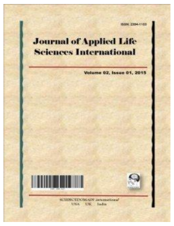

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Diatom Checklist, Composition and Abundance of a Lotic Aquatic Ecosystem in Edo State, Southern Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author OE designed the study, statistical analysis and wrote the first draft of the manuscript. Author EMD performed and managed the literature searches. Author MAA managed the references. All authors were involved in the discussion, read and approved the final manuscript.

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ABSTRACT

The diatoms of Osse River, Edo State, were studied at monthly intervals for 16 months (January 2003–April 2004) across five stations. Stations 1, 2 and 3 were freshwater stations while stations 4 and 5 were brackish environments. Phytoplankton samples for qualitative analysis were collected monthly in the open water using a plankton net of 55 µm mesh size tied unto a motorized boat and towed at low speed at all stations each time for 5minutes. Samples for quantitative analysis were collected using a 10 litre bucket to take River water into 55 µm mesh size plankton net which was held in a vertical position five times making 50 litres. Net catches of the different samples were preserved in 4% formalin solution in well labelled plastic containers and analysed in the phycology laboratory, University of Benin, Benin City. Samples for physico-chemical analysis were taken from the open water using a 1 litre plastic container in each station and taken to the chemistry division of

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Nigeria Institute for Oil Palm Research (NIFOR) for analysis using standard methods. The aim of this work was to investigate the diatoms of Osse River as well as their composition and abundance. A total of 53 diatom species belonging to 26 genera were recorded. Osse River diatoms were observed to be rich and diverse with a significant difference in the dry and wet season compositions. Results of the physico-chemical parameters show that apart from pH which showed no significant difference (P>0.05), there was significant difference (P<0.05) among the parameters studied. Correlation analysis of Bacillariophyceae with physico-chemical parameters shows significant correlation with pH, electrical conductivity and silica. *Coscinodiscus centralis* Ehrenberg was the most abundant species in the study. Stations 4 and 5 accounted for more diatoms in the study. This is a pioneer investigation reported for diatoms of Osse River.

Keywords: Diatoms; genera; Osse river.

1. INTRODUCTION

Diatoms which are algae with distinctive, transparent cell walls made of hydrated silica occur in freshwater and salt water and in moist vegetation on land [1]. Diatoms are the most numerous unicellular algae in the ocean and fresh water environments and are important sources of food and oxygen for heterotrophs in both freshwater and marine ecosystems. The cell wall of diatoms consist of two halves made of silica [2]. These cell walls (frustules) have elaborate, ornamented patterns and numerous tiny pores. Frustule consists of two halves (two valves), one slightly larger than the other which fit together like the top and bottom of a petri dish [1]. The frustules of dead diatoms dissolve fall to the bottom of the ocean or lake and fossilize. Accumulation of fossilized frustules are the main components of diatomaceous earth and extensively used in sound and heat insulation, abrasives in polishes, filters and absorbents [1]. Two major groups of diatoms are recognised; centric diatoms (Centrales), cells with radial symmetry, e.g *Cyclotella* and pennate diatoms (Pennales), cells with bilateral symmetry e.g *Synedra* [3].

Diatoms are valuable indicators of environmental conditions, since they respond directly and sensitively to many physical, chemical and biological changes that occur in the aquatic environment [4]. Under favourable conditions, diatoms may form blooms that may result in deleterious consequences to other bio systems [5]. The diversity, abundance and distribution of phytoplankton within a River have a direct correlation with the water quality and consequently, the whole community structure.

In Nigeria, some studies on diatoms have been carried out. These include [5], who investigated the diatoms and dinoflagellates phytoplankton of an estuarine creek in Lagos and recorded a total of 37 species centric diatom (18 species) pennate diatoms (12 species) and 7 species of dinoflagellates, [4], who studied the diatoms of Lekki Lagoon for the first time and recorded two hundred and thirty seven (203 pennate and 34 centric forms) diatom species [6] investigated the water chemistry and plankton dynamics of a tropical high energy erosion beach in Lagos and reported 84% diatom composition (37 centric forms and 19 pennate forms). [7] had investigated phytoplankton assemblages of a polluted estuarine creek in Lagos, Nigeria and pointed out the abundance of diatoms.

At present, there is no recorded information of diatoms in Osse River that serves as a means of transport and fish production for the inhabitants of the surrounding communities. The aim of this study was to contribute to the knowledge of phycology in Nigeria, with specific objectives to provide useful information on the composition and abundance of diatoms of Osse River in southern Nigeria and to bridge the gap in the knowledge of diatoms flora between the southern, south-west and other regions in Nigeria.

2. MATERIALS AND METHODS

2.1 The Study Area

The Osse River originates in the Akpata hills in Ekiti State, Nigeria. It flows through Ovia North-East Local Government Area and empties into the Benin River (Fig. 1). The climate has the unique features of the humid tropical wet season and dry seasons. In the wet season, the river is characterized by increased flow rate, high turbidity and muddy water especially after heavy rainfall. The dry season on the other hand is characterized by moderate or slow flow rate and clearer water. The river is the major source of drinking water for the inhabitants of these communities.

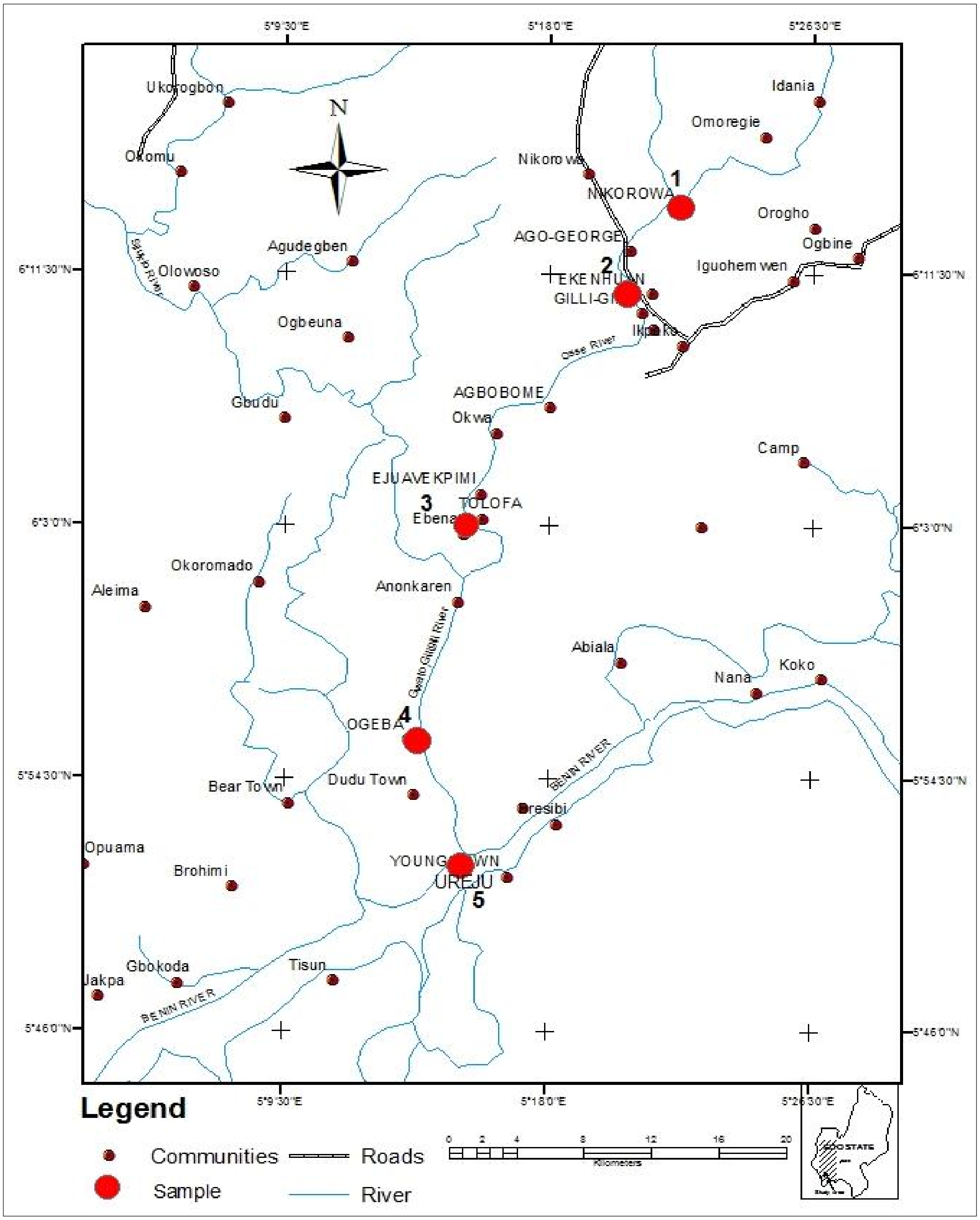

Fig. 1. Map of Osse River showing the sampled stations

2.2 Qualitative Analysis

Phytoplankton collections were carried out from January 2003 to April 2004, covering the rainy and dry seasons. Phytoplankton samples for qualitative analysis were collected monthly in the open water using a plankton net of 55 µm mesh size tied unto a motorized boat and towed at low speed at all stations each time for 5 minutes. The samples were transferred into 250 ml properly labelled plastic containers and immediately preserved with 4% formalin solution and taken to the Phycology laboratory of University of Benin, Benin City for examination using a Leitz Orthoplan Research Microscope.

2.3 Identification

Identification was done by reference to published works of [8,9,10,11,12].

2.4 Quantitative Analysis

Samples for quantitative analysis were collected using a 10 litre bucket to take river water into 55µm mesh size plankton net which was held in a vertical position five times making 50 litres. Net catches were transferred into a 250 ml plastic container and preserved with 4% formalin solution and concentrated to 10 ml in the laboratory. Two drops from this 10 ml were used for each sample mount. Ten mounts were taken and phytoplankton cells counted in each mount as described by [13]. The average was taken to get the relative number of organisms per ml.

2.5 Physical and Chemical Analysis

Samples for physico-chemical analysis were taken from the open water using a 1 litre plastic container in each station and taken to the chemistry division of Nigeria Institute for Oil Palm Research (NIFOR) for analysis. The methods described by America Public Health Association [14] were used for physical and chemical analysis analysis (pH, Turbidity (NTU), Electrical Conductivity (µS/cm), Salinity (o/oo) and Silica (mg/l).

2.6 Statistical Method

Statistical analysis was done using Statistical Package for Social Science (SPSS) 16.0 windows. Simple correlation co-efficient (r) analysis between different parameters and the phytoplankton class and analysis of variance (ANOVA) were also employed for the statistical interpretation of data obtained from the study.

Five stations were sampled along the length of Osse River in Edo State.

Station I (Nikorogha): This is the first station of the study. The sides of this station are characterized by fallen trees with no major human activities.

Station II (Ekenhuan): This is the station for commercial activities by inhabitants of the communities around the river.

Station III (Tolofa): This is the third station of the study as one approach Benin River. The villagers mainly inhabit the sides or banks of the river where their huts are built above the water. They carry out different activities like fishing, swimming, washing and repair of local boats since it is the means of transportation on water.

Station IV (Ogeba): This station is the beginning of Benin River which leads to the sea. *Eicchornia crassipes* dominated the water surface and houses made of palm fronds are abundant. Mangrove trees are the dominant vegetation here. There is turbulence at this station.

Station V (Ureju): This is the last station at Benin River, close to the sea. The river here is turbulent. Mangrove trees are the dominant vegetation. *Eicchornia crassipes* are also abundant and travelling vessels are sometimes seen.

3. RESULTS

A total of 53 diatom taxa belonging to 26 genera were observed in this study. Thirty six were pennate forms while 17 were centric forms. The pennate forms observed include *Fragilaria* sp, *Fragilaria acus* (Kützing) Lange-Bertalot, *Synedra superba* Kützing, *Synedra ulna* (Nitzsch) Ehrenberg, *Surirella elegans* Ehrenberg, *Eunotia flexuosa* (Brébisson ex Kützing) Kützing and *Tabellaria fenestrata* (Lyngbye) Kützing while centrales were represented by *Actinoptychus splendens* (Shadbolt) Ralfs ex Pritchard, *Coscinodiscus centralis* Ehrenberg, *Trieres regia* (M. Schultze) M.P. Ashworth & E.C. Theriot, *Trieres chinensis* (Greville) M.P. Ashworth & E. C. Theriot, *Cyclotella* sp., *Ditylum sol* (Grunow) De Toni, *Odontella longicruris* (Greville) M.A. Hoban *and Triceratium favus* Ehrenberg. Stations 4 and 5 accounted for more diatoms in the study while dry season individual abundance was higher than that of the wet set season.

A total of 53 species of diatoms were observed in the study stations (Table 1). The most abundant species was *Coscinodiscus centralis* Ehrenberg (30376 orgs/ml, 31.21%) followed by *Actinoptychus splendens* (Shadbolt) Ralfs ex Pritchard (13448 orgs/ml, 13.82%), *Aulacoseira granulata* var. *angustissima* (O.F. Müller) Simonsen (11446 orgs/ml, 11.76%) and *Surirella robusta* Ehrenberg (9054 orgs/ml, 9.30%). The maximum number of diatom species (35species) was recorded in station 5 and the minimum (20 species) in station 3.

A checklist of Diatoms of Osse River with authors

Division:	**Bacillariophyceae**
Class:	Coscinodiscophyceae
Order:	**Centrales**
Family:	Coscinodiscaceae
Genus:	***Coscinodiscus*** Ehrenberg
Coscinodiscus centralis Ehrenberg	
Family:	Aulacoseiraceae
Genus:	***Aulacoseira*** Thwaites
Aulacoseira ambigua (Grunow) Simonsen	
A. granulata (Ehrenberg) Simonsen	
A. granulata var*. angustissima* Muller	
A. granulata f. *spiralis* (Hustedt) D.B.Czarnecki & D.C. Reinke	
Family:	Melosiraceae
Genus:	***Melosira*** Agardh
	Melosira moniliformis (O.F.Müller) C Agardh
	M. nyassensis var. *victoriae* Otto Müller
Family:	Stephanodiscaceae
Genus:	***Cyclotella*** Kützing
	Cyclotella sp.
Family:	Heliopeltaceae
Genus:	***Actinoptychus*** Ehrenberg
	Actinoptychus splendens (Shadbolt) Ralfs
Family:	Biddulphiaceae
Genus:	***Terpsinoë*** Ehrenberg
	Terpsinoë musica Ehrenberg
Genus:	***Hydrosera*** G.C.Wallich
	Hydrosera sp.
Family:	Lithodesmiaceae
Genus:	***Ditylum*** Bailey
	Ditylum brightwellii (T.West) Grunow
	D. sol (Grunow) De Toni
Family:	Triceratiaceae
Genus:	***Trieres*** M.P.Ashworth & E.C.Theriot
	Trieres regia (M.Schultze) M.P.Ashworth & E.C.Theriot
	T. chinensis (Greville) M.P.Ashworth & E.C.Theriot
Genus:	***Triceratium*** Ehrenberg
	Triceratium favus Ehrenberg
Genus:	***Odontella*** C.Agardh
	Odontella longicruris (Greville) M.A.Hoban
Order:	**Pennales**
Family:	*Fragilariaceae*
Genus:	***Fragilaria*** Lyngbye
	Fragilaria javanica Hustedt
	Fragilaria sp.
	Fragilaria acus (Kützing) Lange-Bertalot

Genus:	***Synedra*** *Ehrenberg*
	S. ulna (Nitzsch) Ehrenberg
	S. superba Kützing
Family:	*Tabellareaceae*
Genus:	***Tabellaria*** *Ehrenberg*
	Tabellaria fenestrata (Lyngbye) Kützing
	Tabellaria flocculosa var. asterionelloides (Grunow) Knudson
Genus:	***Thalassionema*** *Grunow ex Mereschkowsky*
	Thalassionema frauenfeldii (Grunow) Tempère & Peragallo
Family:	*Eunotiaceae*
Genus:	***Eunotia*** *Ehrenberg*
	Eunotia flexuosa (Brébisson ex Kützing) Kützing
	E. monodon var. tropica (Hustedt) Hustedt
	E. asterionelloides Hustedt
	E. pectinalis (Kützing) Rabenhorst
Genus:	***Eunotioforma*** *J.P.Kociolek & A.L.Burliga*
	Eunotioforma elongata (R.Patrick) J.P.Kociolek & A.L.Burliga
Family:	*Amphipleuraceae Grunow*
Genus:	***Frustulia*** *Rabenhorst*
	Frustulia rhomboides (Ehrenberg) De Toni.
Family:	*Pleurosigmataceae Mereschkowsky*
Genus:	***Gyrosigma*** *Hassall*
	Gyrosigma balticum (Ehrenberg) Rabenhorst
Family:	*Naviculaceae Kützing*
Genus:	***Navicula*** *Bory de Saint-Vincent*
	Navicula sp.
Genus:	***Naviculadicta*** *Lange-Bertalot*
	Naviculadicta vaucheriae (J.B.Petersen) Lange-Bertalot
Family:	*Pinnulariaceae*
Genus:	***Pinnularia*** *Ehrenberg*
	Pinnularia cardinaliculus Cleve
	P. subcapitata W.Gregory
	P. rivularis Hustedt
	P. divergens W. Smith f. capitata Cleve – Euler
	P. viridis (Nitzsch) Ehrenberg
	P. nobilis Ehrenberg
Family:	*Cymbellaceae*
Genus:	***Cymbella*** *Agardh*
	Cymbella sp
Genus:	***Placoneis*** *Mereschkovsky*
Placoneis gastrum (Ehrenberg) Mereschkovsky	
Family:	*Pleurosigmataceae*
Genus:	***Pleurosigma***. *Smith*
	Pleurosigma delicatulum W. Smith
	P. decorum W. Smith
	P. formosum W. Smith
	P. angulatum (Quekette) Smith

Family:	*Bacillariaceae*
Genus:	***Nitzschia*** *Hassall*
	Nitzschia palacea Grunow
Family:	*Surirellaceae*
Genus:	*Petrodictyon D.G Mann*
	Petrodictyon gemma (Ehrenberg) D.G.Mann
Genus:	***Stenopterobia*** *Brébisson ex Van Heurck*
	Stenopterobia rautenbachiae Cholnoky
Genus:	***Surirella*** *Turpin*
	Surirella robusta Ehrenberg
	S. elegans Ehrenberg
	S. gemma Kützing
	S. celebesiana Hustedt
	S. engleri Muller

Stations 4 and 5 (brackish environment) have the highest individuals of diatoms, with *Coscinodiscus* being the highest genus in station 5 with 26180 orgs/ml followed by *Trieres* in station 5 with 10166 orgs/ml.

Dry season count (84985 orgs/ml) was higher than wet season (12348 orgs/ml). The observed abundant species for the dry season was *Coscinodiscus centralis* Ehrenberg (29442 orgs/ml) while the dominant species for the wet season was *Aulacoseira granulata* var. *angustissima* (O.F. Müller) Simonsen (6066 orgs/ml). Seasonally, *Placoneis gastrum* (Ehrenberg) Mereschkovsky, *Ditylum sol* (Grunow) De Toni and *Triceratium favus* Ehrenberg were the least species of phytoplankton recorded in the dry season with 2 orgs/ml each while *Odontella longicruris* (Greville) M.A.Hoban*, Pinnularia viridis* (Nitzsch) Ehrenberg (2 orgs/ml) was the least species recorded in the wet season (Table 2).

Results of the physico-chemical parameters show that apart from pH which showed no significant difference (P>0.05), there was significant difference (P<0.05) among the other parameters studied. Highest pH was recorded in station 5 (6.52) and lowest in station 3 (6.31). Turbidity, electrical conductivity and salinity were highest in station 5 (48.23NTU, 2548.23 µS/cm and 3.90 $^{o}/_{oo}$), while silica was highest in station 1 (11.21 mg/l) and lowest in station 5 (5.93 mg/l) (Table 3).

Correlation analysis of Bacillariophyceae with physico-chemical parameters shows significant correlation with pH, electrical conductivity and silica (Table 4).

4. DISCUSSION

Optimal pH range that can sustain aquatic life is pH 6.5-8.2 [15]. Aquatic organisms are affected by pH because most of their metabolic activities are dependent on pH [16]. The pH result in this study reveals a slightly acidic level with no significant difference across the stations (P<0.05).Similar observations have been reported by [17] for Luubara creek, Niger Delta, Nigeria, [18] on seasonal changes in physico-chemical parameters of river sediments in Ibadan City and [19] for lower Niger River, Kogi state. Since most natural waters have pH between 6.5 and 8.2 [20], Osse River can be said to be of good quality using pH as a water quality index. This pH range observed in this study falls within acceptable limits of 6.0-8.5 for fish production. This observation was also made by [21]. The slightly acidic pH of Osse River could be as a result of the tropical rain forest in the surrounding watershed as supported by [22] and high carbondioxide concentration occurring from organic decomposition [23]. However, with the urbanization in the watershed, increase or decrease in pH levels will have a damaging effect on the aquatic environment. The resultant effect can be toxic to fish and other aquatic lives.

Turbidity is a measure of the ability of the water to absorb light and is caused by small particles [24]. Aquatic plants need light for photosynthesis. If particles shield light out, oxygen production for aquatic life through photosynthesis will be reduced. If the light level is too low, photosynthesis may stop and algae will die. The mean turbidity values observed for Osse River was between 13.59±2.01 and 28.23±4.28 NTU. The values showed that the river had some suspended particles which still allowed light penetration into the river to sustain aquatic life.

The mean conductivity and salinity ranges observed showed that the river is fresh in stations 1,2 and 3 and brackish in stations 4 and 5.The closeness of stations 4 and 5 to the sea waters may have been responsible for the salt concentration observed in these stations (freshwater <0.5‰, brackish >0.5-18‰ and marine>18‰- [3]. [25] had classified waters when he reported that conductivity values below 100 µS/cm are freshwaters while those above 1000 µS/cm are marine or salt water whereas those in- between are brackish waters. Low conductivity depicts paucity of most dissolved ions and higher concentrations could be as a result of evaporation and a higher concentration of salt with the water body [26]. The brackish water zones were under the influence of the sea, hence, the mean salinity and conductivity ranges observed. Diatoms which were most abundant in these stations include *Cyclotella* sp, *Coscinodiscus centralis* Ehrenberg, *Actinoptychus splendens* (Shadbolt) Ralfs ex Pritchard and others. The most abundant genus in this study was *Coscinodiscus*. This agrees with [27], who reported that *Coscinodiscus* is known to be a prominent and abundant diatom in river ecological system. [28] also reported *Coscinodiscus* sp as cosmopolitan in their investigation. Diatoms correlated significantly with electrical conductivity. This corresponded to its abundance in the dry season when ions were concentrated in the river.

Mean silica concentration was highest in station 1 with 11.21±0.16 and lowest in station 5 with 5.93±0.15 mg/l. [23] reported that high silica concentration could come from washing of alumnio-silicate minerals present in the rocky substrate basement complex aided by dilution from the rain. Silica content of natural water most commonly range from 1-30 mg/l, although concentration as high as 100 mg/l are not unusual and concentration exceeding 1000 mg/l are found in some brackish waters [14]. However, silica levels of Osse River in this study were low compared to the investigation [23]. Diatoms also correlated with silica. Abundance of diatoms as a result of high concentration of silica was reported by [29]. However, in this study, lower concentrations of silica were observed in the brackish environments perhaps due to the incorporation of silica into their cell wall as a result of the abundance of diatoms in the brackish stations. [1] stated that the growth of diatoms is highly dependent on the presence of sufficient dissolved silica in water and that accumulation of silica in their frustule gives diatoms a density approximately two and a half times that of sea water. Possible sea water incursions and flood waters as important sources of recruitment of diatoms was corroborated by [5].

Diatoms are valuable indicators of environmental conditions since they respond directly and sensitively to many physical, chemical and biological changes that occur in the aquatic environment [4]. From the study, Osse River diatoms are diverse floristically.

From the study, water quality (arising from the result of the selected physico-chemical parameters) was good. This could be due to the absence of nuisance conditions like refuse and sewage dumps, agricultural wastes and industrial effluent discharges that often lead to the reduction in aesthetic value of water bodies. Diatoms can be good indicator species in case of an alteration in the aquatic ecosystem. [30], pointed out that diatoms are a class of phytoplankton that are extensively being used as bio indicators for environmental monitoring. They can reproduce quickly and are sensitive to a number of environmental pressures including changes in salinity, pH, nutrients, turbidity, various pollutants, etc.

By comparison, this report of 53 diatoms species is lower than the investigations of other workers like [31] who reported 56 diatom species for Lagos beach, [4] reported 209 diatom species for Lekki lagoon, Davies [32] recorded 108 diatom species for Elechi creek, Niger Delta and [33] also recorded 69 diatom species for an estuarine creek, South Western Nigeria; while it is higher than the observations of other researchers like the reports of [34] who recorded 18 diatom taxa from Ikpoba reservoir, [35] reported 12 diatom species for Okhuahe River, [36] recorded 18 diatom species from Sombreiro River, Niger Delta and [28] documented 6 diatom species in their study.

By this investigation, information on the composition and abundance of diatoms of Osse River which prior to this time was not documented has been brought to the fore. Moreso, with the information provided, Osse River can be seen as a water body which is ecologically safe and can support aquatic life.

Table 1. Abundance of diatoms in study stations

S/N	Bacillariophyceae species (diatoms)	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 brightwellii* (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* (Kützing) Rabenhorst	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.	*Fragilaria* sp	248	565	236	372	1176	2597
18.	*Fragilaria acus* (Kützing) Lange-Bertalot	88	102	108	36	34	368
19.	*Frustulia rhomboides* (Ehrenberg) De Toni	28	40	28	20	18	134
20.	*Gyrosigma balticum* (Ehrenberg) Rabenhorst				2	4	6
21.	*Hydrosera* sp	30	6	14	12		62
22.	*Melosira moniliformis* (O.F.Müller) C.Agardh				86	76	162
23.	*Melosira nyassensis* var. *victoriae* Otto Müller				70	56	126
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.	*Petrodictyon gemma* (Ehrenberg) D.G.Mann	220	86	8	2		316
29.	*Pinnularia cardinaliculus* Cleve	38	68	16	16	12	150
30.	*Pinnularia divergens* W. Smith f. *capitata* Cleve-Euler		6				6
31.	*Pinnularia nobilis* (Ehrenberg) Ehrenberg	4	2				6
32.	*Pinnularia rivularis* Hustedt	4					4
33.	*Pinnularia subcapitata* W.Gregory		4				4
34.	*Pinnularia viridis* (Nitzsch) Ehrenberg	6	6	4	6	2	24
35.	*Placoneis gastrum* (Ehrenberg) Mereschkovsky					2	2

S/N	Bacillariophyceae species (diatoms)	Station 1	Station 2	Station 3	Station 4	Station 5	Total
36.	*Pleurosigma angulatum* (Queckett) W. Smith					18	18
37.	*Pleurosigma delicatulum* W. Smith		4				4
38.	*Pleurosigma decorum* W. Smith				4	8	12
39.	*Pleurosigma formosum* W. Smith				52	60	112
40.	*Stenopterobia rautenbachiae* Cholnoky				2		2
41.	*Surirella elegans* Ehrenberg	416	326	24	326	32	1124
42.	*Surirella engleri* Muller	2	4			2	8
43.	*Surirella robusta* Ehrenberg	22	6		5506	3520	9054
44.	*Surirella celebesiana* Hustedt	8	36	4	12		60
45.	*Synedra superba* Kützing	616	40	164	60	40	920
46.	*Synedra ulna* (Nitzsch) Ehrenberg	82	182	134	34	24	456
47.	*Tabellaria -fenestrata* (Lyngbye) Kützing	2		24	42	64	132
48.	*Tabellaria flocculosa* var. *asterionelloides* (Grunow) Knudson					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
Total (orgs/ml^{-1})		2288	8507	2568	30870	53100	97333
No of species		30	27	20	34	35	

Table 2. Relative diatoms abundance of Osse River during the wet and dry seasons

S/N	Bacillariophyceae	Wet season	Dry season	Total
1.	*Actinoptychus splendens* (Shadbolt) Ralfs ex Pritchard	142	13306	13448
2.	*Aulacoseira ambigua* (Grunow) Simonsen	12	82	94
3.	*Aulacoseira granulata* (Ehrenberg) Simonsen	6	10	16
4.	*Aulacoseira granulata* f. *spiralis* (Hustedt) D.B.Czarnecki & D.C. Reinke	6066	5480	11546
5.	*Aulacoseira granulata* var. *angustissima* (O.F. Müller) Simonsen	276	4042	4318
6.	*Coscinodiscus centralis* Ehrenberg	934	29442	30376
7.	*Cyclotella* sp	218	800	1018
8.	*Cymbella* sp	6	10	16
9.	*Ditylum brightwellii* (T.West) Grunow	6	296	302
10.	*Ditylum sol* (Grunow) De Toni	-	2	2
11.	*Eunotia asterionelloides* Hustedt	6	76	82
12.	*Eunotia flexuosa* (Brébisson ex Kützing) Kützing	12	18	30
13.	*Eunotia monodon* var. *tropica* (Hustedt) Hustedt	6	-	6
14.	*Eunotia pectinalis* (Kützing) Rabenhorst	12	-	12
15.	*Eunotioforma elongata* (R.Patrick) J.P.Kociolek & A.L.Burliga	82	88	170
16.	*Fragilariforma javanica* (Hustedt) C.E.Wetzel, E.Morales & L.Ector	1015	1556	2571
17.	*Fragilaria* sp	238	502	740
18.	*Fragilaria acus* (Kützing) Lange-Bertalot	164	192	356
19.	*Frustulia rhomboides* (Ehrenberg) De Toni	67	67	134
20.	*Gyrosigma balticum* (Ehrenberg) Rabenhorst	-	6	6
21.	*Hydrosera* sp	40	22	62
22.	*Melosira moniliformis* (O.F.Müller) C.Agardh	78	84	162
23.	*Melosira nyassensis* var. *victoriae* Otto Müller	44	82	126
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	2	4	6
28.	*Petrodictyon gemma* (Ehrenberg) D.G.Mann	8	-	8
29.	*Pinnularia cardinaliculus* Cleve	54	96	150
30.	*Pinnularia divergens* W. Smith f. *capitata* Cleve-Euler	-	6	6
31.	*Pinnularia nobilis* (Ehrenberg) Ehrenberg	-	10	10
32.	*Pinnularia rivularis* Hustedt	4	-	4
33.	*Pinnularia subcapitata* W.Gregory	-	4	4
34.	*Pinnularia viridis* (Nitzsch) Ehrenberg	2	18	20
35.	*Placoneis gastrum* (Ehrenberg) Mereschkovsky	-	2	2
36.	*Pleurosigma angulatum* (Queckett) W. Smith	-	18	18

S/N	Bacillariophyceae	Wet season	Dry season	Total
37.	*Pleurosigma delicatulum* W. Smith	-	12	12
38.	*Pleurosigma decorum* W. Smith	4	-	4
39.	*Pleurosigma formosum* W. Smith	4	108	112
40.	*Stenopterobia rautenbachiae* Cholnoky	2	-	2
41.	*Surirella elegans* Ehrenberg	6	54	60
42.	*Surirella engleri* Muller	354	782	1136
43.	*Surirella robusta* Ehrenberg	78	236	314
44.	*Surirella celebesiana* Hustedt	976	8078	9054
45.	*Synedra superba* Kützing	576	240	816
46.	*Synedra ulna* (Nitzsch) Ehrenberg	192	380	572
47.	*Tabellaria -fenestrata* (Lyngbye) Kützing	62	70	132
48.	*Tabellaria flocculosa* var. *asterionelloides* (Grunow) Knudson	4	-	4
49.	*Terpsinoë musica* Ehrenberg	10	16	26
50.	*Thalassionema frauenfeldii* (Grunow) Tempère & Peragallo	54	2830	2884
51.	*Triceratium favus* Ehrenberg	-	2	2
52.	*Trieres regia* (M.Schultze) M.P.Ashworth & E.C.Theriot	268	8762	9030
53.	*Trieres chinensis* (Greville) M.P.Ashworth & E.C.Theriot	250	7092	7342
	Total	**12348**	**84985**	**97333**

Table 3. Summary of mean value of physical and chemical parameters of Osse River, January 2003-April 2004

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	Statistical significance
pH	6.46±0.08	6.48±0.07	6.31±0.08	6.41±0.09	6.52±0.14	P>0.05
Turbidity (NTU)	13.59±2.01	12.82±1.73	9.96±1.42	26.89±2.89	48.23±4.28	P<0.05
Electrical Conductivity (µS/cm)	36.64±1.88	35.54±1.74	33.06±1.85	1065.45±341.30	2548.23±802.53	P<0.05
Salinity ($^{o}/_{oo}$)	0.25±0.12	0.28±0.12	0.35±0.02	2.06±0.45	3.90±0.93	P<0.05
Silica (mg/l)	11.21±0.16	9.86±0.11	7.81±0.13	6.54±0.17	5.93±0.15	P<0.05

Table 4. Matrix correlation

			Matrix correlation			
	pH	***EC***	***Salinity***	***Silica***	***Turb***	***Bacillariophyceae***
pH	1					
EC	0.554957	1				
Salinity	0.466704	**0.964825**	1			
Silica	0.185052	-0.32426	-0.42896	1		
Turb	0.21395	0.463483	0.440016	-0.55893	1	
Bacillariophyceae	**0.98614**	**0.91613**	-0.3168	**0.854589**	0.669716327	1

Note: bold values show significant correlation df = 5, r2(0.05) = 0.755

5. CONCLUSION

The diatom flora of Osse River reveals both freshwater and brackish water species. It adds to the present knowledge of the diatoms of Nigeria water bodies. Proper monitoring of the water body should be done in other to sustain the biological structure of the river.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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