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Research Article

SPATIO-TEMPORAL DYNAMICS OF PHYTOPLANKTON OF A TIDAL COASTAL CREEK, LAGOS, NIGERIA

***Medina OmoKadiri**

Department of Plant Biology & Biotechnology, University of Benin, P.M.B. 1154 Benin City, Nigeria.

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ABSTRACT

An annual study of the phytoplankton and physical and chemical variables of Five Cowries Creek (FCC), a tropical tidal creek, in Lagos, in the coastal region of Nigeria, was undertaken from July 2002 to June 2003, at monthly intervals, to investigate spatial and temporal variations of phytoplankton flora. The phytoplankton flora comprised a moderately diverse taxa of 75, of the divisions Bacillariophyta (76%), Chlorophyta (12%), Cyanobacteria (10.6%) and Dinophyta (1.33%). The diatoms or Bacillariophyta was the most representative division or group, both qualitatively and quantitatively, represented by both Pennales (60%) and Centrales (40%). The Chlorophytes were chiefly Zygnematales (5 Zygnemataceae-*Mougeotia* (1) and *Spirogyra* (2); and Desmidiaceae (*Closterium*-1) *Cosmarium*-1). Cyanobacteria were mainly non-heterocystousNostocales (Oscillatorialceae-*Oscillatoria* (3), *Trichodesmium*(1), *Spirulina major*, and *Lyngbyamajuscula* and a few Chroococcales (Chroococaceae-*Merismopediaglauca, Microcystis wassenbergii*). The only member of Dinophyta (dinoflagellates) was a freshwater species-*Ceratiumhirundinella*. Four assemblages could be discerned on the basis of season and these were rainy season assemblage, dry season assemblage, season-indifferent assemblage and transitional assemblage. Phytoplankton of FCC was subjected to both spatial and temporal distribution, though the former was qualitatively less evident. Phytoplankton with large spatio-temporal distribution were *Coscinodiscus centralis* (69%) occurrence, followed by *Pleurosigmaangulatum*(47%) occurrence and *Thalassiosirarotula*(42%) occurrence. Phytoplankton density was generally low in the rainy season and high during the dry season. The seasonal variation of the consistently quantitatively dominant species reveals peak densities in December (*Coscinodiscus centralis*) and February (*Aulacoseira granulata* and *Thalassiosirarotula*). The Creek is brackish, essentially circum-neutral pH (7.04-7.78), with high conductivities ranging from 2.025 to 37.6 mS/cm, total dissolved solids, 1.013-18.95g/l and salinities, 1. 03 – 23.9‰. Regular and continuous monitoring of the creek is essential to ascertain the possible onset of phytoplankton bloom and occurrence of harmful algae, to enable formulation of good management practices important or critical for fisheries, navigation, recreation and ecosystem health.

Keywords: Phytoplankton, Creek, Nigeria, West Africa.

INTRODUCTION

Tidal creeks are geomorphologically, typically shallow, narrow, long and prone to tidal water level fluctuations, weak hydrodynamic energy environments, with insignificant wave action or strong current (Heayly, 2005). The main current in Five Cowries Creek is from the frequent movement of several speed boats of different sizes. Generally, historically, numerous extensive studies of tidal creeks were initially focused in temperate areas, especially in regions subjected to extensive human development, though studies of tidal creeks in Africa are presently gaining interest as a result of the astronomical rates of development, both for industrialization and domestic purposes, in tropical and sub-tropical latitudes (Badylak, *et al.,* 2015). They have been aptly described as the most active micro-geomorphological entity in the land-sea interphase (Wang *et al.*, 1999). Tidal creeks play a vital role as providers of critical habitats for numerous important estuarine-dependent nekton species as complementary ecotone to the larger adjacent water body such as harbors, lagoons, or estuaries, where they play vital roles in ecological processes and biogeochemical cycles (Wessel, 2022), as well as the maintenance of the equilibrium between sedimentary processes and the hydrodynamic aquatic environment in the intertidal zones (Zhao *et al*, 2019). They represent critical pathways of nutrients between the landscape and the larger water body, receiving and dispensing such nutrients from both natural sources such as decomposition and anthropogenic sources such as cultural eutrophication and pollution(Wessel, 2022). Additionally, tidal creeks carry out very important functions for the docking of ships, as habitats for vegetation and wildlife, including juvenile fish, and in the transport of sediment and nutrients (Zhao *et al.*, 2019).

Worldwide, river ecosystems are considerably influenced by human activities such as land use alterations, river diversion operations, and flood control measures, all of which cause substantial increases in nutrients, such as N, P, and Si, consequently triggering algal blooms formations (Bargu *et al.*, 2019). Such algal blooms affect local economies, ecology or aquatic ecosystems, and human and animal health. Unlike the unidirectional flow system of non-tidal or terrestrial river networks which are unidirectional (Coco *et al.,* 2013, Zhao *et al.*, 2019), tidal creeks are characterized by a bi-directional flow. Tidal influences are generally complex, and aggregative, and emanate from a plethora of sources like run-off, sea-level changes, storm surges, tidal action, wave action, and anthropogenic activities, exposing them to frequent channel migration, incision and erosion, sedimentation, and activation, thus affecting their navigable waterways (Zhao *et al.*, 2019). Though phytoplankton studies were previously done in the creek, they are intermittent studies and spot sampling programme. The present study is a comprehensive, full seasonal phytoplankton study covering phytoplankton community structure or assemblage, density, diversity, distribution, both spatial variability and temporal changes, coupled with environmental variables. The present study stipulates empirical surveillance on phytoplankton dynamics of the area. This study will provide phycological information for the extremely dynamic, ecologically important aquatic ecosystem, as well as enable formulation of

***Corresponding Author: Medina OmoKadiri,**
Department of Plant Biology & Biotechnology, University of Benin, P.M.B. 1154 Benin City, Nigeria.

efficient management practices of the creek. The aim of this study was to ascertain the shift or pattern of variation of phytoplankton composition and biomass at both spatial and temporal scales. Phytoplankton form the base of the aquatic food chain and web. For this reason, it has been asserted that maintaining aquatic ecosystem goods and services is partly tied to phytoplankton dynamics (Lefebvre and Devreker, 2023), hence constituting a very important study.

MATERIALS & METHODS

Study Area.

The study was carried out in Five Cowries Creek Lagos, located at Latitude 6° 26' 01" to 6° 26' 01" N and Longitude 3° 24' 00" to 3° 28' 30" E (Fig.1). The creek has a mean length of 5.58 km and mean width of 360 m. As a distributary of Lagos Lagoon, it connects the Lagos Lagoon to Lagos habour. It opens at the eastern end into the Lagos Lagoon and at the western end into the Lagos habour, which eventually opens into the Atlantic Ocean. Five Cowries Creek is located in between built-up areas of high population density. It aptly demarcates Ikoyi and Lagos Island from Victoria Island. The creek is prone to boating activities for recreation and/or transportation; fishing activities, sand mining and dredging.

Five Cowries Creek, like other coastal creeks, are small tidal inlets, with Five Cowries Creek being sandwiched between two major and larger water bodies-Lagos Lagoon and Lagos Harbour. Five Cowries Creek is tidal, specifically semi-diurnal, and characterized by bi-directional flow-one at low tide toward the sea (Atlantic Ocean) and the second, at high tide away from the sea into the creek. At low tides, water flows out of the creek through Lagos Lagoon into the Atlantic Ocean, lowering the water level, whereas at high tides, water flows into the creek from the Atlantic Ocean via the Lagos harbour, increasing the water level. The creek is influenced by rainfall, inflows via run-off from different sources of Lagos harbour, and freshwater input from Lagos Lagoon, and watershed from the metropolis or built-up areas, which include mainly commercial and residential land-uses. The watershed comprises of many activities like hotels, restaurants, clubs, and entertainment in residential and commercial streets like Awolowo Road, Alexander Road, Bourdillon Road on the Ikoyi axis and Walter Carrington Crescent, Lekki-Epe expressway, OzumbaMbadiwe and Maroko roads in the Victorian Island axis.

In this region, the climate involves regular alternation of two seasons-the dry and rainy seasons. The dry season commences in November and terminates in April, while the rainy or wet season span from May to October; both seasons are interrupted by 'August Break', a period of brief cessation of rains. Three sampling locations were earmarked for the study. Station 1, Latitude 6° 26' 21"N, Longitude 3° 26' 26.59" Eis located at the Lagos Lagoon end, while Station 3 (Latitude 6° 26' 9.92"N, Longitude 3° 24' 4.86"E) is situated at the Lagos Harbour end. Station 2 (Latitude 6° 26' 21.80"N, Longitude 3° 24' 53.75" E) is located after Walter Carrington Avenue point.

In Situ Measurement

Abiotic ecological parameters were measured in the field. Temperature (air and water) was measured using a mercury-in-glass thermometer, pH with a pH meter, conductivity/TDS/Salinity were measured using a conductivity, TDS, and Salinity meter (Hach Model Co 150).

Sample Collection

Sample collection was done for twelve months.

Water samples: These were collected into clean water containers, preserved, and transported to the laboratory for analysis.

Phytoplankton Samples: Phytoplankton samples were collected on a motorized speed boat, using a 55 µm mesh plankton net, at a low speed of 4knots for 10 minutes. The collected samples were drained through the plankton bucket into plankton containers and preserved with Lugol's iodine.

Fig.1 Map of Five Cowries Creek

RESULTS

Phytoplankton composition of Five Cowries Creek

The qualitative phytoplankton composition of Five Cowries Creek (Fig.2) shows phytoplankton assemblage of 75 taxa, distributed amongst four divisions of Bacillariophyta (diatoms), Chlorophyta (green algae), Cyanobacteria (blue-green algae) and Dinophyta (dinoflagellates). The diatoms constituted the largest proportion of the phytoplankton flora, comprising 57 taxa (76.0%), followed ata distant second by Chlorophyta with 9 taxa, constituting 12%, then Cyanobacteria with 8 taxa (10.67%) and lastly, Dinophyta with only one taxon (1.33%). The diatoms composition, though made up of the traditional Pennales and Centrales, of the total diatom proportion, 60% were Pennales and the rest 40%, Centrales. The centric diatoms with fair /highest diversity of taxa, were Thalassiosiraceae (*Aulacoseira*(2), *Cyclotella*(1), *Thalassiosira*(2); *Eupodiscaceae (Odontella*(3), *Pleurosira*(1). *Triceratium*(1) and Coscinodiscaceae (genus *Coscinodiscus*). These three families consisted of 5 taxa each, while Melosiraceae consisted of 3 taxa (*Melosira*(2); *Leptocylindrusdanicus*(1). All other respective families were represented by less than 3 taxa each. Of the Pennate diatoms, the most diverse group was the Family Naviculacea with 15 taxa (*Navicula*(2) *Pleurosigma*(7), *Gyrosigma*(1), *Pinnularia*(1), *Frustulia*(1), *Diploneis*(1), *Anomoeneis*(1) and the assymetricalbiraphid*Encyonema*(1). This family was followed by Nitzschiaceae with 8 taxa (*Nitzschia*(6), *Hantzschia*(1), *Bacillaria*(1) and this was closely followed by the Family Surirellaceae with 7 taxa, comprising *Surirella*(4) and the saddle-shaped –*Campylodisscus.* The Family Diatomaceae was represented by 4 taxa (*Fragillaria*(1), *Ulnaria* (1), *Thalassionema*(2) while the Family Eunotiaceae consisted of only two taxa, comprising two species of *Eunotia.* From ecological point of view, prominent marine diatoms amongst the diatom assemblage include, *Bacillariaparadoxa, Coscinodiscus centralis, C. radiatus, C. coincinus, Ditylumbrightweilli, Guinardiaflaccida, Leptocylindrusdanicus, Melosira moniliformis, Odontellaregia, O. sinensis, Thalassionemanitzschiodes,* *Thalassiosirafrauenfeldii, T. rotula, T. leptopus, Triceratiumfavus, Hemialushauckii, Pleurosigmaangulatum, P. balticum, Nitzschiaaccicularis, Campylodiscus clypeus, Surirellaovalis, Terpsinoe Americana*and *T. musica.* The Chlorophytes were chiefly Zygnematales (5), represented by Zygnemataceae-*Mougeotia*(1) and *Spirogyra (2)* and Desmidiaceae (*Closterium*-1) *Cosmarium*-1). Other green algae were represented by only one each of Chaetophorales (Chaetophoraceae-*Chaetophora*); Volvocales (Volvocaceae-*Volvox); Chlorococcales* (Dictyoshpaeriaceae-*Botryococcus);* and Microsporales (Microsporaceae-*Microspora*). Some of the other phytoplankton species ranged from oligohaline to mesohaline. On the other hand, the few Cyanobacteria were spectacularly, strictly mainly non-heterocystousNostocales (Oscillatorialceae-*Oscillatoria*(3), *Trichodesmium*(1), *Spirulina major,* and *Lyngbyamajuscula*and a few Chroococcales (Chroococaceae-*Merismopediaglauca, Microcystiswassenbergii*). Finally, the only member of Dinophyta (dinoflagellates) was a freshwater species-*Ceratiumhirundinella.*

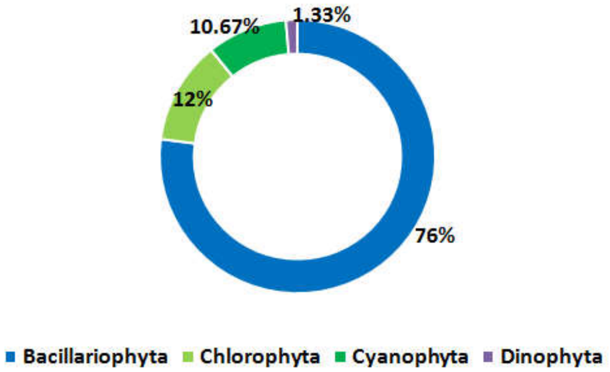

Fig 2. Phytoplankton Composition of Five Cowries Creek

Seasonal variation of Phytoplankton of Five Cowries Creek

The seasonal dynamics of the phytoplankton of Five Cowries Creek (mean values of the three stations) is represented in Fig 3. Phytoplankton density was generally low between July and November, increasing gradually from November until a peak in March. Phytoplankton abundance declined systematically from Aprilto May.

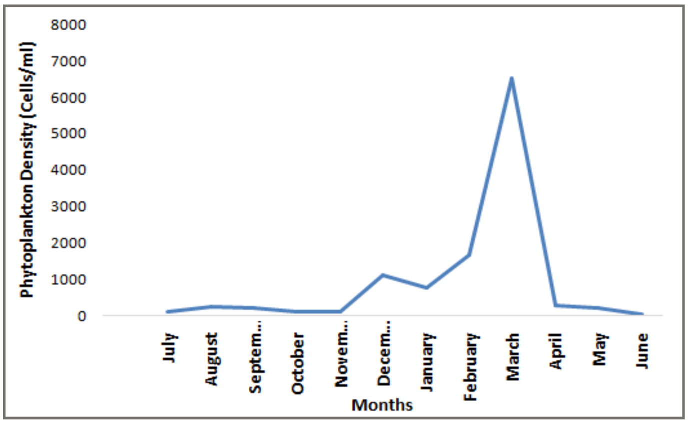

Fig 3. Seasonal Variation of the Phytoplankton of Five Cowries Creek.

Aulacoseiragranulata was prevalent from July to October, although this was less true for *A. granulata*var. *angustissima,* which had sporadic occurrences during this period, being more prominent July to August. Of the *Coscinodiscus* spp, *Coscinodiscus centralis* was outstanding, occurring throughout the year, but with greater population densities from November to February. *Coscinodiscus centralis*had dense populations from March until June, with population reaching peak (205 cell/ml) in March in station 2.*Coscinodiscus coincinus*had minimal abundance and sporadic occurrence at other periods except in February (station 3) , where it had density of 73 cells/ml at station 3. *Thalassiosirarotula* was largely prominent from November to April, with extremely high and peak population density (513 cells/ml) at station 2 in December. Generally, the green algae (Chlorophytes) were present mainly during the rainy season. The seasonal variation of the consistently quantitatively dominant species (Fig. 4) reveals peak densities in December (*Coscinodiscus centralis*) and February (*A. granulata* and *Thalassiosirarotula*).

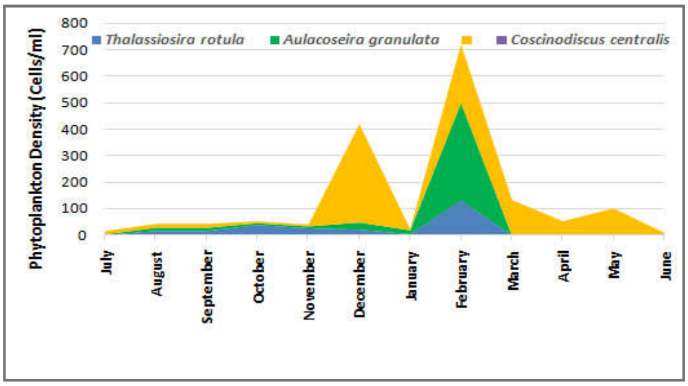

Fig. 4: Seasonal Variation of Dominant Phytoplankton species

Spatial Variation of Phytoplankton of Five Cowries Creek

Spatial distribution of phytoplankton generally shows a paucity of phytoplankton abundance from July to November (station 2), January (station 3) or February (station 1). At station 2, there was a gradual increase from November until peak in March, due to the diatom *Nitzschiaaccicularis*. For station 1, minimal increases occurred from January until peak in March. For station 3, phytoplankton population increased from January, declined to low values from April to June.

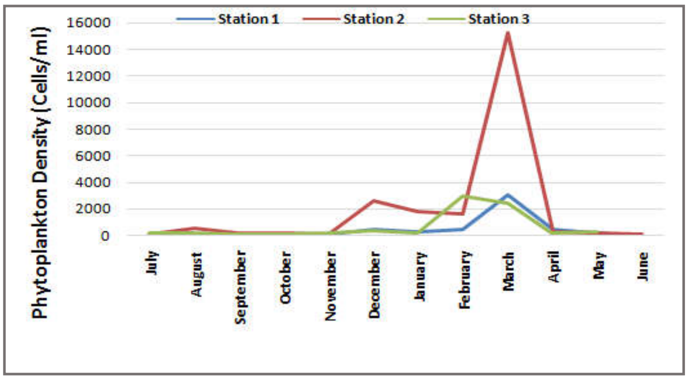

Fig 5 Spatial Variation of Phytoplankton

Seasonal Assemblages of Phytoplankton in Five Cowries Creek

Four assemblages could be discerned on the basis of season and these were Rainy season assemblage, dry season assemblage, season-indifferent assemblage and transitional assemblage. Rainy season assemblage includes the diatoms *Lauderiaborealis, Leptocylindrusdanicus, Triceratiumfavus,* the zygnematalean green algae *Spirogyra communis and Mougeotiasphaerocarpa,* while dry season assemblage includes the diatoms *Bacillariapaxillifer, Pleurotaeniumdelicatulum, Terpsinoemusica, Nitzschia*spp and the cyanobacterium *Microcystiswassenbergii.* The transitional species i.e. occurring at the transition between rainy and dry seasons includes the diatoms *Thalasiosiraleptotus, Thalasionemafrauenfeldii,* *Nitzschiaaccicularis* and the nostocalean blue-green algae*Lyngbya majuscula* and *Oscillatoriacurviceps*..

Phytoplankton Distribution in Five Cowries Creek

Phytoplankton of Five Cowries Creek was subjected to both spatial and temporal distribution, though the former was less evident, qualitatively. Phytoplankton with very high percentage occurrences had large spatio-temporal distribution. Overall, the most widely distributed species was *Coscinodiscus centralis* (69%) occurrence, followed by *Pleurosigmaangulatum*(47%) occurrence and *Thalassiosirarotula* (42%) occurrence. Species with 25% occurrences include the centric diatoms *Coscinodiscus* and *Cyclotellameneghiniana* and the filamentous cyanobacterium *Oscillatoriabornettia.* Other species were *Gyrosigmabalticum* (22%), and *Aulacoseiragranulata*with about 20% occurrence. Species with > 10 < 20% occurrences include the diatoms *Aulacoseiragranulata*var. *angustissima, Ecyonema prostata, Leptocylindrusdanicus, Nitzschiaaccicularis, Pinnulariadelicatulum, Thalasiothrixfrauenfeldii, Thalasiosiraleptopus*, and the cyanobacterium*Microcystis was senbergii.* Phytoplankton species with <10% occurrences include the dinoflagellate *Ceratiumhirudinella,* the cyanobacteria *Spirulina major, Oscillatoriacurviceps, O. ornata,* and *Lyngbyamajuscula;* the chlorophytes *Spirogyra communis, Closteriumacerosum;* and the diatoms *Triceratiumfavus, Terpsinoemusica, Ulnariaacus, Bacillariapaxillifer, Eunotiaasterionelloides, Lauderia borealis, Pleurosiralaevis, Pleurosigmaaustrale, Odontellasinensis, O. regia* and *Surirellasublinearis.* Phytoplankton species with rare occurrences (<5%) include the diatoms *Nitzschiascalpelloides, N. obtusa, Pleurosigmaformosum, P. scalpelloides, Terpsinoe Americana, Anomoeneissphaerophora,* the filamentous green algae *Spirogyra insignis, Chaetophora*and the chroococcalean colonial blue-green alga *Merismopediaglauca.* Rare species, with sporadic occurrences include *Campylodiscushibernicus, Diploneissmithii, Hantzschiaspectabilis, Melosira, moniliformis,* and *M.nyassensis.*

Ecological Indices of Five Cowries Creek

Temporal variation in the ecological indices of Five Cowries Creek is represented in Fig 6. There was a general paucity of taxa, ranging from as low as 2 in May to 11 in March. The range of dominance index was 0.146 – 0.861, with the lowest value recorded in July and the maximum in May. The diversity index Shannon-Wiener was above 1 in most cases and in fact as high as 2 in November, while the lowest value of 0.28 in May. The equitability index, on the other hand was 0.348 in March to a maximum of 0.8942 in July, though a commensurately high value of 0.8935 was also recorded in November. Generally, the lowest values were recorded in the various indices in the rainy season, while the highest values were recorded in the dry season, except for Evenness, which was the reverse.

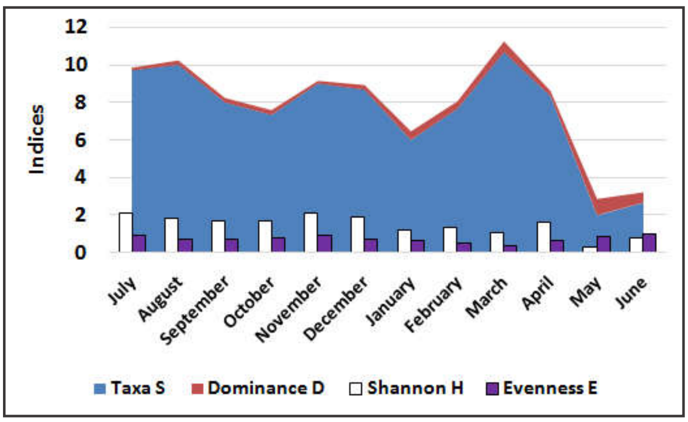

Fig 6. Ecological indices of Five Cowries Creek

Environmental Variables of Five Cowries Creek

The environmental physico-chemical parameters of the creek are displayed in Table 2.The water temperature was minimally lower than the air temperature throughout the year except between May and June when the reverse was the case. The pH of the creek was circumneutral (7.04 – 7.78) throughout the entire year, underscoring the highly buffered nature of the creek. Salinity, conductivity, and total dissolved solids increased consistently from October until March, with a second pulse in May. Dissolved oxygen, on the other hand, declined consistently from August until January and attain a maximum in February and decline again thereafter until June.

DISCUSSION

The dominance of diatoms in Five Cowries Creek is typical of tropical creeks, as corroborated by Sa *et al.*(2022). These authors note the influence of hydrological characteristics such as water column turbidity, low residence time, and high freshwater inflows as significant environmental factors affecting the distribution of phytoplankton community generally, and particularly favour the growth of taxonomic groups such as diatoms. On the contrary, cyanobacteria are dominant in brackish water and stagnant water, reminiscent of seawater incursion (Sa *et al.*, 2022). The dominance of diatoms is explainable from the physiological point of view, whereby increased salinity (from seawater incursion), culminates in eco-environmental influence responsible for osmotic stress on phytoplankton, with eventual phytoplankton community structure reorganization enabling the proliferation of diatoms because of their greater ecological plasticity (Liu *et al.*, 2019; Sa *et al.,* (2022). Some of the phytoplankton species ranged from oligohaline (low salinity) to mesohaline (moderate salinity). These species respond to shifts in salinity regimes, throughout the year. Different phytoplankton groups do not respond similarly to the spatial gradient (Sampaio*et al.*, 2023).The general paucity of chlorophytes and dinophytes is unsurprising as these taxa have different ecological preferences. Whereas the green algae or chlorophytes are largely freshwater, the dinoflagellates are principally marine. The occurrence of only freshwater *Ceratium (C. hirundinella*) is an attestation of its intolerance to saline conditions.

The seasonal influence on phytoplankton dynamics of the creek is largely determined by the salinity, nutrients (conductivity), and total dissolved solids of the creek. The dry season is reminiscent of high salinity, low discharge and therefore high residence times. The reverse is the case in the rainy season. Phytoplankton density which was generally low in the rainy season can be attributed to lower salinity, lower conductivity, and high turbidity. On the contrary, the increased abundance during the dry season was due to higher salinity, higher conductivity, and low turbidity. During the rainy season when rainfall increased with a concomitant decline in salinity, there is a prevalence of less salinity-tolerant phytoplankton groups. Conversely, during the dry season, there is increased salinity and as such more salinity-tolerant species thrive and consequently increased phytoplankton abundance. This increased biomass and abundance of phytoplankton in the creek was also corroborated by Lisan *et al.,* 2020, for an estuary in Brazil. Cira *et al.,* (2021) opined that though rains bring increased nutrients into the creek, it does not translate to increased phytoplankton biomass due to the counteracting effects of decreased residence times associated with increased inflow into the creek. It was concluded that low freshwater inflows into the creek, with corresponding high salinities, low turbidity, high transparency, and high residence times all culminate in increased phytoplankton biomass and decreased phytoplankton diversity in the dry season. The influence of rains on phytoplankton of creeks is paradoxical, because whereas rainfall brings in nutrients via runoff, the flushing effects of rains result in reduced residence time for phytoplankton and increased turbidity, both of which cause a decline in population. Badylak *et al.,* (2015) explicitly explain the conditions for high phytoplankton biomass as predicated on the balance between nutrient loads associated with watershed discharge and the effects of increased discharge on water residence times in the creek. They note that extended high-flow periods usually culminate in short water residence times, thereby limiting increased phytoplankton biomass despite high nutrient loads. On the other hand, shortened rhythms of watershed discharge supply nutrients required to trigger phytoplankton bloom events even without affecting water residence times. High rainfall and freshwater discharge cause lower residence time which prevents phytoplankton biomass accumulation. Thus the apparent disconnect between nutrient concentrations and phytoplankton biomass, which is a common phenomenon in estuarine ecosystems is due to water residence times, freshwater flushing rates, and grazing losses (Badylak *et al.*, 2015).

The highly significant growth of phytoplankton premised on high salinity, and low turbidity in the dry season was also observed by Lisana *et al.,* (2020), recording *Thalassiosirarotula* amongst other species of *Coscinodiscus, Nitzschia*and *Cyclotella*during this period. Badylak *et al.,* (2015) stated that the significant growth of phytoplankton (abundance and biomass) in the dry season was due to the highest salinity and light availability (low turbidity and total particulate matter). These authors found key species such as *Discostellastelligera*,*Coscinodiscus oculusiridis* and *Trieressinensis* in the rainy period*, Nitzschia reversa, Thalassiosira* sp and *Bellerocheahorologicalis* in the transitional period, and *Protoperidinium* sp*Thalassiosirasubtilis*, *Cyclotellastriata* and *Thalassiosirarotula* in the dry period.

The prevalence of chlorophytes during the rainy observed in this study accords with the study of Sa *et al.* (2022) in Itapecuru River estuary, Brazil. These authors observed the quantitative dominance of *Aulacoseiragranulata*var*angustissima*, ((93.66× 10^4 cells/L) which is contrary to the findings of this study, where it occurred in not too substantial quantities (0.7 – 4.4 10^4 cells/L).

Generally posited, is the fact that fast-growing phytoplankton (r-selected species in the r versus k evolutionary ecology concept of Kilham and Kilham; or the C-selected in C-S-R model (Reynolds, 2006; usually small-sized-piccoplankton and nannoplankton (<25µm) often dominate aquatic ecosystems with short water residence times and high nutrient concentrations (Badylak *et al.*, 2015). This is due to their high growth rates on account of their large surface-to-volume ratio. The preponderance of diatoms is further explained by Reynold's Theory, whereby diatoms which have higher rates of sedimentation than other groups of phytoplankton, a feature conferring an advantage for grazing pressure reduction by herbivores, and consequently increasing buoyancy (Santana *et al., 2018, Sa et al.*, 2022). This in addition to cell-size (large phytoplankton are prevalent in nutrient-rich coastal waters (Madhu *et al.,* 2010) change provides greater tolerance and competitive advantage on diatoms. The sensitivity of tidal creeks to climatic, hydrologic and nutrients loads of anthropogenic and natural origin is exacerbated by the large watershed area to small creek volume. Hydrologic factors like freshwater discharge from the watershed are affected by climatic conditions such as rainfall, which consequently influence phytoplankton composition, abundance, biomass and diversity via alterations of water residence time, salinity, and nutrient regimes (Badylak *et al.,* 2015). Some of the phytoplankton species from this present study which were also observed as making major contribution to phytoplankton bio volume in Ten Mile Creek, Florida include the diatoms *Aulacoseiragranulata, Guinardiaflaccida, Odontellaregia, Coscinodiscus* spp*, Pleurosigma,* spp*, Gyrosigma*spp*, Nitzschia*spp*, Letocylindrus,* the dinoflagellate *Ceratiumhirudinella,* the cyanobacteria *Microcystis*sp*, Oscillatoria*sp*, Lyngbya*sp*,* (Badylak *et al.*, 2015). Although the study of Badylak *et al.*,2015) observed large biomass of these phytoplankton species as well as bloom of the dinoflagellates *Peridinium* and *Akashiwosanguinea,* the present study did not record large populations or biomass of these species, except *Coscinodiscus* and *Aulacoseiragra nulata.* The dominance of *A. granulata* was also reported in Murray River, Australia, though it was replaced by *Aulacoseiraambigua* after river input was cut off (Gell *et al.*, 2002). *A granulata*, a meroplanktonic species, found in lotic and lentic ecosystems is a common diatom in eutraphentic rivers (Mohanty*et al.,* 2022). *Cyclotellameneghiniana*is also regarded as a eutraphentic (eutrophic) species (Gell*et al.*, 2002). A dominance of *Thalassiosira*sp in the order *Thalassiosira*sp., >*Skeletonema*sp., >*Leptocylindrus*sp., >*Plagioselmis*sp., >*Chaetoceros*sp., >*Cylindrotheca*sp., >*Teleaulax*sp. >*Alexandrium*sp., >*Nitzschia*sp., >*Gyrodinium*sp >*Surirella*sp >*Guinardia*sp and *Pyramimonas*sp was reported for Thane Creek, India by Niveditha *et al.,*(2022). These authors noted that of all the environmental variables studied, salinity was the most influential parameter affecting phytoplankton distribution and density.

The diversity index Shannon-Wiener was above 1 in most cases and in fact as high as 2 in November, while the lowest value of 0.28 in May. Applying the Shannon Wiener index as a pollution index scale of 0–1 for high pollution (poor), 1–2 for moderate pollution (bad), 2–3 for marginal pollution (moderate), and 3–4 for incipient pollution (good) (Balloch *et al*., 1976, Niveditha *et al.,* 2022), it can be said that the Five Cowries Creek oscillates between moderate pollution and high pollution. The remarkably lowest diversity value of 0.28 recorded in May is ascribed to the dominance of *Coscinodiscus centralis* for that period. On the contrary, the highest Shannon-Wienner index in November is generally due to the fact that many species were present in smaller quantities, thus providing equal opportunities for the co-existence of the numerous species.

Specifically, the phytoplankton biomass in Five Cowries Creek in December was mainly due to populations of *Bacillariapaxillifer, Thalasiossirarotula, Coscnonodiscuscentralis, Gyrosigmabalticum, Pleurosigmadelicatulum, Terpsinoemusica* and *Navicula*sp. In January, the main phytoplankton species contributing to population density, though in small quantities were *T.rotula, Nitzschiaaccicularis, P. angulatum, Cyclotellameneghiniana, A. granulata*var*angustissima,* and some *Coscinodiscus* sp. For the month of February, the phytoplankton density was mainly due to *Hemialushauckii,* then*, Pleurotaeniumangulatum, Coscinodiscus centralis, Thalasiosirarotula,* other *Coscinodiscus* species, and to a small extent, *Thalasithrixfrauenfeldii.* On the other hand, the peak phytoplankton biomass or density recorded in March, was largely due to *T. rotula, N. accicularis, C. centralis, C. radiatus, Cyclotellameneghiniana, Pleurotaeniumangulatum, Terpsinoemusica* and some contribution from the cyanobacterium*, Microcystiswassenbergii.* It can be inferred that the cosmopolitan (occurring throughout the season) diatoms of the Five Cowries Creek were generally euryhaline species, able to tolerate the salinity spectrum of the creek throughout the annual study period (Kadiri, 2002). The commonality of the diatoms in Five Cowries Creek with similar creeks in other parts of the globe is an attestation of the interconnectivity of the world oceans, and which subsequently influences adjacent tidal creeks via seawater incursion. Alteration of phytoplankton community structure has ecological consequences on the aquatic ecosystems. Changes in the distribution and community structure of phytoplankton affect ecological balance, as these changes at the phytoplankton primary level of the food chain can be extended to the entire trophic food web. The type of phytoplankton group present or dominant in the creek at any anytime determines the types of zooplankton. There is also the possibility of a succession of dominant phytoplankton species and formation of algal blooms, as well as cascading effects of herbivorous zooplankton which can reduce phytoplankton diversity (Xiang *et al*., 2021; Sa *et al.,* 2022). Generally, ecosystem functions and structure including alteration of phytoplankton composition, productivity and biomass, which ultimately culminate in harmful algal blooms are caused by anthropogenic changes to creeks (Badylak *et al*., 2015). The overall phytoplankton dynamics in the tidal creek are collectively driven by inherent biogeochemical interactions, exacerbated by coastal or estuarine hydrodynamics, which control biogeochemistry, physical mixing, and advection across multiple spatiotemporal scales in these systems (Babitch *et al.,* 2021).

CONCLUSION

The seasonal study of the Five Cowries Creek, a brackish, circum-neutral pH, high conductivity, TDS, and salinity creek, in the coastal area of Lagos State, Nigeria, reveal both spatial and temporal distribution. The fairly diverse phytoplankton flora of 75 taxa was typically dominated by diatoms (57 taxa), pennate forms (34 taxa), and centric forms (23 taxa); followed by green algae (9 taxa), blue-green algae (8 taxa) and dinoflagellate (one taxon). The green algae were mainly Zygnematales (5 Zygnemataceae-*Mougeotia*(1) and *Spirogyra* (2)*;* and Desmidiaceae (*Closterium*-1) *Cosmarium*-1). Cyanobacteria were spectacularly, strictly mainly non-heterocystousNostocales (Oscillatorialceae-*Oscillatoria*(3), *Trichodesmium*(1), *Spirulina major,* and *Lyngbya majuscula*and a few Chroococcales (Chroococaceae-*Merismopediaglauca, Microcystiswassenbergii*). Dinoflagellate was a freshwater species-*Ceratiumhirundinella.* The phytoplankton composition comprised four assemblages of rainy season assemblage, dry season assemblage, season-indifferent assemblage, and transitional assemblage. The cosmopolitan species were *Coscinodiscus centralis* (69%) occurrence, followed by *Pleurosigmaangulatum* (47%) occurrence and *Thalassiosirarotula* (42%) occurrence, while rare species included include the diatoms *Nitzschiascalpelloides, N. obtusa, Pleurosigma formosum, P. scalpelloides, Terpsinoe Americana, Anomoeneissphaerophora,* the filamentous green algae *Spirogyra insignis, Chaetophora,* and the chroococcalean colonial blue-green alga *Merismopediaglauca* .Phytoplankton density was generally low in the rainy season and high during the dry season. Consistent quantitative dominants were *Aulacoseiragranulata*(July-October), *Coscinodiscus centralis* (November-February) and *Thalassiosirarotula* (November - April). The seasonal influence on phytoplankton dynamics of the creek is largely determined by the salinity, nutrients (conductivity), and total dissolved solids of the creek. The overall observation of the phytoplankton response in this study may be an affirmation of the interactive effect of the phytoplankton response to disturbance gradients (pollution, cultural eutrophication) and transition gradients- a spectrum of salinity (from freshwater to saltwater) since it is a tidal ecosystem. With regular routine monitoring of the creek, the early warning signal of algal blooms, inclusive of harmful algal blooms, can be detected and appropriate measures propounded.

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