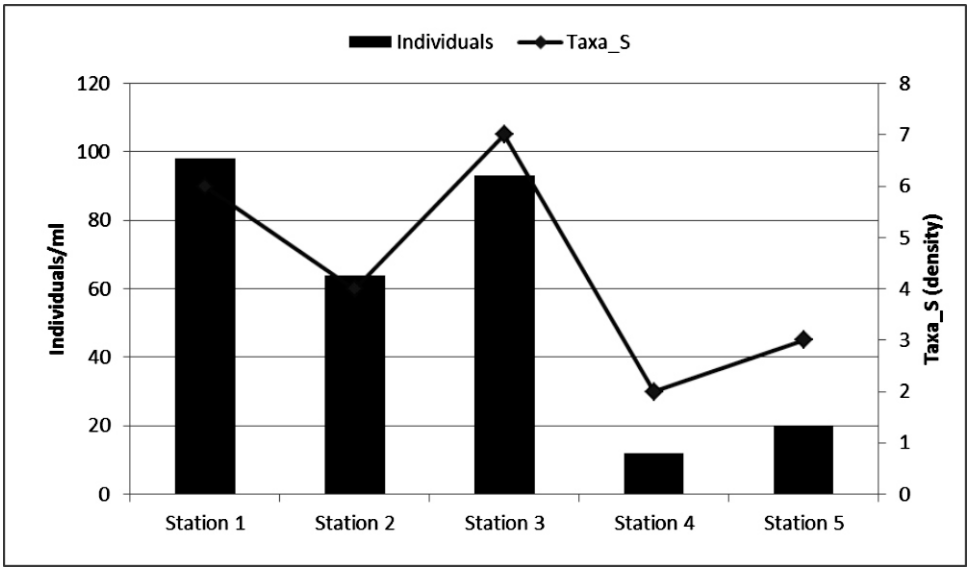

Fig 6: Individuals and taxa density of Euglenophyceae species in the study stations, January 2003-April 2004.

TABLE 10: Ecological indices of Osse River for Chlorophyceae group, January 2003-April 2004.

Chlorophyceae	Station 1	Station 2	Station 3	Station 4	Station 5
Taxa_S	55	55	51	32	23
Individuals	3461	7328	7015	6244	318
Shannon_H	2.75	1.7	1.466	1.112	2.559
Simpson_1-D	0.8758	0.6906	0.6372	0.5755	0.8852
Evenness_e^H/S	0.2845	0.09951	0.08494	0.09499	0.5616
Margalef	6.626	6.068	5.646	3.547	3.818

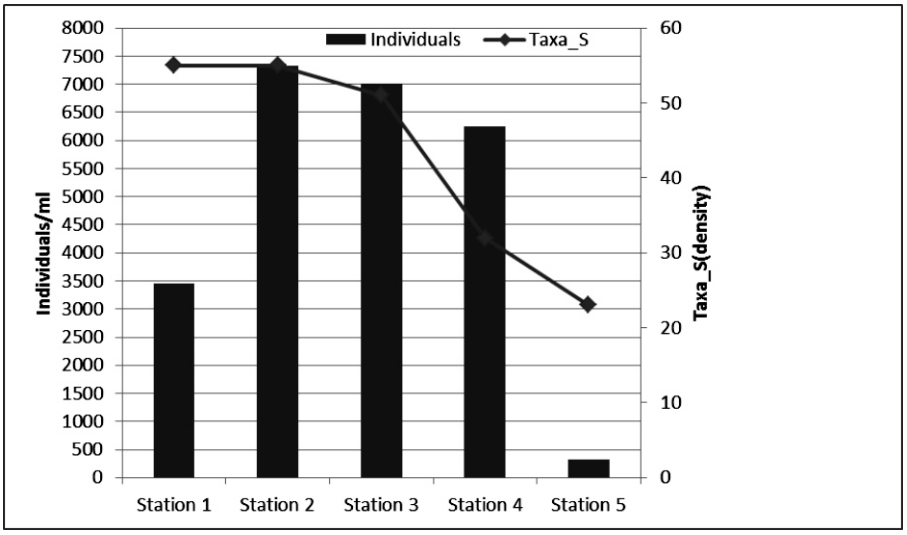

Fig 7: Individuals and taxa density of Chlorophyceae species in the study stations, January2003-April 2004.

Similarity analysis (fig 8), reveals that stations 1 and 2 have similar species present in them while stations 4 and 5 have similar species present in them as well but different from what obtained in Stations 1,2 and 3. More so, the similarity between species in Stations 1 and 2 is closer to species present in Station 3 than they are to Stations 4 and 5.

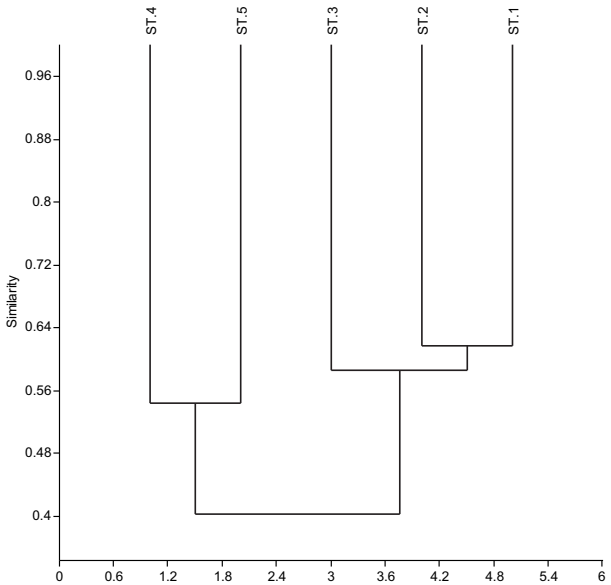

Fig 8: CLUSTER ANALYSIS AMONG STATIONS USING JACCARD SIMILARITIES

Monthly Variations in Phytoplankton Abundance

Figures 9 – 13 show the monthly variations in phytoplankton abundance across the stations studied. In Station 1, Chlorophyceae was dominant in the month of October with 926 orgs/ml. This was followed by Bacillariophyceae with 598 orgs/ml in March. In Station 2, Bacillariophyceae was the dominant group in the month of May with 5543 orgs/ml. This was closely followed by Chorophyceae in February with 4476 orgs/ml. For Station 3, Chlorophyceae group was dominant in February (3900orgs/ml) followed by 1878 orgs/ml in May for the same division before Bacillariophyceae (888 orgs/ml) in May. In Station 4, the dominant group was Bacillariophyceae in April (13002 orgs/ml). This was followed by 9148 orgs/ml in January in the same group, and distantly followed by Chlorophyceae in May (5300 orgs/ml). Bacillariophyceae dominated in the month of April (32912 orgs/ml) in Station 5 while few Chlorophyceae forms were observed at this station during the period of study.

Cyanophyceae and Englenophyceae counts were low compared to the observations in the Bacillariophyceae and Chlorophyceae groups

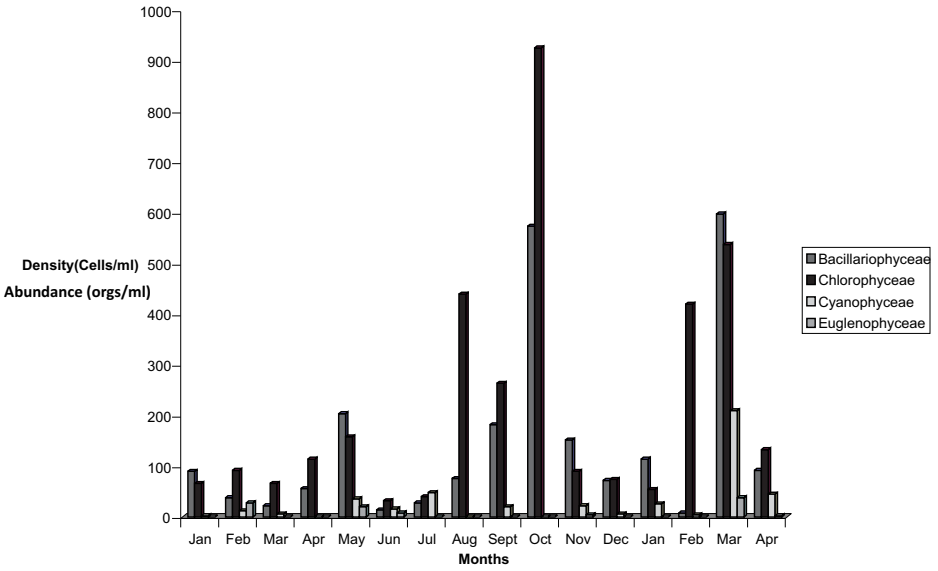

Fig.9: Monthly variations in phytoplankton abundance (orgs/ml) in Station 1 from January 2003 to April 2004

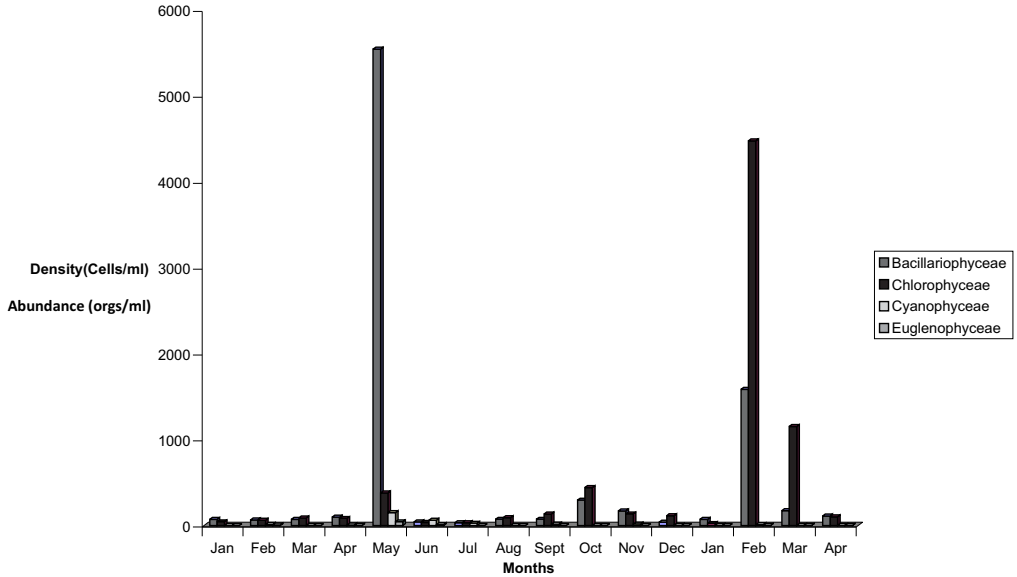

Fig.10: Monthly variations in phytoplankton abundance (orgs/ml) in Station 2 from January 2003 to April 2004

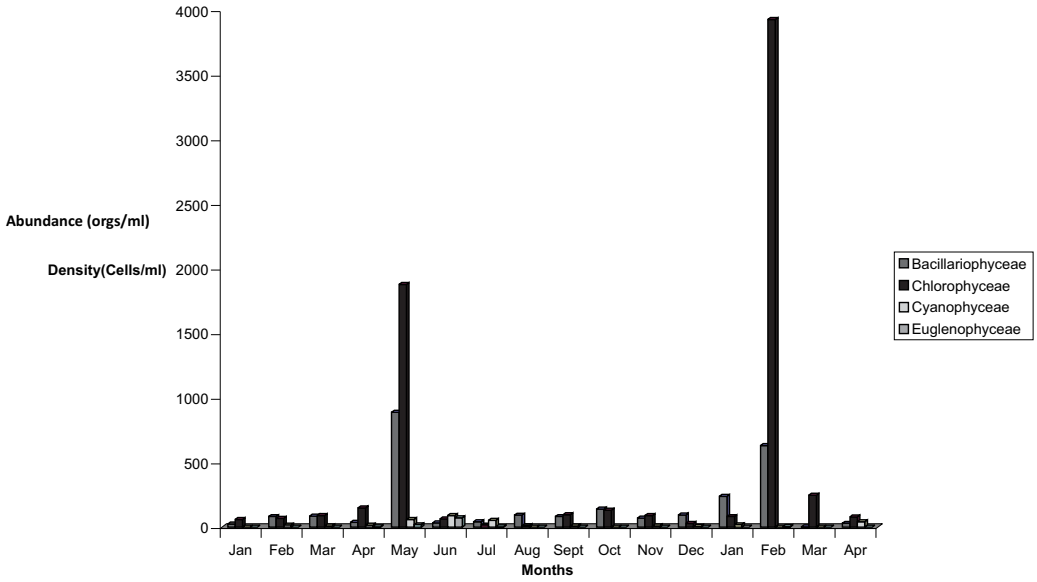

Fig.11: Monthly variations in phytoplankton abundance (orgs/ml) in Station 3 from January 2003

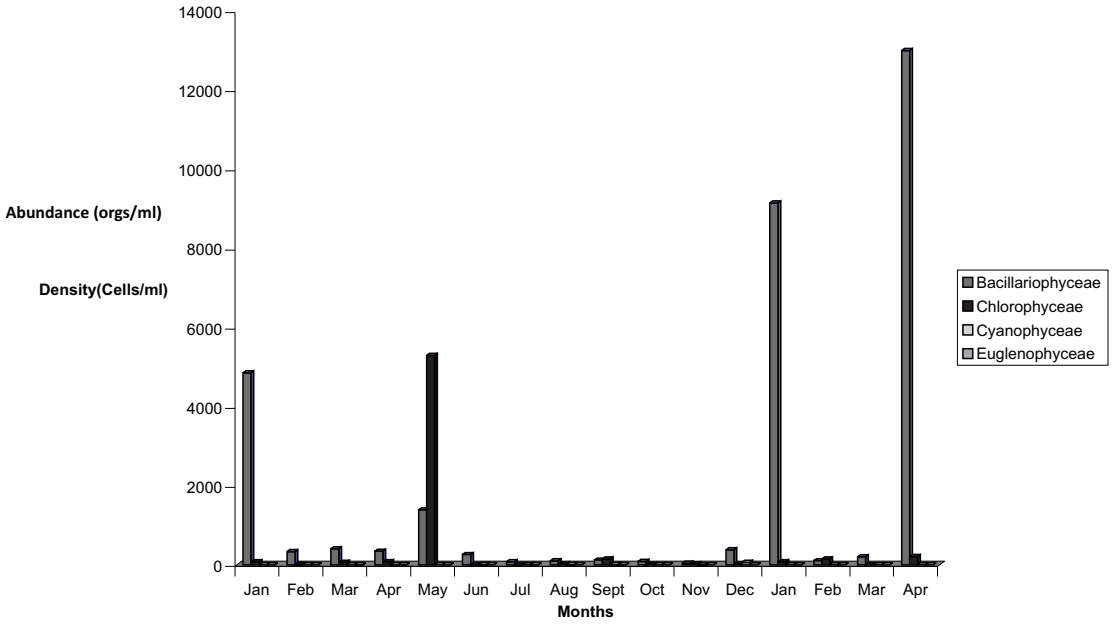

Fig.12: Monthly variations in phytoplankton abundance (orgs/ml) in Station 4 from January 2003 to April 2004

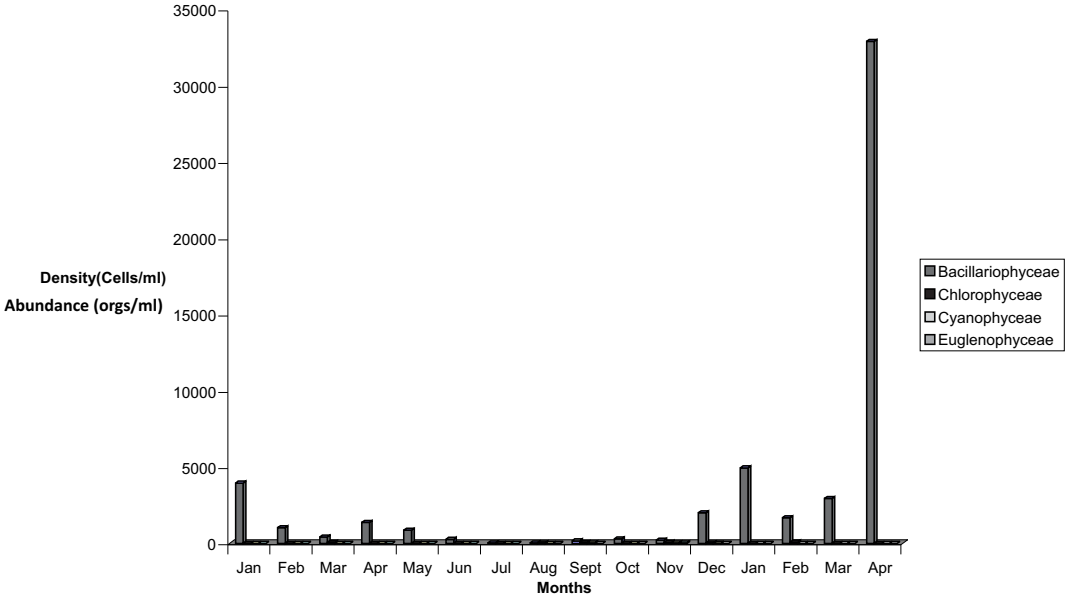

Fig.13: Monthly variations in phytoplankton abundance (orgs/ml) in station 5 from January 2003 to April 2004

DISCUSSION

The diversity of a community depends on the species richness and species evenness. Species richness is the aspect of diversity that relates to the number of species present in the community whereas, species evenness relates to the evenness with which the individuals are apportioned among the species (Uttah *et al.*, 2008). Diversity is an important attribute of a natural community and it has been widely used to characterize community structure (Ogawa and Ichimura, 1984). The diversity index of the phytoplankton among the sample stations (Tables 2, 3, 4 and 5) showed that in the group Bacillariophyceae, Margelef species richness (d) was highest in Station 1 (3.75) followed by Station 4 (3.19). The least was 2.42 in Station 3. In Chlorophyceae, it was highest in Station 1 (6.63) and lowest in Station 4 (3.55). In Euglenophyceae, highest was in Station 3 (1.32) and the lowest was in Station 4 (0.40) and Cyanophyceae had the highest species richness in Station 5 (1.72) and lowest in Station 4 (0.81). The dominance of *Coscinodiscus, Aulacoseira* and *Actinoptychus* taxa may have accounted for the low diversity indices recorded for the Bacillariophyceae class. The Shannon-Weiner diversity index (H) is influenced by both number of species and evenness. In Osse River, lower H values observed could be attributed to low evenness. The low evenness values observed in this study represents a situation in which all the species are not equally abundant.

Generally, for all species across the stations (table 2), diversity was lowest in station 5 (1.83) and highest in station 1 (3.43). Simpson index was low and this signifies that there is the low probability that two individuals drawn at random from a population belong to the same species. This may have resulted in the higher diversity indices observed in all stations, as low Simpson dominance index result in higher diversity and vice versa (Ogbeibu, 2005). However, the generally low diversity observed in this study, represents a situation where many of the individuals belong to the same species. A stress condition in this kind of system affects, if not eliminate many of the individuals belonging to the same species. Species richness was highest in Station 1 (11.43) and lowest in Station 5 (6.25).This is as a result of the total number of species (taxa S) in relation to the total number of individuals observed in each station. The low species evenness recorded represents a situation where all the species are not equally abundant.

Similarity analysis (Fig 8), reveals that Stations 1, 2 and 3 have similar species present in them while Stations 4 and 5 have similar species present in them as well but different from what obtained in Stations 1,2 and 3. This may be due to the scope of the study that gives rise to freshwater and brackish

water phytoplankton compositions. The phytoplankton flora of Osse River can be categorized into three compositions:

a) Cosmopolitan or frequent species
b) Occasional species
c) Restricted or rare species

The cosmopolitan forms represent those found everywhere and most frequently encountered. These were among the Chlorophytes, *Spirogyra dubia, Oedogonium grande, Closterium monoliferum, Eudorina elegans, Closterium ehrenbergii, Mougeotia, sphaerocarpa, Closterium acerosum, Closterium kuetzingii, Volvox aureus* and *Volvox africana*. Among the diatoms were *Fragilaria* sp, *Fragilaria acus, Surirella elegans, Synedra ulna, Pinnularia cardinaliculus, Fragilaria javanica, Synedra superba* and *Frustulia rhomboides*. Among the Cyanophytes were *Tychonema bornetti, Oscillatoria princeps* and *Oscillatoria proboscideae*. Euglenoids*; Lepocinclis oxyuris.*

The occasional species were among the Chlorophytes; *Closterium gracile, Pediastrum duplex, Closterium lineatum, Micrasterias fimbriata, Spirogyra insignis, Pleurotaenium ovatum* and *Euastrum didelta*. Among the diatoms, *Pinnularia viridis, Aulacoseira ambiqua, Eunotia pectinalis* and *Pinnularia nobilis.* Cyanophytes; *Coelospharium* sp, *Microcystis aeruginosa* and *Anabaena alastospora.* Euglenoids: *Phacus longicauda* and *Lepocinclis helecoidea.*

The rare species among the Chlorophytes, include; *Triplocerus gracile, Pandorina* sp, *Cladophora rivularis, Desmodesmus magnus, Coelastrum microporum, Coelastrum cambricum, Micrasterias ambadiensis, Bambusina kinahani* sp, and *Actinotaenium mooreanum.* Diatoms; *Navicula* sp, *Surirella engleri, Cymbella* sp, *Eunotia monodon, Pinnularia divergens, Pinnularia subcapitata, Pleurosigma delicatum, Pinnulaira rivularis* and *Nitzchia palaceae*. Cyanophyta; *Coelespharium pallidum and Oscillatoria limosa*. Euglenophyta: *Strombomonas ensifera, Trachelomonas dastuguei, Euglena viridis,* and *Trachelomonas caudata.*

Other compositions that are recognized in this study are the dry and wet season compositions. Chlorophyceae species which were found during the dry season include *Desmidium swartzii, Cosmarium monodii, Pandorina* sp, *Closterium dianae, Micrasterias radians, Pediastrum boryanum, Euastrum didelta, Cosmarium depressum* and *Cosmarium birectum.* Chlorophyceae wet season composition include *Triplocerus gracile, Micrasterias ambadiensis, Cosmarium sabbulteum* and *Bambusina brebissoni.* Some species however occurred in both dry and wet seasons. They include *Cladophora rivularis, Spirogyra dubia, Micrasterias foliaceae, Oedogonium grande, Closterium monoliferum, Pleurotaenium ovatum, Micrasterias torreyi* and *Eudorina elegans*. Diatom dry season composition include *Pinnularia nobilis, Pinnularia divergens, Pinnularia subcapitata, Navicula vaucheriae, Navicula gastrum, Ditylum sol* and *Triceratium Favus.* Diatom wet season composition was represented by *Navicula sp, Surirella engleri, Eunotia monodon, Eunotia pectinalis, Pleurosigma decorum, Stenepterobia rautenbachiae, Pinnularia rivularis* and *Nitzschia palae.* Other diatom species which occurred in both seasons include; *Fragilaria* sp, *Fragilaria javanica, Surirella robusta, Surirella elegans, Fragilaria acus, Hydrosesa* sp, *Eunotia asterionelloides, Trieres regia, Trieres chinensis* and *Actinoptychus splendens.* Dry season composition of Cyanophyta observed was *Coelosphaerium palladium* while *Anabaena alatospora* and *Coelosphaerium* sp - were observed as wet season compositions. Other species encountered in this group occurred in both seasons. Wet season composition in Euglenophyceae group include *Trachelomonas caudata, Strombomonas australica, Trachelomonas eurystoma, Trachelomonas spinosa, Trachelomonas dastuguei and Strombomonas ensifera.* Dry season composition was represented by *Lepocinclis acus, Lepocinclis spirogyroides, Lepocinclis viridis and Lepocinclis dextrosa, Lepocinclis oxyuris and Phacus longicauda* were encountered in both dry and wet seasons respectively.

Another unique composition observed in this study is the one brought about by salinity spectrum. Some phytoplanktons were found in freshwater zone, that is Stations 1 to 3; regions of low salinity range ($<1^{o}/_{oo}$) while some occurred in the brackish zone, Stations 4 and 5; a region of wide salinity. Phytoplanktons found in low salinity range (freshwater zone) are predominantly Chlorophytes (Fig.9-11), which decreased in abundance towards the brackish zone, while those occurring at high salinity range (brackish environment) are some diatoms (Fig 12-13), which increased in abundance in this zone throughout the study. Thus, there were

differences that existed between the phytoplankton spectra of the seaward part of the river and those further inland. Whereas a typical brackish flora existed for some months in the stations closer to the sea especially in the dry season, a low brackish/freshwater community existed in areas more inland from the sea (Fig. 9-11), especially in the wet season. This accounts for a higher number of diatoms in the seaward part of the study than the freshwater zones. However, from Fig. 4 and 5, it was observed that during the rainy months (June to October), diatom abundance was reduced in the brackish environment with an influx of more freshwater species as a result of dilution of the brackish zone (Fig. 9-11)

Generally, the phytoplankton compositions of Osse River were diverse and abundant. The phytoplankton observed in this study was highly abundant during the dry season than the wet season. This finding does not compare favourably with the report of other authors (Mustapha, 2010 and Davies *et al.* 2009) who reported higher phytoplankton count in the wet season than dry season but favourably compares well with Adesalu and Nwankwo (2008), Onuoha *et al.* (2011), Nwankwo (1998) and Nwankwo and Onyema (2003) who obtained similar results in their investigations.

Counts encountered during the dry season (98375 orgs/ml, relative abundance, 79.836.6%) was higher than wet season (24846 orgs/ml, relative abundance, 20.164%).This could be that in the dry season, the more important source of recruitment of planktonic algae may have been the sea (Onyema, 2007). This may have increased the number of diatom counts in the brackish zone. The phytoplankton diversity is affected by the number of component phytoplankton taxa (richness) and phytoplankton compositions (evenness) (Ogawa and Ichimura, 1984).

CONCLUSION

Some scientific contributions to knowledge arising from this study include the observations of 154 species of phytoplankton belonging to 4 divisions; Bacillariophyta, Chlorophyta, Euglenophyta and Cyanophyta, the river is now recognized as a water body having a wide array of phytoplankton that is floristically rich and diverse and moreso, the heterogeneity and abundance of phytoplankton observed in this study shows the river to be eutrophic and can support fish production.

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