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Research Article

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Variability in Planktonic Flora Density in Three Fixed Seasons in the Luanda Bay Area

Paulo Coelho

Department of Oceanography and Marine Ecosystem Health, National Institute for Fisheries and Marine Research, Angola

***Corresponding author**
Paulo Coelho, Department of Oceanography and Marine Ecosystem Health, National Institute for Fisheries and Marine Research, Angola.
E-mail: poolcoelho@gmail.com

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ABSTRACT
This work aimed to study the variability of planktonic flora, environmental data and phytoplankton species that cause Harmful Algae Blooms (HAB), in fixed stations of Luanda (8º44.30S; 13º16.56E), Floresta (8º46.77S; 13º15.43E) and Porto Pesqueiro (8º47.07S; 13º16.25E) in the area of the Bay of Luanda. The samples were collected during the period from February to December 2014, together with meteorological data and physico-chemical parameters of water (transparency, water temperature, and salinity) on the surface. A total of 164 microalgae taxa were found, being the predominant community made up of Dinophyceae and Bacillariophyceae in the forest and fishing port (inner bay), Bacillariophyceae and Dinophyceae at the fixed station Luanda. The Bacillariophyceae and Dinophyceae classes dominated the study area, while Chrysophyceae, Cyanophyceae and Euglenophyceae contributed little in phytoplankton composition during the study period in terms of abundance. The most abundant species for Bacillariophyceae were Leptocylindrus danicus, Chaetoceros spp, Asterionella glacialis, Skeletonema costatum and for Dinophyceae the Alexandrium tamarense, Prorocentrum micans, Protoperidinium spp, and Gonyaulax sp. The species Prorocentrum micans and Alexandrium tamarense, belonging to the group Dinophyta, were more abundant and dominant, especially in the dry season. The largest phytoplankton densities occurred in the dry season, which coincided with a reduction in richness and phytoplankton species diversity in the study area. The presence of Alexandrium tamarenses, Dinophysis acuminata, Pseudo-nitzschia spp and Gambierdiscus toxicus indicates the presence of potentially toxic species, and there may be possible problems to public health if that ecosystem is not monitored.

Keywords: Variability, Abundance, Planktonic Flora, Temperature, Salinity

Introduction

The Luanda Bay ecosystem constitutes a strategic asset that extends beyond the province, impacting the entire nation. Its relevance is determined by its high biodiversity, exceptional natural beauty, and considerable potential for tourism and economic development.

According to HARRIS 1986; RÖRIG et al 2009 apud FERREIRA et al, in recent years, anthropogenic disturbances (organic and industrial pollution, and coastal constructions that alter the coastline) or natural disturbances (increased discharges from nearby rivers, changes in wind direction, among others) have been affecting marine ecosystems, causing visible modifications in the development, survival, and dispersal of phytoplankton organisms, selecting an adapted biota with complex patterns of spatial and temporal distribution [1].

In this ecosystem, microalgae populations directly serve as a staple food source for various consumers, such as zooplankton, fish, and bivalves. For example, Clupeiformes (Sardinella) are generally planktivorous fish, which consume both zooplankton and, in some species from each region, phytoplankton (LONGHURST & PAULY 2007).

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The study of the taxonomic characterisation of phytoplankton in Luanda Bay is extremely scarce, considering its rich biodiversity. However, the amount of domestic and industrial effluents, including waste from port and shipping activities, treated or not, considerably reduces this biodiversity. The first studies characterising phytoplankton in this marine ecosystem were carried out by RANGEL et al. (2002), RANGEL & SILVA [2].

In this context, this work represents yet another qualitative and quantitative contribution to the study of phytoplankton in the Luanda Bay area, aiming to examine the variability of planktonic flora, environmental data, and phytoplankton species causing harmful algal blooms at the fixed stations of Floresta, Porto Pesqueiro, and Luanda in 2014.

Description of the Study Area

The fixed stations of Floresta, Porto Pesqueiro and Luanda are located in the Luanda Bay area (Figure 1), approximately 6.6 km long and 2.5 km wide, between The waters generally have a temperature above 24°C and a salinity of 35.8 in the surface layer. During the warm season, temperatures range between 27° and 30°C, and during the cold season, temperatures range between 20° and 26°C (LASS et al. 2000).

The coordinates 8º 44' 59"; 8º 48' 27'S and 13º 16' 34"; 13º 13' 32 "E (GOOGLEARTH 2015). According to CONSULMAR (1994), this ecosystem presents a very irregular bathymetry that conditions the internal circulation of the waters and, on the other hand, presents a large extent of depths greater than 20 m. According to the classification of THORNTHWAITE & MATHER, this area has a semi-arid climate [3].

However, according to DINIZ (1973), the annual climate cycle in the region is characterized by two defined seasons: the cold season (late May to August), corresponding to the cooler period of the year, and the hot season, mid-September to April. The average annual rainfall is 449 mm, with strong concentrations in April (65% of the annual average). (AZEVEDO et al., 1972).

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Location of Stations

To determine the sampling stations, prior investigations were carried out, observing several environmental factors such as temperature, oxygen and salinity, water circulation, population density, discharge of wastewater, anthropogenic activities, among others.

Table 1: Location of the three stations along the Luanda Bay area

Location			
Stations	**Lat (S)**	**Long (E)**	**Features**
Floresta (30 m)	8º46.77'	13º15.43'	Near the Floresta of Luanda Island, considered the most coastal (1), under strong anthropogenic influence, including redging, shipyard and other activities.
Porto Pesqueiro (18 m)	8º47.07'	13º16.25'	Located opposite the sewage discharge channel for the adjacent neighbourhoods, which daily release untreated industrial and domestic effluents into the sea.
Luanda (45 m)	8º44.30	13º16.56'	Approximately 4.92 km from the coastal station (1), under the influence of the open sea and surrounding rivers that are part of this marine complex.

Materials and Methods

Sample collection was carried out between February and December 2014, at one sampling point in each station, once a week throughout the year. Hydrological and biological studies were conducted at each station, the methodology of which is described below, in addition to climatological studies.

The local depth value at each station was obtained using an echo sounder coupled to the GPS of a small vessel, "AMBIENTE". Water temperature and salinity measurements were obtained in situ using a mercury thermometer and a manual refractometer, respectively.

The rainfall data were obtained from the Luanda Meteorological Station, belonging to the National Institute of Meteorology and Geophysics of Angola (INAMET).

Water transparency was recorded in situ using a 30 cm diameter Secchi disk, from which light extinction coefficients were calculated according to the formula of Poole and Atkins [4].

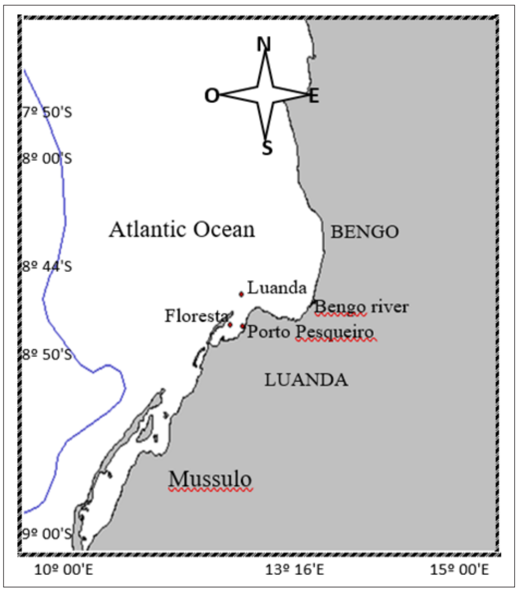


Figure 1: Location of the fixed stations in Luanda, Floresta and Porto Pesqueiro

Water samples were collected from the surface using 250 ml polystyrene bottles at all fixed stations.

For the qualitative and quantitative analyses (species richness and cell density), the water samples were immediately fixed with 2% formalin.

The counting and identification of phytoplankton organisms were performed using the classic Utermöhl method on an XDS-1B inverted microscope (40x magnification), and the results were expressed in cells per litre [5].

For the interpretation of relative abundance, the categories used were dominant for values above 50% and abundant for values above the average (LOBO & LEIGHTON 1986).

Species diversity was based on the species diversity index (H') based on Shannon, and the results were classified, according to Margalef, as high diversity (5 ├2.5 decits), low diversity (2.5 ├1 decits), and very low diversity (≤1 decits) [6,7].

The phytoplankton abundance data were transformed using the "natural logarithm + constant" [log (X+1)]. Depending on the frequency value, taxa were classified as very frequent (> 75%), frequent (< 75% and ≥ 50%), infrequent (< 50% and ≥ 25%) and sporadic (< 25%). (MATEUCCI & COLMA 1982).

For the identification of the observed organisms, the works of Balech, Trégouboff and Rose, Tomas (1997), Sournia and Fukuyo et al. were used [8-12].

Statistical analyses - To identify significant differences ($p < 0.005$) between the fixed stations, the non-parametric Kruskal-Walli's test (R program) in conjunction with the Multiple Comparisons Method was applied to the biological variables.

Results

Rainfall (mm)

Rainfall data recorded during the study period showed monthly values below 40 mm between February and December, except in April, where these values exceeded 160 mm.

Rainfall amounts ranged from 1.7 mm (November 2014) to 169 mm (April 2014). Between May and September (beginning of the cold period and transition to the warm period) no rainfall was observed (Figure 2).

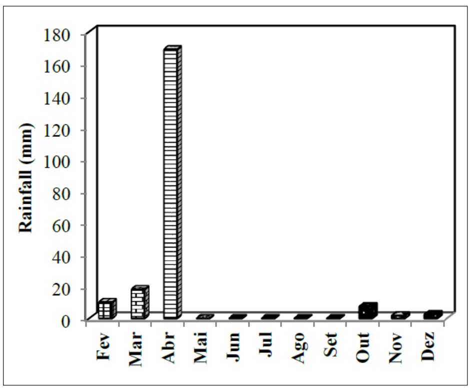


Figure 2: Total rainfall (mm) for 2014 in the study area (Source: INAMET)

Water Transparency and Light Extinction Coefficient

The Secchi disk depth (Zds) ranged from 8.90 m (light extinction coefficient of 0.23) in March to 2.20 m (light extinction coefficient of 0.83) in August. The lowest water transparency values were obtained during the cold season.

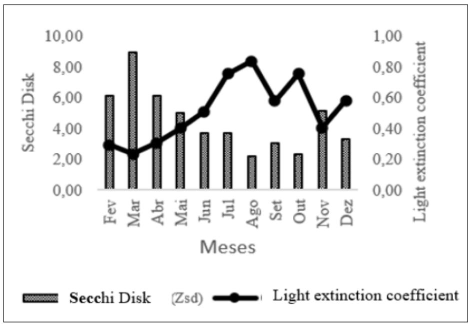


Figure 3: Values of the Secchi disk depth (Zds) and the light extinction coefficient in the study area

Physical-Chemical Parameters of Water

The average water temperature showed a well-defined seasonal pattern in both areas; the lowest average temperatures occurred during the cold season in August (13.3°C), while the highest temperatures occurred during the warm season in February (27.8°C). A similar pattern exists between the areas, as differences between them never exceeded 2.0°C.

Similar to temperature, the highest salinity values were observed during the cold season in all three stations. The average salinity ranged from 36.1 to 34.9 in the study area. The minimum salinity value of 34.9 was observed at the Luanda fixed station, and the maximum was 36.1 at Porto Pesqueiro, both during the warm season.

Composition of the Planktonic Flora in the Luanda Bay Area

The planktonic flora in the study area consisted of 164 species, belonging to 5 groups: Bacillariophyta, Dinophyta, Chrysophyta, Cyanophyta, and Euglenophyta; 5 classes; 3 subclasses; 28 orders; 42 families; and 64 genera.

Main Phytoplanton Groups in the 3 Seasons

The Dinophyta and Bacillariophyta groups dominated the plankton community in Porto Pesqueiro and Floresta, with the opposite occurring at the fixed station in Luanda. Chrysophyceae, Cyanophyceae, as well as Euglenophyceae (Floresta and Porto Pesqueiro) contributed little to the phytoplankton composition during the study period (Figure 4).

The Bacillariophyta group and its representatives were distributed into 3 subclasses: Coscinodiscophycidae, Fragilariophycidae, and Bacillariophycidae. The Coscinodiscophycidae subclass presented the largest number of taxa, distributed in 13 orders, 16 families, 27 genera, and 59 species. The most representative genera were Rhizosolenia and Chaetoceros, with 11 and 13 species, respectively. For Dinophyta, the most representative genera were Ceratium and Prorocentrum, with 15 and 10 species, respectively.

The common species found in the three oceanographic stations and capable of causing imbalance in the ecosystem during the study period totalled 11 species, distributed among the Bacillariophyta (Leptocylindrus danicus, Leptocylindrus mininus, Skeletonema costatum, Pseudo-nitzschia spp), Dinophyta (Alexandrium tamarenses, Dinophysis acuminata, Gymnodinium spp, Prorocentrum micans and Scrippsiella trochoidea) and Chrysophyta (Dictyocha crux and Dictyocha octonaria).

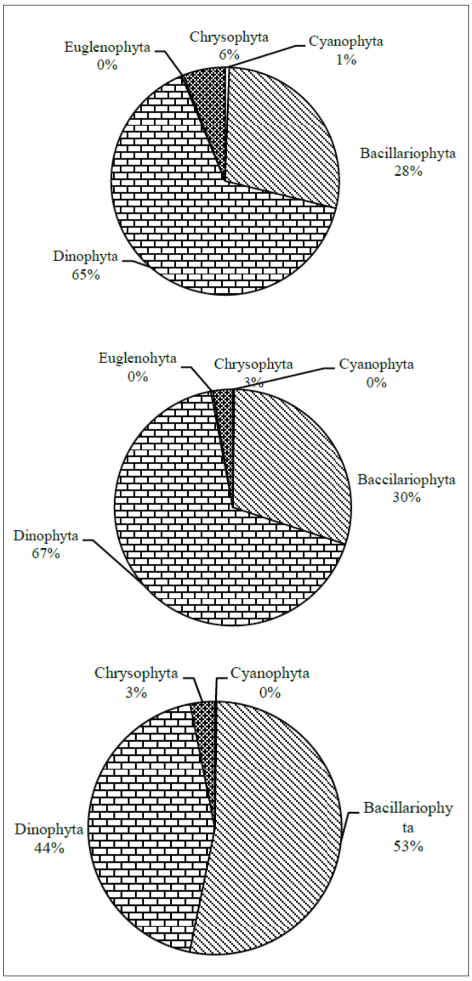


Figure 4: Phytoplankton groups at the fixed stations of Floresta, Porto Pesqueiro and Luanda

In terms of abundance, the most density species for the Bacillariophyta were Leptocylindrus danicus, Chaetoceros ssp, Asterionella glacialis, Skeletonema costatum and for the Dinophyta Alexandrium tamarenses, Prorocentrum micans, Protoperidinium spp, and Gonyaulax sp.

The species Alexandrium tamarense (74%) and Prorocentrum micans (76%), belonging to the Dinophyta group, were considered dominant at the fixed stations of Luanda and Porto Pesqueiro.

Prorocentrum micans, belonging to the division Dinophyta, was considered very frequent, being represented (100%) in all three seasons during the study period.

The species Bacillariophyceae: Coconeis spp, Diploneis spp, Ethmodiscus sp, Chaetoceros aequatorialis, Chaetoceros concavicornis, the Dinophyceae: Heterocapsa triquetra, Noctiluca scintillans, Oxyphysis oxytoxoides, Pyrophacus horologicum and Oscillatoria erythraea were considered sporadic, as they had representation less than 25 %.

Seasonal and spatial variation of phytoplankton the highest average phytoplankton densities were recorded at the fixed stations in Porto Pesqueiro and Luanda between June and July (Figure 5). However, in Floresta, the highest density was recorded in October, compared to the other stations.

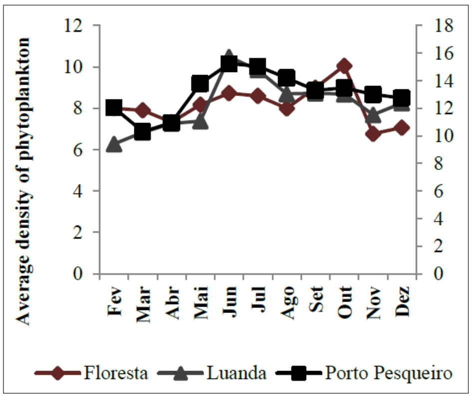
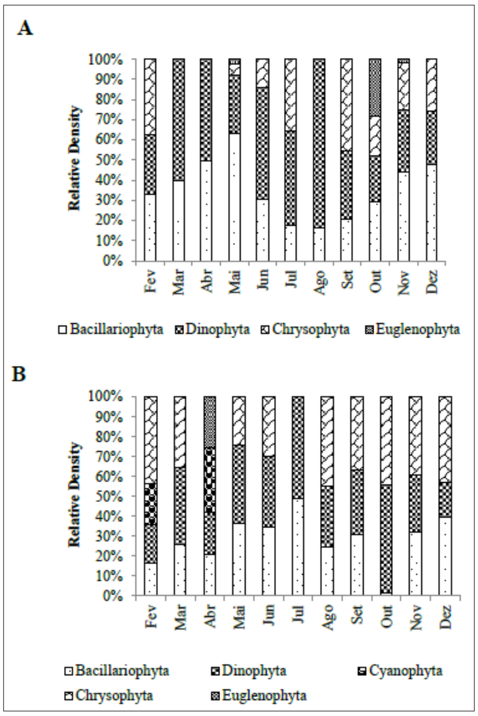


Figure 5: Horizontal variation of phytoplankton at fixed stations in the Luanda Bay area

Figure 6 shows the variations in the relative density (%) of the different groups (Baccilariophyta, Dinophyta, Cyanophyta, Floresta, Euglenophyta and Chrysophyta) of phytoplankton organisms present in the Porto Pesqueiro and Luanda.



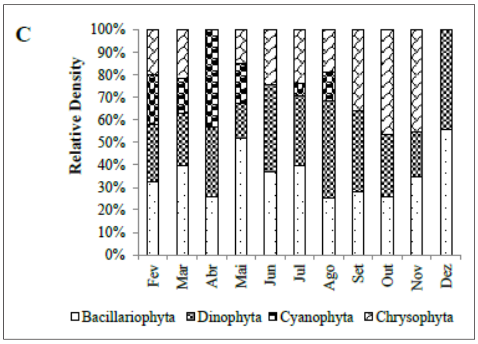


Figure 6: Relative density (%) of phytoplankton groups recorded in the Luanda Bay area

Taxonomic classification.
According to the classification of Tomas, Balech, Fukuyo et al., Trégouboff and ROSE (1978), the taxa (Table 1) found in the [8-12].

Cyanophyta
Cyanophyceae
Nostocales
Oscillatoriaceae
Oscillatoria erythraea Vaucher Ex Gomont, 1893
Chrysophyta
Chrysophyceae
Dictyochales
Dictyochaceae
Dictyocha crux Ehrenberg 1840
Dictyocha staurodon Ehrenberg 1844
Dictyocha speculum Ehrenberg 1839:
Ebria tripartita (J.Schumann) Lemmermann 1899
Bacillariophyta
Fragilariophyceae
Fragilariales
Fragilariaceae
Asterionella japonica Cleve
Asterionella glacialis Castracane
Fragilaria sp Lyngb.
Licmophorales
Licmophoraceae
Licmophora abbreviata
Coscinodiscophyceae
Hemiaulales
Hemiaulaceae
Cerataulina pelagica
Climacodium frauenfeldianum
Hemiaulus membranaceus
Chaetocerotales
Chaetocerotaceae
Bacteriastrum delicatulum
Bacteriastrum hyalinum
Chaetoceros aequatorialis Cleve
Chaetoceros affinis Lauder
Chaetoceros brevis
Chaetoceros danicus Cleve
Chaetoceros decipiens Cleve
Chaetoceros didymus
Ehrenberg
Chaetoceros messanensis Castracane
Chaetoceros similis Cleve
Chaetoceros sp Ehrenberg
Corethrales
Corethraceae
Corethron pelagicus
Coscinodiscales
Coscinodiscaceae
Coscinodiscus sp Ehrenberg
Coscinodiscus gigas
Thalassiosirales
Thalassiosiraceae
Detonula pumila (Castracane) Gran
Planktoniella sol
Thalassiosira rotula
Thalassiosira sp
Lithodesmiales
Lithodesmiaceae
Ditylum brightwellii
Helicotheca thamesis (Shrubsole) M.Ricard 1987
Biddulphiales
Biddulphiaceae
Eucampia zodiacus Ehrenberg
Rhizosoleniales
Rhizosoleniaceae
Guinardia striata (Stolterfoth) Hasle in Hasle & Syvertsen 1996:
Guinardia flaccida (Castracane) H. Perag
Rhizosolenia sp Ehrenberg
Rhizosolenia alata Brightwell
Rhizosolenia bergonii
Rhizosolenia calcar-avis
Rhizosolenia delicatula
Rhizosolenia fragilissima
Rhizosolenia imbricata
Rhizosolenia indica H. Peragallo, 1892
Rhizosolenia robusta
Rhizosolenia setigera Brightwell, 1858
Thalassiosirales
Skeletonemaceae
Skeletonema costatum (Grev.) Cleve
Melosirales
Stephanopyxidaceae
Stephanopyxis turris
Triceratiales
Triceratiaceae
Triceratium sp
Coscinodiscales
Hemidiscaceae
Hemidiscus cuneiformis Wallich, 1860
Thalassiosirales
Lauderiaceae
Lauderia sp
Lauderia annulata
Lauderia borealis Cleve
Leptocylindrales
Leptocylindraceae
Leptocylindrus minimus
Leptocylindrus danicus Cleve

Bacillariophyceae
Bacillariales
Bacillariaceae
Fragilariopsis doliolus (Wallich) Medlin & P.A.Sims 1993
Nitszchia closterium
Nitszchia longissima
Nitszchia sp
Pseudo-nitszchia H. Perag. in H. Perag. and Perag
Centrales
Eupodiscaceae
Odontella mobilensis (J. W. Bailey) Grunow
Dinophyta
Dinophyceae
Gonyaulacales
Goniodomataceae
Alexandrium sp Halim 1960
Alexandrium affine (H.Inoue & Y.Fukuyo) Balech 1995
Gambierdiscus sp Adachi and Fukuyo, 1979
Gambierdiscus toxicus Adachi and Fukuyo, 1979
Gonyaulacales
Ceratiaceae
Ceratium sp Schrank, 1793
Ceratium furca
Ceratium horridum Gran, 1902
Ceratium kofoidii
Ceratium lineatum
Ceratium macroceros
Ceratium petersii Steemann Nielsen, 1934
Ceratium teres
Ceratium trichoceros
Ceratium tripos (O. F. Müller) Nitzsch, 1817
Ceratium vultur Cleve, 1900
Ceratium tripos breve
Ceratium tripos tripos
Gymnodiniales
Gymnodiniaceae
Cochlodinium sp Schütt, 1896
Dinophysiales
Dinophysiaceae
Dinophysis sp Ehrenberg, 1839
Dinophysis acuminata Claparède and Lachmann, 1859
Dinophysis caudata Saville-Kent, 1881
Dinophysis fortii Pavillard, 1923
Dinophysis rudgei
Gonyaulacales
Gonyaulacaceae
Lingulodinium polyedrum (Stein) J. D. Dodge
Gonyaulax sp Diesing
Gonyaulax verior Sournia
Gonyaulax turbynei Murray and Whitting, 1899
Gonyaulax spinifera (Clap. and J. Lachm.) Diesing, 1866
Gonyaulax polygramma Stein, 1883
Gonyaulax grindleyi P.
Reinecke
Gymnodiniales
Gymnodiniaceae
Gymnodinium sp Stein, 1878
Katodinium sp Fott, 1957
Katodinium glaucum
Peridiniales
Peridiniaceae
Heterocapsa sp Stein, 1883
Heterocapsa triquetra (Ehrenberg) Stein, 1883
Gonyaulacales
Oxytoxaceae
Oxytoxum sp Stein, 1883
Peridiniales
Peridiniaceae
Peridinium sp Ehrenberg, 1832
Peridinium quinquecorne
Noctilucales
Noctilucaceae
Pronoctiluca spinifera (Lohmann, 1920)
Porocentrales
Prorocentraceae
Prorocentrum sp Ehrenberg, 1833
Prorocentrum minimum (Pavillard) Schiller, 1933
Prorocentrum sigmoides
Prorocentrum triestinum Schiller, 1918
Prorocentrum compressum (Bailey) Abé ex Dodge, 1975
Prorocentrum gracile Schütt, 1895
Prorocentrum compressum
(Bailey) Abé ex Dodge, 1975
Prorocentrum gracile Schütt, 1895
Prorocentrum micans Ehrenberg, 1833
Peridiniales
Protoperidinaceae
Protoperidinium sp Bergh, 1881
Protoperidinium claudicans
Protoperidinium conicum
Protoperidinium divergens (Ehrenberg) Balech, 1974
Protoperidinium oblongum
Protoperidinium pentagonum
Gonyaulacales
Pyrophacaceae
Pyrophacus steinii (Schiller) Wall and Dale
Gonyaulacales
Calciodinellaceae
Scrippsiella trochoidea
Scrippsiella spinifera G.Honsell & M.Cabrini 1991
Naviculales
Naviculaceae
Navicula directa
Navicula distans
Naviculales
Pleurosigmataceae
Pleurosigma sp
Pleurosigma acutum
Surirellales
Surirellaceae
Surirella sp Turp
Thalassionematales
Thalassionemataceae
Thalassionema nitzschioides (Grunow, 1862) Van Heurck, 1896
Thalassiothrix frauenfeldii
EUGLENOPHYTA
Euglenophyceae
Euglenales

Euglenaceae
Euglena sp
Euglena acus

Specific Richness

The spatiotemporal distribution of phytoplankton taxonomic richness in the study area is presented in Table 2. In general, the largest number of species were observed at the fixed stations in Luanda, Floresta, and lastly at Porto Pesqueiro. Regarding temporal variation, the months of February, April, and November showed the highest (average) richness, and the months of July and December, the lowest species richness.

Specific Diversity Index of Phytoplankton Density

Figure 8 presents the specific diversity index values for phytoplankton density, expressed in decits. Overall, the diversity values remained relatively consistent throughout the months, ranging from a minimum of 0.98 decits in October at Porto Pesqueiroto a maximum of 1.56 decits in April at Floresta. This indicates that, despite some monthly variation, the diversity index generally demonstrated a stable pattern across the study period and sampling locations.

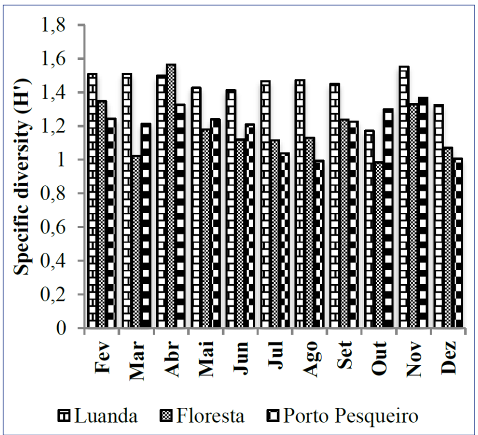


Figure 8: Species diversity index calculated for fixed stations in Luanda, Floresta and Porto Pesqueiro in the Luanda Bay area

In April, all points showed a high species diversity index, probably related to increased rainfall and turbulence. In a spatial analysis, phytoplankton species diversity showed the highest values at the Luanda fixed station and the lowest in August (0.99) at Porto Pesqueiro and in October (0.98) at Floresta.

During the quantitative and qualitative analyses, several species that produce toxins or are harmful to the ecosystem were identified in the samples (Table 1). All identified species are on the list of toxic species compiled by the Intergovernmental Oceanographic Commission of ENEVOLDSEN).

The Kruskal-Wallis statistical analysis, with the multiple comparison test of p-values ($p<0.05$) to analyse the occurrence of significant differences in phytoplankton means among the three collection areas, revealed a $\chi^2 = 16.838$; $p < 0.05$: df=2.

Discussion

According to Sassi, Tundisi and Tundisi, rainfall is one of the main factors that condition hydrological and biological parameters, directly or indirectly influencing salinity, nutrient concentration, and phytoplankton density [13,14].

One of the factors that influences phytoplankton productivity is water transparency and luminosity.

Water transparency is affected by suspended particles (organic and inorganic compounds, bacteria, phytoplankton), among others.

The highwater transparency in March and the low light extinction coefficient are due to high rainfall or flooding of rivers adjacent to the study area. On the other hand, the poor water transparency that occurred in August and the high light extinction coefficient are probably related to the excess of living (phytoplankton) or dead particles present in the water that scatter or absorb light. In regions where particles are very numerous, such as coastal areas, the water tends to be more turbid than in the open sea, making the photic zone much more restricted.

According to Tenenbaum, in tropical regions there is no typical pattern for water transparency, which can be modified mainly depending on proximity to the coast and other differentiated sources of origin [15].

A seasonal variation in temperature and salinity was observed in the studied area, with the highest values recorded during the dry season. This seasonality likely influenced the blooming of phytoplankton organisms, although factors such as nutrients, winds, and others were not analysed during this study.

Similar results were found by Rangel et al., (2002), Rangel & Silva for this same area [2].

According to Patrick (1967), Tundisi (1969) and Tundisi (1969), the abundant presence of Bacillariophyta in coastal areas is justified by their euryhaline characteristics, which enable them to withstand salinity variations and, in addition, is also due to their rapid growth.

Regarding Dinophyta, it was the second representative group, probably adapting better to open oligotrophic regions with greater water transparency, such as oceanic areas (SOURNIA 1986). On the other hand, several species of Dinophyta prefer waters with salinity greater than 30 and very rarely greater than 40 (SMAYDA, 1958).

Chrysophyta (flagellates), as well as Cyanophyta (cyanobacteria), contributed little to the phytoplankton composition in the study area.

An increase in cyanobacteria can cause disturbances in the ecosystem (blooms) in surface waters, due to the accelerated process of eutrophication. Although these organisms have not, to date, presented serious problems for health and the economy, a potential danger exists, especially due to the intensive use of the ocean as a food source (Moore 1981) and for recreation. Among the genera capable of producing cyanotoxins (neurotoxins), we can find Anabaena and Oscillatoria erythraea (Soares-Gomes & PEREIRA 2009) [16].

During the execution of this work, the species Oscillatoria erythraeum was referenced, but in low concentrations. However, RÖRIG et al 1998 state that Oscillatoria erythraeum blooms are generally associated with calm weather, low rainfall, high water temperature (25-30 ºC), salinity greater than 34 and few dissolved inorganic nutrients.

According to ESTEVES (1950), all Euglenophyta plants are more or less heterotrophic, living in waters rich in organic matter. These act as indicators of water quality in eutrophication processes and in the self-purification of aquatic systems.

The species found in the Floresta and Porto Pesqueiro, and the consequent increase in turbidity and low transparency, may have favoured the development of this group in the study area.

According to FERREIRA et al., a reduction in species richness may indicate the existence of a large proliferation of some group of microalgae [17].

The presence of Prorocentrum micans in high density may have caused the reduction in species richness in the study area.

The greatest species richness was observed during the rainy season; rainfall may be the cause of this increase. According to MARGALEF, in natural communities, the numerical values of the Shannon diversity index rarely exceed 5 decits. The same author reports that in coastal regions, diversity is normally between 1.0 and 2.5 decits and may be especially low in eutrophic estuaries and polluted environments. While values between 3.5 and 4.5 decits are found in oceanic regions [18].

The lowest diversity values (0.99 and 0.98 decits) are related to the dominance of the species Prorocentrum micans during the months of August and October in Porto Pesqueiro and Floresta.

In a spatial analysis, the specific diversity of phytoplankton showed higher values at the fixed station in Luanda. This point is greatly influenced by the open sea, and environmental conditions are constantly changing.

The lowest diversity values were obtained in August (Porto Pesqueiro) and October (Floresta). These points are located near the most anthropised areas of the study area, which receive untreated effluents that may contribute to an increase in nutrients in the area.

Among the organisms belonging to the division Dinophyta, the species Prorocentrum micans was considered very frequent, representing 100%.

The non-toxic, but potentially harmful species, Prorocentrum micans, causes several blooms, and according to its frequency, it is present in all months in the study area, and any alteration in the ecosystem can manifest as a bloom.

Among the genera identified in this work capable of producing toxins, we can mention, for Baccilaryohyceae, Pseudo-nitzschia sp, while for Dinophyta, Alexandrium, Gymnodinium, Dinophysis, Cochlodinium, and Gambierdiscus.

During the execution of this work, no species producing Neurotoxic Shellfish Poisoning (NSP) toxin was found.

General Considerations

The data obtained allow us to conclude that: The Luanda Bay area is, in general, subject to the phenomenon of "blooming" in the Forest and Fishing Port. The evolution of this area caused an expected alteration in the phytoplankton community, with a greater frequency of Bacillariophyceae and Dinophyceae.

The classes most represented in number of species, both in the dry and rainy seasons, were Bacillariophyceae and Dinophyceae.

The greatest abundances of phytoplankton occurred in the cold season; probably the low temperatures, lack of precipitation, among other factors, favoured the growth of phytoplankton organisms.

Seasonal variation exerted a great influence on the community structure. The richness and diversity of specific characteristics showed higher values during the rainy season.

High frequencies of Prorocentrum micans were recorded as both an abundant and dominant species.

The lack of hydrological (circulation, turbulence) and water chemistry (nutrients) data, parallel to the sampling, limited the explainability of the different compositions in the phytoplankton structure, as correlation analyses between these data could not be performed.

The presence of Alexandrium tamarensis, Dinophysis acuminata, Pseudo-nitzschia spp., and Gambierdiscus toxicus indicates the toxic potential and possible public health problems that could occur if this ecosystem is not monitored. Further studies are recommended to avoid harmful effects on the environment and public health.

The species Leptocylindrus danicus and Leptocylindrus minimus in Paraná (Brazil) have been linked to the mortality of the croaker Cynoscion regalis and two species of salmonids, Salmo salar and Oncorhynchus kisutch, when present in large concentrations [19].

In September 2010, the species Leptocylindrus minimus 3846 cells/L was present in the multispecies bloom that occurred in the panorama area – Luanda Bay.

According to Hasle & Fryxell Ferrario et al, the species Cerataulina pelagica has already caused mortality in molluscs and fish, due to anoxia and gill blockage in these organisms [20,21].

The species Leptocylindrus danicus and Leptocylindrus minimus in Paraná (Brazil) have been linked to the mortality of the croaker Cynoscion regalis and two species of salmonids, Salmo salar and Oncorhynchus kisutch, when present in large concentrations [19].

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The species Skeletonema costatum has already been associated with fish mortality in aquaculture during bloom periods in the North Atlantic [19].

Species of Pseudo-nitzschia sp. are producers of domoic acid, causing Amnesic Shellfish Poisoning (ASP), which accumulates in the food chain and contaminates aquatic organisms and the animals that feed on them [22,23].

Common effects include gastrointestinal disturbances, dizziness, and in severe cases, death (Fehling et al. 2004) [22].

Tourism can also be affected, as microalgae excrete protein compounds that give the water an unpleasant smell and appearance, compromising its suitability for swimming [24-27].

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References

1. Ferreira LC, Cunha MD, Koening ML, Feitosa FA, Santiago MF, Muniz K. Temporal variation of phytoplankton on three urban beaches of the southern coast of the state of Pernambuco, Northeast Brazil. Acta botanica brasílica. 2010.24: 214-224.
2. Silva RAC. Chemical Oceanography. Editora Interciência Ltda., Rio de Janeiro. 2011.
3. Thornthwaite CW, Mather JR. The water balance. Publications in Climatology, Centerton. 1955.
4. Poole HH, ATKINS WRG. Photo-electric measurements of submarine illumination throughout the year. Journal of the Marine Biological Association of the United Kingdom, Plymouth. 1929. 16: 234-297.
5. Utermöhl H. Zur Vervollkommnung der quantitativen Phytophankton-Methodik. Mitt. Int. Ver. Theor. Angew. Limnol. Verh. 1958. 9: 1-39.
6. Shannon CE, Weaver W. A mathematical model of communication. Urbana, IL: University of Illinois Press. 1949. 11: 11-20.
7. Margalef R. The biological types of phytoplankton considered as survival alternatives in an unstable environment. Ocoeanologica, Acta. 1978. 4: 493-509.
8. Balech E. The dinoflagellates of the southwestern Atlantic. 1988. 310.
9. Trégouboff G, Rose M. Manual de Planctonologie Méditerranéenne Centre National de la Recherche Scientifique. Tome I. Paris. 1978. 585.
10. Tomas CR. Identifying marine phytoplankton. ACADEMIC PRESS, INC., Oval Road, London. 1997. 858.
11. Sournia A. Phytoplankton manual. United Nations Educational, Scientific and Cultural Organization. United Kingdom. 1978. 764.
12. Fukuyo Y, Takano H, Chihara M, Matsuoka K. Red tide organisms in Japan. An illustrated taxonomic guide. Tokyo: Uchida Rokakuho, Co. Ltd. 1990.
13. Sassi R. Phytoplankton and environmental factors in the Paraíba do Norte River Estuary, northeastern Brazil: composition, distribution and quantitative remarks. Boletim do Instituto Oceanográfico, São Paulo. 1991. 9: 93-167.
14. Tundisi J, Tundisi TM. Organic production in aquatic ecosystems. Cien.Cul. 1976. 28: 864-887.
15. Tenenbaum DR. Phytoplankton in a tropical coastal region impacted by the effluent from a pulp mill (Espírito Santo, Brazil). Thesis (Doctorate in Biological Sciences) – São Carlos – SP. Federal University of São Carlos – UFSCar. 1995. 245.
16. Moore R. Constituents of Blue-Green Algae. Natural Products of the Marine. Chemical and Biological Prospectives, No. 4. 1981. 1-52.
17. Ferreira RA, Cavenaghi AL, Velini ED, Correa MR, Negrisoli E, et al. Monitoring phytoplankton and microcystyn at the Americana reservoir. Weed plant. 2005. 23: 203-214.
18. Margalef, R. Diversity. In: SOURNIA, A. (Org.). Phytoplankton manual. Paris: Muséum National d'Histoire Naturelle. UNESCO. 1976.
19. Fryxell GA, Villac MC. Toxic and harmful marine diatoms. The Diatoms: Applications for Environmental and Earth Sciences. 1999: 419-428.
20. Hasle GR. Taxonomy of diatoms. Manual on Harmful Marine Microalgae. 1995: 339-364.
21. Ferrario M, Sar E, Sala S. Potentially toxigenic diatoms of the South American cono. En Floraciones algales nocivas en el Cono Sur Americano (E.A. Sar, M.E. Ferrario, & B. Reguera, eds). Spanish Institute of Oceanography. 2002. 169-194.
22. Bates SS, Garrison DL, Horner RA. Bloom dynamics and physiology of domoic acid-producing Pseudo-nitzschia species. in Physiological ecology of thick algae blooms (D.M. Anderson, A. D. Cembella & G.M. Hallegraef, eds), Springer–Verlag, New York. 1998. 267-292.
23. Rines JE, Donaghay PL, Dekshenieks MM, Sullivan JM, Twardowski MS. Thin layers and camouflage: hidden populations of Pseudo-nitzschia spp. (Bacillariophyceae) in a stream in the San Juan Islands, Washington, USA. Marine Ecology Progress Series. 2002.225: 123-137.
24. Cergole MC. Stock assessment of the Brazilian sardine, Sardinella brasiliensis, of the southeastern coast of Brazil. Sci. 1995. 59: 597-610.
25. Marques AK. Analysis of phytoplankton diversity in the reservoir of the Luis Eduardo Magalhães Hydroelectric Power Plant, in the Middle Tocantins: community structure, temporal and spatial fluctuations, Palmas – UFT. 2005. 157.
26. Tyler JE. The Secchi Disc Limmology and Oceanography, Baltimore. 1968. 13: 1-4.
27. Zingone A, Enevoldsen HO. The Diversity of Harmful Algal Blooms: A Challenge for Science and Management, Ocean & Coastal Management. 2000. 43: 725-748.