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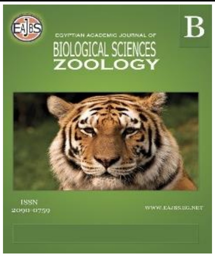

Phytoplankton Diversity and Distribution in the Festac Creek, Lagos, Nigeria

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ABSTRACT

Phytoplankton are photosynthetic microscopic organisms that inhabit the upper sunlit layer (euphotic zone) of marine and fresh water bodies. Phytoplankton, as the primary producer of the aquatic ecosystem's food chain and are very sensitive to environmental changes as energy stored up in them determine the basic primary productivity of an ecosystem. There is dearth of information on the phytoplankton community of the Festac creek and thus the need for this study which aims at microscopically investigating the phytoplankton community of the Festac creek. The Phytoplankton diversity and distribution of the Festac creek, Lagos, Nigeria. was investigated for 12 months (November 2021 – October, 2022). Phytoplankton samples were collected monthly for 12 months, using a 55 µm mesh size standard plankton net towed horizontally from a motorized boat for 5 mins at < 4 Km/h and preserved by adding 4% unbuffered formalin. The drop count microscopic analysis method was used to study the phytoplankton species. A total of 34 phytoplankton species from 7 algal classes namely Bacillariophyceae (16 species), Cyanophyceae (9 species), Chlorophyceae (2 species), Conjugatophyceae (3 species), Dictyochophyceae (2 species), Tintinnid (1 species) and Dinophyceae (1 species) were recorded. Notable species were recorded such as: *Lyngbya* sp, *Prorocentrum lima, Navicula* sp. *Nitzschia lineola, Phormidium bohneri, Oscillatoria limosa, Oscillatoria nigro viridis, Oscillatoria formosa* and some other known marine species such as *Coscinodiscus radiatus*, *Coscinodiscus marginatus Skeletonema costatum*, *Odontella sinensis, Thalassionema nizschoides*, *Fragillaria oceanica*, *Spirulina subsalsa* and *Tintinnopsis radix*. The most abundant class was the Cyanophyceae (Blue-green algae) with *Oscillatoria limosa* being the most abundant species. This could be attributed to the constant addition of nutrient particularly nitrate and phosphate run offs from industries around the study area which enhances cyanobacterial growth and indicates that the Festac creek is eutrophic.

INTRODUCTION

Phytoplankton is one of the primary producers of the aquatic ecosystem, as well as the first organisms to produce energy, which they generate from light sources, such as solar.

Phytoplankton converts light energy into carbohydrates through photosynthesis. (Souza *et al,* 2022). Phytoplankton play a crucial role in the marine food web and are sensitive indicators of environmental change (Cerfonteyn *et al,* 2023), they usually undergo a fairly predictable annual cycle, but some species may develop explosively and form blooms. Phytoplankton have important applications in the assessment of water quality and ecosystem health (Guo *et al*., 2020). For example, the balance between phytoplankton, the environment, and the quality of water health can be evaluated using phytoplankton diversity and biological integrity index (Tan *et al*., 2017; Liu *et al*., 2020). Phytoplankton are functional groups of prokaryotic and eukaryotic organisms (Dos Santos *et al*., 2017) that inhabit near the water surface where there is sufficient light to support photosynthesis and are an important primary producer and the basis of the food chain in open water because they are the first link in nearly all aquatic food chain (Onyema and Akanmu, 2017; Babatunde *et al*., 2017). Knowledge of phytoplankton population dynamics is essential because temporal and spatial fluctuations in its composition and biomass may be excellent indicators of natural or anthropogenic perturbations in the aquatic ecosystems. Phytoplankton is regarded as one of the most critical ocean players, accounting for roughly 50% of global primary production (Mohamed and Nassar, 2023). They form the foundation of marine food webs, drive the chemical composition of the atmosphere and thus influence the climate. The composition of phytoplankton species is naturally influenced by seasonal environmental changes and nutrient availability (Käse and Geuer 2018). Any negative effect on their population may have detrimental consequences in the food chain and the entire community of the aquatic ecosystem (Larbi, 2017).Previous researches on phytoplankton composition and abundance studies have been in the creeks, lagoons, Lagos lagoon complex, Lagos harbour, Niger Delta regions and other parts of Nigerian coastal waters. Some available literature includes, Asuquo *et al*., (2022) on the phytoplankton composition and abundance in Cross river estuary, Okonkwo *et al*, (2021) on the assessment of physiochemical characteristics and phytoplankton of the Ajegunle creek, Okere *et al*, (2021) on the variation of the physiochemical parameters, nutrient and some heavy metals of the Tincan island creek, Agarin *et al*, (2020) on the effect of water quality on the distribution of phytoplankton in Tincan Island creek, Isichei *et al*., (2020) on the taxonomic composition of phytoplankton in Esa-Odo Reservoir, Okere *et al*, (2020) on the seasonal variation of the hydro – environmental factors and phytoplankton of the waters around Tincan Island, Effiong *et al*., (2018) spatial distribution of phytoplankton community in the Obolo River Estuary, Niger Delta and Onyema and Akanmu, (2017) on the environmental variables, algal pigments and phytoplankton in the Atlantic ocean off the Badagry coast, Lagos, (Balogun and Ajani, 2015) the spatial and temporal variations of phytoplankton pigments and primary productivity of Badagry creek, (Ekhator *et al*., 2014) on the checklist of phytoplankton of a Southern Nigeria lotic ecosystem, (Dimowo, 2013) on the monthly variation of phytoplankton in the Ogun River, (Onyema, 2012) on the diatom composition of the Port-Novo creek, (Adesalu *et al*, 2010) on the hydrochemistry and phytoplankton composition of two tidal creeks in South-Western Nigeria, (Onuoha *et al*., 2010) checklist of phytoplankton species of the Ologe lagoon, and (Onyema, 2008) on the phytoplankton diversity of the Iyagbe lagoon (Chukwu and Nwankwo, 2003) on the impact of pollution on the microbenthic community of the Festac creek. There is dearth of information on the phytoplankton community (with identified species by microscopic investigation) of the Festac creek. The aim of this study was to microscopically investigate the phytoplankton community of the Festac creek and provide a systematic list for the creek.

MATERIALS AND METHODS

Study Area:

The Festac Creek (Fig. 1) is a tidal creek in the South-Western part of Nigeria, it flows into the Badagry creek and into the Atlantic Ocean through the Lagos harbour on the highly industrialized western axis. It lies between latitude N 6° 27′ 55.2″ and longitude E 3° 14′ 20.0″ and is subject to strong maritime influence from the adjacent Lagos harbour.

The Festac creek is joined by a canal all the way from Oshodi down to Isolo and has a total total distance of 25.6 kilometers covering 1,651square meters which flows into the Badagry creek. Fishing, commercial boating, sand miners and recreational activities are known to occur within the creek, but it has also been identified as a eutrophic water body. The climate of the area is dominated by rainy season which last from April to October and dry season which lasts from November to March. Two peaks mark the rain in May to July, and September to October. Rainfall is usually heavier during the first period creating serious flash floods which are aggravated by the characteristics poor surface drainage conditions of the surrounding coastal lowlands. The Festac creek is heavily polluted owing to the prevalence of industries located in the Festac area and activities such as ship docking, boat transportation, industrial waste water discharge, noticeable ship wrecks and sand discharge. Riparian communities make a living from these activities. However, the consequences of these activities on the environment are enormous. Additionally, the Festac creek is located in a densely populated area, and it is likely that the creek is receiving a significant amount of nutrients from sewage and agricultural runoff. This is likely contributing to the eutrophication of the creek. The adjoining waters around the Festac creek are heavily contaminated due to the wanton activities of sand miners, dredgers, the discharge of untreated sewage, and the relatively unregulated activities of ships and other vessels (Davies and Okonkwo, 2021).

Collection of Phytoplankton Samples:

The study was carried out for a period 12 months (November, 2021 – October, 2022), covering the wet and dry seasons. Plankton net of mesh size 55µm was used to collect phytoplankton samples from below the water surface after towing for 5 minutes. The content was emptied into a plastic container and fixed immediately with 4% formalin in the field for preservation. The samples were then transported to the laboratory for analysis.

Phytoplankton Investigation:

After 48hrs in the laboratory the preserved phytoplankton samples were concentrated to 10 ml. and examined, identified and counted using an Olympus binocular microscope with a calibrated eye piece at different magnifications (10X and 40X). The drop counts microscopic analysis method as adapted by (Onyema, 2008; Wu *et al.,* 2014) was used for investigation of the fixed phytoplankton samples. Five drops of concentrated plankton sample were used (using a long nose disposable pipette/dropper) of the concentrated sample (10 ml) were investigated at different magnifications (50X, 100X and 400X) and the average recorded. The final data were presented as number of organisms (cells, filaments, colonies and organism) per ml. Confirmation of species identification were done using pertinent texts (Al-Kandari *et al*., 2009 a, b; Bellinger 2010, Onyema *et al.,* 2010; Sharma 2011; Costello *et al*., 2013; Guiry and Guiry, 2017 and World Register of Marine Species (WoRMS).

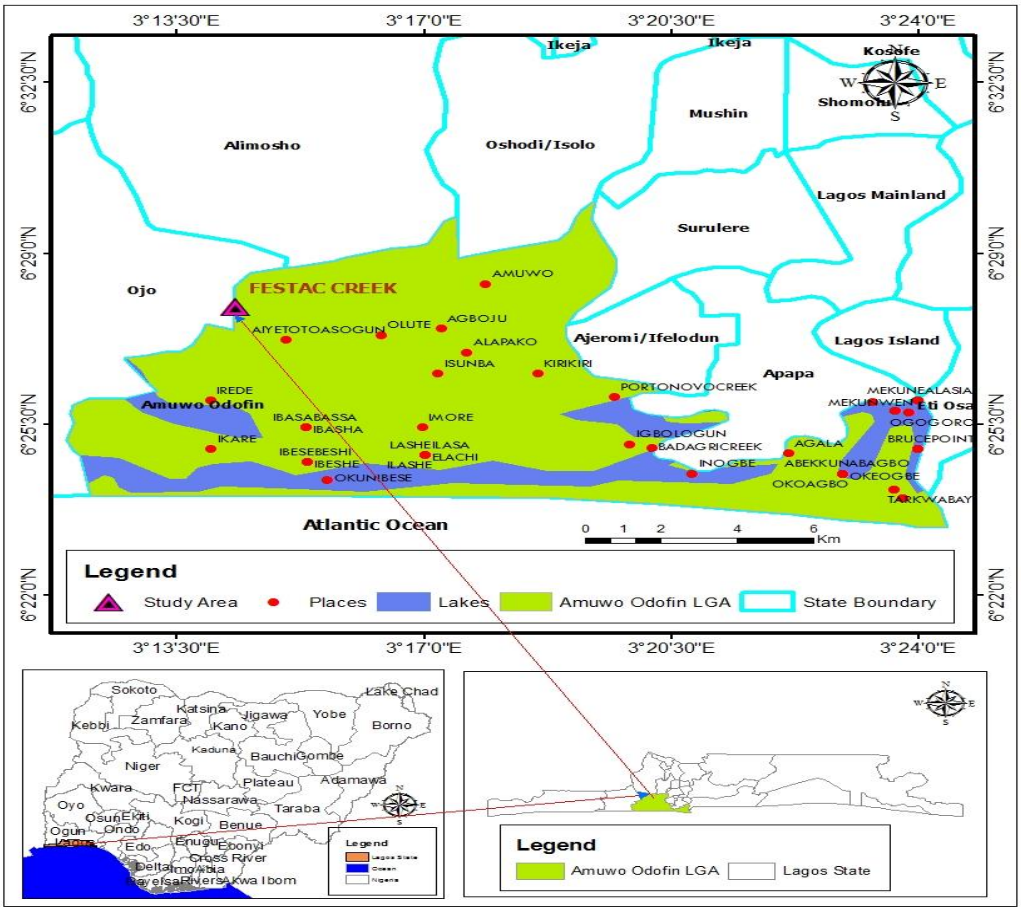

Fig. 1: Amuwo Odofin, Lagos State Showing the Festac Creek.

RESULTS

A total of 34 species of phytoplankton (totaling 954 individuals) belonging to seven major algal groups were represented in the micro-flora of the sampled areas within the Festac creek during the study as shown in (Table 1). These were the Cyanophyceae, Bacillariophyceae, Chlorophyceae, Conjugatophyceae, Dictyochophyceae, Tintinid and Dinophyceae. Tintinid (*Tintinnopsis radix*) and Dinophyceae (*Prorocentrum lima*) recorded a single species each. Presented below are notable species, trends and their percentage frequency of occurrence for the different groups and species of algae. Table 2, shows a summary of dominant species and their most frequent associates in the Festac creek (Abundance per ml). Figure 2, also shows the relative abundance of phytoplankton species in Festac creek, Lagos, Nigeria (November, 2021 – October, 2022) and Figure 3, shows the abundance composition of phytoplankton species in Festac creek, Lagos, Nigeria (November, 2021 – October, 2022).

Cyanophyceae (Blue – green algae):

The cyanophyceae were the predominant group at all stations for the duration of the study in terms of phytoplankton species diversity and were numerically more abundant (85.68%) during the sampling period. 9 species of blue-green algae were recorded with *Oscillatoria 148ediast* being the most abundant species in the study area. With regard to species and their percentage frequency of occurrence, *Oscillatoria nigra* (38.3%), *Oscillatoria princeps* (0.73%), *Oscillatoria limosa* (17.31%). *Oscillatoria 148 ediast* (40.14%), *Spirulina subsalsa* (2.57%), *Arthrospira platensis* (0.18%), *Phormidium bohneri* (0.36%,) *148ediastrum*. (0.18%) and *Chroococcus* sp. (0.18%).

Table 1: Phytoplankton species in Festac Creek, Lagos, Nigeria (November 2021 – October 2022)

S/N	TAXA	TOTAL
	CYANOPHYCEAE	
1.	*Oscillatoria nigro viridis*	208
2.	*Oscillatoria princeps*	4
3.	*Oscillatoria limosa*	364
4.	*Oscillatoria formosa*	216
5.	*Spirulina subsalsa*	14
6.	*Arthrospira platensis*	1
7.	*Phormidium bohneri*	2
8.	*149ediastrum.*	1
9.	*Chroococcus* sp.	7
	BACILLARIOPHYCEAE	
10	*Coscinodiscus radiatus*	30
11	*Coscinodiscus concinnus*	2
12	*Coscinodiscus marginatus*	10
13	*Coscinodiscus gigas*	1
14	*Pinnularia* sp.	4
15	*Nitzschia lineola*	4
16	*Navicula* sp.	11
17	*Thalassiosinema nitzchoides*	3
18	*Synedra ulna*	23
19	*Tabellaria floculosa*	1
20	*Skeletonema costatum*	14
21	*Hyalodiscus stelliger*	2
22	*Surirella* sp.	4
23	*Fragilaria islandica*	1
24	*Pleurosigma obscurum*	1
25	*Odontella sinensis*	1
	CHLOROPHYCEAE	
26	*Pediastrum simplex*	2
27	*Pediastrum duplex*	9
	CONJUGATOPHYCEAE	
28	*Genicularia* sp.	1
29	*Closterium acerosum*	3
30	*Closterium strigosum*	3
	DICTYOPHYCEAE	
31	*Dictyocha speculum*	2
32	*Dictyocha* sp.	3
	OLIGOTRICHEA	
33	*Tintinnopsis radix*	1
	DINOPHYCEAE	
34	*Prorocentrum lima*	1
	Total Taxa/Species	34
	Total number of Individuals	954

Table 2: Summary of dominant species and their frequent associates in the Festac Creek, Lagos Nigeria. November 2021 – October 2022 (abundance per ml).

Months	Dominant species	Associated species
November 2021	*Oscillatoria nigro viridis* (45)	*Navicula* sp. (11), *Coscinodiscus marginatus* (10), *Coscinodiscus radiatus* (9), *Coscinodiscus concinnus* (2), *Pinnularia* sp. (3), *Nitschia lineola*. (3), *Spirulina subsalsa* (1)
December 2021	*Oscillatoria nigro viridis* (74)	*Coscinodiscus radiatus* (7), *Dictyocha* sp. (3), *Dictyocha speculum* (2), *Spirulina subsalsa* (2), *Nitschia lineola* (1), *150 ediastrum*. (1), *Oscillatoria princeps* (1)
January, 2022	*Oscillatoria nigro viridis* (80)	*Coscinodiscus radiatus* (3) *Spirulina subsalsa* (3), *Pinnularia* sp (1). *Oscillatoria limosa* (1), *Pediastrum simplex* (2), *Prorocentrum lima* (1)
February, 2022	*Oscillatoria limosa* (83)	*Skeletonema costatum* (8), S*urirella* sp. (4), *Oscillatoria nigro viridis* (3) *Fragilaria islandica* (1) *Spirulina subsalsa* (1)
March, 2022	*Oscillatoria limosa* (56)	*Synedra ulna* (2), *Skeletonema costatum* (2), *Coscinodiscus radiatus* (1), *Spirulina subsalsa* (1)
April, 2022	*Coscinodiscus radiatus* (6)	*Oscillatoria limosa* (5), *Sprulina subsalsa* (1), *Pediastrum duplex* (1)
May, 2022	*Oscillatoria limosa* (75)	*Oscillatoria nigro viridis* (4), *Spirulina subsalsa* (4), *Closterium acerosum* (3), *Oscillatoria princeps* (3), *Skeletonema costatum* (2), *Coscinodiscus radiatus* (2), *Phormidium bohneri* (1), *Thalassionema nitzchoides* (1), *Hyalodiscus stelliger* (1), *Pleurosigma obscurum* (1), *Coscinodiscus gigas* (1), *Chroococcus* (1), *Synedra ulna* (1), *Odontella sinensis* (1)
June, 2022	*Oscillatoria* sp. (7)	*Oscillatoria limosa* (4), *Skeletonema costatum* (2), *Pediastrum duplex* (1) *Tintinnopsis radix* (1)
July, 2022	*Oscillatoria limosa* (13)	*Synedra ulna* (5), *Closterium strigosum* (3), *Oscillatoria 150 ediast* (2), *Thallasionema nitzschoides* (1) *Coscinodiscus radiatus* (1), *Oscillatoria nigro viridis* (1)
August, 2022	*Oscillatoria limosa* (71)	*spirulina subsalsa* (1) *Synedra ulna* (1) *150ediastrum duplex* (1) *Oscillatoria nigro viridis* (1) *Genicularia sp* (1)
September, 2022	*Synedra ulna* (*3*)	*Pediastrum duplex* (2), *Coscinodiscus radiatus* (1)
October, 2022	*Oscillatoria limosa* (270)	*Synedra ulna* (12), *Chroococcus* (6), *Pediastrum duplex* (4), *Tabellaria flocculosa* (1), *Hyalodiscus stelliger* (1), *Arthrospira platensis* (1), *Thallasionema nitzschoides* (1), *Phormidium bohneri* (1)

Bacillariophyceae (Diatoms):

16 species of green algae which included *Coscinodiscus radiatus* (25.66%), *Coscinodiscus concinnus* (1.77%), *Coscinodiscus marginatus* (8.85%), *Coscinodiscus gigas* (0.88%), *Skeletonema costatum* (12.38%), *Odontella sinensis* (0.88%) were the more abundant and frequently occurring centric species that occurred in the creek. With regards to the pennate diatoms important members included *Pinnularia* sp.(3.54%),*Nitzschia lineola* (4.42%), *Navicula* sp. (9.73%), *Thalassiosinema nitzchoides* (2.65%), *Synedra ulna*

(21.23%), *Tabellaria floculosa* (0.88%), *Hyalodiscus stelliger* (1.77%), *Surirella* sp. (3.54%), *Fragilaria islandica* (0.88%) and *Pleurosigma obscurum* (0.88%).

Chlorophyceae (Green algae):

The green algae were represented by two species namely – *Pediastrum simplex* (10%) and *Pediastrum duplex* (90%).

Conjugatophyceae (Desmids):

Genicularia sp. (14.2%) and *Closterium acerosum* (42.85%) and *Closterium strigosum* (42.85%) were the desmids that occurred.

Dictyochophyceae (Silicoflagellates)

2 species namely – *Dictyocha speculum* (40%) and *Dictyocha* sp. (60%) were the only silicoflagellates recorded for the study

Oligotrichea (Tintinnids):

Tintinnopsis radix (100%%) was the only tintinnid recorded for the study.

Dinophycea (Dinoflagellates):

The dinoflagellates were represented by one specie only, namely *Prorocentrum lima* (100%).

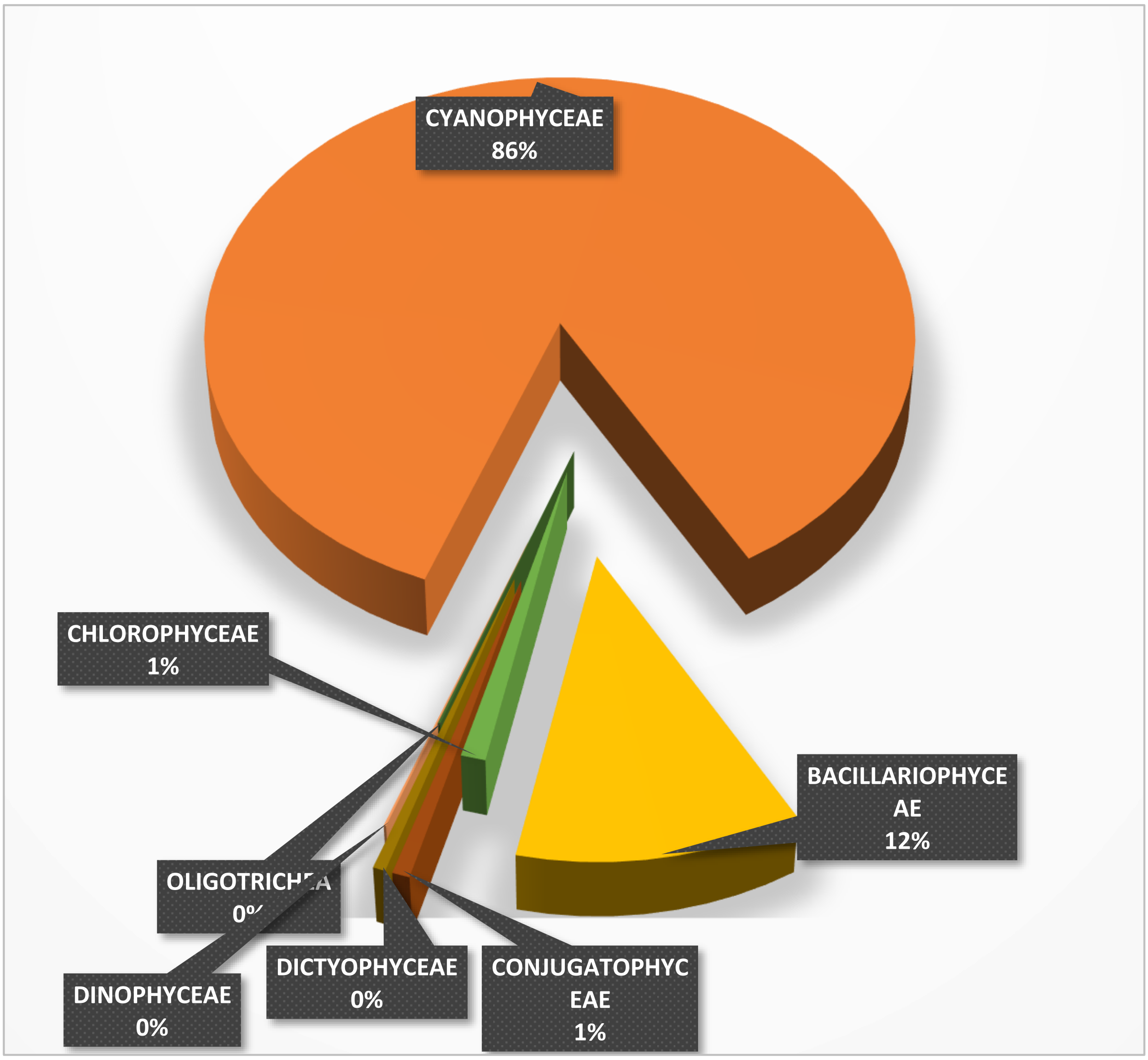

Fig. 2: Relative abundance of phytoplankton species in Festac Creek, Lagos, Nigeria (November, 2021 – October, 2022).

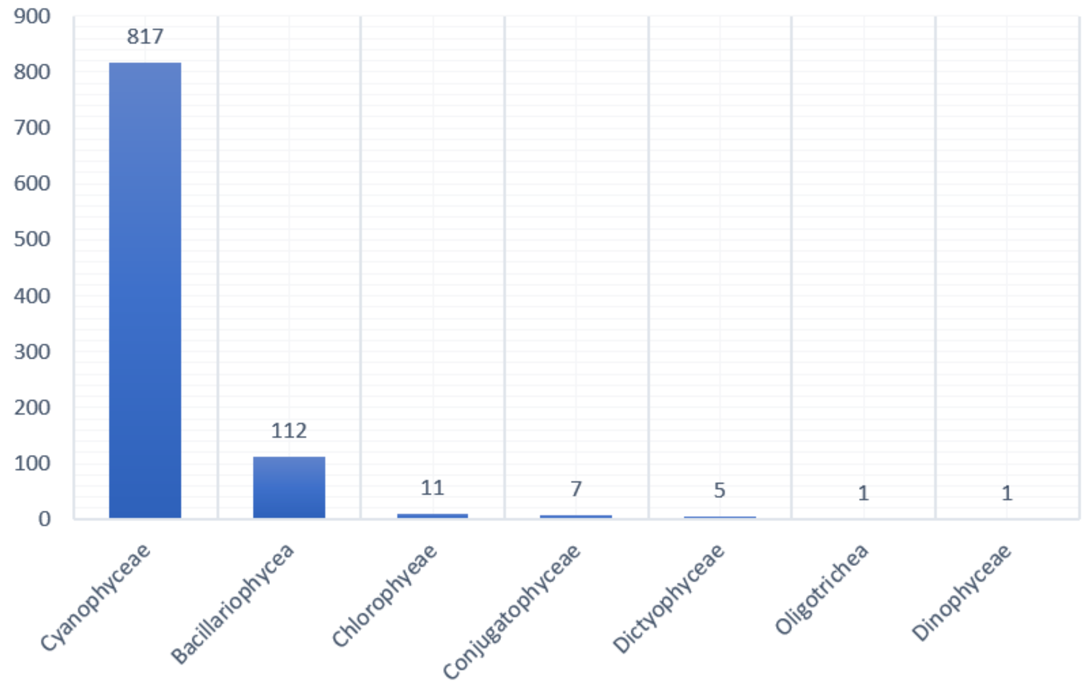

Fig. 3: Abundance composition of phytoplankton species in Festac Creek, Lagos, Nigeria (November, 2021 – October, 2022)**.**

DISCUSSION

Thirty-four species belonging to 7 taxonomic groups were recorded for the study. Their contribution in terms of species abundance is thus, Cyanophyceae> Bacillariophyceae >Chlorophyceae>Conjugatophyceae>Dictophyceae>Oligotrichea and Dinophyceae.

The blue-greens were numerically more abundant (85.68%) during the sampling period, with *Oscillatoria limosa* being the most abundant species. The abundance of cyanophyta in terms of species could be a pointer that the hydrochemistry and salinity of the studied area favours its growth. Notable species were recorded Some of these are bloom species such as *Lyngbya* sp, *Prorocentrum lima*, *Navicula* sp. *Nitzschia lineola*, *Phormidium bohneri*, *Oscillatoria limosa*, *Oscillatoria nigro viridis, Oscillatoria formosa* and some known marine species such as *Coscinodiscus radiatus*, *Coscinodiscus marginatus*, *Skeletonema costatum, Odontella sinensis, Thalassionema nizschoides, Fragillaria oceanica, Spirulina subsalsa* and *Tintinnopsis radix* were also reported. The particular high diversity of blue-greens (*Oscillatoria limosa)* observed in the creek could be a result of favourable water chemistry. It may also be due to the constant addition of nutrients particularly through nitrate and phosphate run-offs from industries around the study area and which will enhance their growth. Similar observations of the abundance of blue-green algae have been reported by Agarin *et al*., (2020) who observed that the blue-green algae were numerically more abundant as a result of the high number of *Microcystis aeruginosa* and the low population of the other phytoplankton at the studied area was attributed to high nutrient levels and the fluctuations in the physicochemical parameters and this affected their distribution pattern. Perez *et al*., (2023) indicated in a study that the relationship between cyanobacterial abundance and physicochemical variables was positively related to temperature, TP and TN, thus indicating that there is a direct relationship between increasing nutrients, increasing temperature, and cyanobacteria proliferation. Gilbert, (2020) also reached a similar conclusion. These groups of algae (blue-green) are said to fix nitrogen, causing eutrophication in the wetland plains. They additionally produce toxins that pose a health risk to humans and animals when exposed to them in large quantities. Cyanobacterial blooms are known to render freshwater ecosystems unsuitable for drinking water and recreational uses by producing metabolites and metabolic byproducts with unpleasant olfactory and gustatory properties (Wang *et al*., 2019).

On the other hand, in terms of species diversity, diatoms outnumbered all the other groups. The pennate diatoms (11 taxa) had more species than the centric diatoms (5 taxa). This may be a pointer to the scouring action of flood water on the substratum (Agarin *et al,* 2020). *Coscinodiscus radiatus* was the most abundant species closely followed by *Synedra ulna*. This species is known to indicate alkaline, pH and high levels of nutrients in the water (Onyema, 2021: Dienye and Sikoki, 2023)

The green algae were represented by *Pediastrum duplex* and *Pediastrum simplex*. Their very low occurrence in the study area could be attributed to the influence of fresh and acidic water conditions (Nwankwo and Akinsoji, 1992: Sarmaja *et al*, 2006). *Closterium* sp. dominated the conjugatophycea and their presence suggests that there are a lot of nutrients available in the water body. (Onyema, 2021), The presence of *Dictyocha* sp. in this study was also found to be associated with the presence of other indicator species of high water quality, such as diatoms and desmids. Seldom occurrence of *Tintinnopsis radix* was recorded in the study area which is an indication of low water quality and thus, may be a sign of eutrophication.

According to Inyang *et al*, 2016, the phytoplankton community has shown significant response to changes in hydroclimatic variables such as TDS, silicate, turbidity, pH, transparency and rainfall, this explains the effect of these variables on the phytoplankton. It would seem also from the dynamics of phytoplankton occurrences that apart from gross amounts of biodegradable contaminant, signs of toxic chemical waste are also reflected in the phytoplankton diversity. The presence of *Odontella sinensis*, *Spirulina subsalsa* and *Phormidium bhoneri* at one time or another are clear bio-indicators of the alkaline and brackish nature of the creek, its high nutrients status and the presence of toxic contaminants (Onyema, 2007)

The findings of this study agree with that of Sorayya *et al*., 2011 who reported that the phytoplankton community in freshwater is mostly made up of Chlorophyta, Cyanophyta, Bacillariophyta and Dinophyta

CONCLUSION

The presence of the blue-green algae, the most abundant genera in this study, indicates that the water is not portable except after proper treatment. The presence of blue-green algae such as *Oscillatoria limnosa* and diatom species such as *Nitzschia lineola* strongly showed that the Festac Creek is eutrophic (Onyema, 2021: Asuquo *et al*, 2022). Since phytoplankton play a major role in the food chain, it is pertinent to monitor natural and anthropogenic changes in plankton populations. It can be opined that the major pollution sources in the study area include the discharge of raw sewage, wood shavings, sand and gravel extraction, dredging, hydrocarbon spent oil discharge and industrial wastes. The study therefore recommends the need to create educational awareness among the inhabitants of this study area and the general public on the effects of anthropogenic activities such as dumping of industrial waste, discharge of untreated sewage and runoff of agricultural fertilizers in aquatic ecosystems for sustainable management and a healthy aquatic ecosystem and wetland.

Declarations:

Ethical Approval: Not applicable.

Conflicts of Interest: The authors declare that they have no competing interests.

Informed consent: All the authors of this manuscript accepted that the article is submitted for publication in the Egyptian Academic Journal of Biological Sciences, B. Zoology, and this article has not been published or accepted for publication in another journal, and it is not under consideration at another journal.

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