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Cyanobacteria community in two tropical eutrophic reservoirs in northeastern Brazil

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ABSTRACT. This study investigated the effect of seasonality on the Cyanobacteria community in two tropical eutrophic reservoirs in northeastern Brazil. Monthly samplings were conducted in the sub-surface of reservoirs. The following abiotic variables were analyzed: apparent color, turbidity, conductivity, alkalinity, calcium, magnesium, sodium, potassium, sulfate, total phosphorous, ammonia, nitrate, nitrite, chlorides, total hardness and chlorophyll-a, according to APHA (2012). Cyanobacteria density was quantified through biomass. Data were analyzed using one-way ANOVA and Redundancy Analysis (RDA). Higher mean values of Cyanobacteria biomass occurred in the dry (9.9mm^3 L^{-1}) and rainy (19.0mm^3 L^{-1}) season in Jucazinho and Carpina reservoirs, respectively, especially *Planktothrix agardhii, Cylindrospermopsis raciborskii* and *Geiterinema amphibium,* which occurred in 100% of the samples. RDA analysis revealed that the variables nitrite, ammonia, conductivity, calcium, sulfate, chlorides and alkalinity influenced most the Cyanobacteria community in both reservoirs. High trophic state index was observed throughout the year. Seasonality affected both biotic and abiotic variables.

Keywords: abiotic parameters, phytoplankton, seasonality.

Comunidade de cianobactérias em dois reservatórios eutróficos e tropicais no nordeste do Brasil

RESUMO. Este estudo investigou o efeito da sazonalidade sobre a comunidade de cianobactérias em dois reservatórios eutróficos tropicais no nordeste do Brasil. Mensalmente, amostras foram coletadas na subsuperfície dos reservatórios. Foram analisados os seguintes fatores abióticos: cor aparente, turbidez, condutividade, alcalinidade, cálcio, magnésio, sódio, potássio, sulfato, fósforo total, amônia, nitrato, nitrito, cloretos, dureza total e clorofila-a, de acordo com APHA (2012). A densidade de cianobactérias foi quantificada por meio de sua biomassa. Os dados foram analisados usando Anova (*one-way*) e Análise de Redundância (RDA). Maiores valores médios de biomassa de cianobactérias ocorreram na estação seca (9,9 mm^3 L^{-1}) e chuvosa (19,0 mm^3 L^{-1}) nos reservatórios de Jucazinho e Carpina, respectivamente, especialmente *Planktothrix agardhii*, *Cylindrospermopsis raciborskii* e *Geitlerinema amphibium* que ocorreram em 100% das amostras. A análise de RDA revelou que os parâmetros nitrito, amônia, condutividade, cálcio, sulfato, cloretos e alcalinidade foram mais influentes na comunidade de Cyanobacteria em ambos os reservatórios. Elevado índice de estado trófico foi detectado durante todo o ano. A sazonalidade exerceu influência tanto nas variáveis bióticas como abióticas.

Palavras-chave: parâmetros abióticos, fitoplâncton, sazonalidade.

Introduction

The occurrence of Cyanobacteria has been observed in various environments (freshwater, brackish, marine and terrestrial), but prevalent in freshwater ecosystems (LEE, 2008). Certain characteristics make some Cyanobacteria genera particularly suitable for blooming, such as presence of sheath and mucilage; specialized cells for nitrogen fixation (heterocysts) and resistance (akynetes); aerotopes; tolerance to large fluctuations in temperature; phosphorus storage capacity, among others (DOKULIL; TEUBNER, 2000).

In tropical reservoirs, temperature has no significant influence on phytoplankton dynamics, due to little variations with values usually high above, the limiting ones to growth, but seasonal patterns of phytoplankton communities cannot be neglected (FIGUEREDO; GIANI, 2009). In these ecosystems, environmental conditions are influenced by rainfall events (BORGES et al., 2008, CHELLAPPA et al., 2008), which alter the volume and level of the ecosystem, being especially important to the dynamics of the phytoplankton community (ALMEIDA et al., 2012, DANTAS et al., 2008, 2012).

Plankton communities depend on adaptations to biotic and abiotic characteristics of each environment. Changes in the trophic status of reservoirs can cause serious damages to the system, especially when eutrophication takes place, since this process interferes with ecological balance and leads to alterations in limnological conditions (ALMEIDA et al., 2012, BARBOSA et al., 2014, OLIVEIRA et al., 2014).

Climate changes and eutrophication have provided ecological conditions for the development of cyanobacteria in a large number of Brazilian reservoirs. In works carried out over the past five years in eutrophic reservoirs in Northeastern Brazil, there are frequent reports of cyanobacterial blooms (LIRA et al., 2009, 2011, MOURA et al., 2011, DANTAS et al., 2011, ALMEIDA et al., 2012, BITTENCOURT-OLIVEIRA et al., 2012, 2014, OLIVEIRA et al., 2014). This region has relatively uniform seasonal characteristics, such as a dry season (summer), with high temperatures and low rainfall index, and a rainy season (winter), with milder temperatures and a more intense rainfall regime (BITTENCOURT-OLIVEIRA et al., 2012).

Studies have correlated the dynamics of cyanobacterial communities with environmental variables in an attempt to propose models and patterns for eutrophic reservoirs. However, the spatial and temporal heterogeneity in reservoirs allow, even for a short period, sudden changes in the composition of biological communities and also in the limnological parameters, thus producing distinct ecological dynamics. The Capibaribe River basin is considered one of the largest and most important of the Pernambuco State, used for multiple purposes and constantly subjected to anthropogenic eutrophication along its mainly urban stretch.

Accordingly, the hypothesis of this study is that the seasonal variation in rainfall promotes significant fluctuations in hydrological variables, and hence modifies the structure and composition of the Cyanobacteria community in two tropical eutrophic reservoirs in Northeastern Brazil.

Thus, this work aims to contribute to better understanding of the role of environmental variables on cyanobacterial ecology in two large eutrophic reservoirs in the Capibaribe River basin (Pernambuco State, Brazil), as well as contribute to a survey on the cyanobacteria species recorded.

Material and methods

Study area

The Carpina (7°54'41"S and 35°20'2"W) and Jucazinho (7°57'50"S and 35°44'30"W) reservoir are located in the municipalities of Feira Nova (Mata zone) and Surubim (Agreste zone), respectively, in the Pernambuco State (Brazil). They are situated in the middle (Carpina) and low (Jucazinho) stretches of the Capibaribe River. Carpina is located downstream of Jucazinho. In both regions, the climate is warm, humid, pseudo-tropical (Carpina) and semi-arid (Jucazinho), with two well-defined seasons: rainy (March to August) and dry (September to February). The reservoirs Carpina and Jucazinho have a storage capacity of 270×10^6 m^3 and 327×10^6 m^3, respectively and are mainly used for supplying water for approximately 370 thousand inhabitants (ALBUQUERQUE; OLIVEIRA, 2010).

Sampling and laboratory analysis

Samples for qualitative and quantitative analysis of the cyanobacteria community were collected monthly between January 2013 and December 2014 at three sampling sites in the limnetic zone, during two seasons: rainy (March to August) and dry (January to February and September to December) seasons. All samples were obtained in duplicate under the water surface (approximately 30 cm deep), collected, preserved and stored in accordance with APHA (2012).

Data on air temperature (°C) and rainfall (mm) were obtained from the National Institute for Space Research (INPE) and from the Pernambuco Agency of Water and Climate (APAC), respectively, in meteorological stations located at a maximum of 2 km distance from the sampling sites.

In situ measurements were made for the determination of pH, using a potentiometer (Digimed, DMHP-2). Measurements of apparent color (UH), turbidity (UT), conductivity (µS cm^{-1}), alkalinity (mg L^{-1} $CaCO_3$), calcium (mg L^{-1}), magnesium (mg L^{-1}), sodium (mg L^{-1}), potassium (mg L^{-1}), sulfate (mg L^{-1}), total phosphorous (µmol), ammonia (µmol), nitrate (µmol), nitrite (µmol), chlorides (mg L^{-1}), total hardness (mg L^{-1}) and chlorophyll-a were made in accordance with APHA (2012).

Cyanobacteria were identified to the lowest possible taxonomic level with the use of specialized literature (KOMÁREK; ANAGNOSTIDIS, 1989, 1999, 2005; KOMÁREK; CRONBERG, 2001). Density (cel mL^{-1}) was determined by the method of Sedgewick-Rafter (APHA 2012). Biomass (mm^3 L^{-1}) was calculated from values of cell biovolume (n = 30), based on Hillebrand et al. (1999).

TN: TP molar ratio was determined according to Downing et al. (1992). For the estimation of nutrient limitation, TN: TP < 20 was considered as limited by nitrogen; TN: TP > 38 was considered as limited by phosphorus (KOSTEN et al., 2009).

The trophic state index was calculated based on Carlson (1977).

Analysis of variance (ANOVA) was used to test differences in abiotic and biotic variables ($p < 0.05$) between rainy and dry seasons using the Statistica software (test version). Redundancy Analysis (RDA) was applied to assess associations between Cyanobacteria and environmental variables, using the R software. The matrix with biotic data was constructed only with species of cyanobacteria with higher biomass than 5% of the total biomass.

Results

Data of air temperature and rainfall confirmed the occurrence of two distinct seasons in the regions where the Jucazinho and Carpina reservoirs are located. The dry and rainy seasons were characterized by average temperatures above 23ºC. Rainfall was higher in the rainy season in comparison to the dry season, which showed an average rainfall of 3mm (Jucazinho Reservoir).

Temperature values (ANOVA: $F = 10.7$, $p < 0.05$ for Jucazinho and $F = 12.2$, $p < 0.05$ for Carpina) and rainfall (ANOVA: $F = 11.9$, $p < 0.05$ for Jucazinho and $F = 8.9$, $p < 0.05$ for Carpina) were significantly different between seasons during the study.

Limitation of nitrogen throughout the study was observed in both reservoirs. Although the average concentrations of the three nitrogen inorganic forms (ammonia, nitrite and nitrate) have not shown significant differences between the seasons, higher values were verified in the rainy season in both reservoirs, especially the nitrate concentrations with average concentrations above 0.3 μmol in both reservoirs. Regarding pH, alkaline values occurred throughout the study, but without significant differences between the seasons, as well as for the other parameters.

In the reservoirs, values of chlorophyll-a and total phosphorous classified these waters as eutrophic (Jucazinho) or hypereutrophic (Carpina) throughout the study.

Ten taxa of Cyanophyta were identified, belonging to the orders Oscillatoriales, Chroococcales, Nostocales and Pseudanabaenales (Table 1).

In this study, total biomass of cyanobacteria exceeded 1.0 mm^3 L^{-1} in all samples. Greater biomass of all cyanobacteria species occurred during the rainy and dry seasons in Carpina and Jucazinho reservoirs, respectively, as shown in Table 1. *Planktothrix agardhii* (Gomont) Anagnostidis and Komárek (1988) occurred on 100% of samples, with greater mean biomass in Carpina (mean: 9.9 ± 2.1 mm^3 L^{-1}) than in Jucazinho (mean: 5.3 ± 1.0 mm^3 L^{-1}). This species represented 71.8 and 88.6% of the total biomass of Jucazinho and Carpina reservoirs, respectively, considered a dominant species in both reservoirs.

There was a significant difference in biomass between dry and rainy seasons in both reservoirs (ANOVA: $F = 7.84$ and $F = 8.72$, $p < 0.05$ for Jucazinho and Carpina, respectively).

Table 1. Average values of Cyanobacteria biomass (mm^3 L^{-1}) in Carpina and Jucazinho reservoirs during rainy and dry seasons; + = occurrence of biomass lower than 0.1 mm^3 L^{-1}; - = absence; DS = dry season; RS = rainy season.

Taxon	Carpina		Jucazinho	
	DS	RS	DS	RS
Oscillatoriales				
Geitlerinema amphibium (C. Agardh) Anagnostidis (1989)	0.8	0.9	0.5	0.3
Planktothrix agardhii (Gomont) Anagnostidis and Komárek (1988)	8.6	8.7	5.4	4.7
Chroococcales				
Merismopedia tenuissima Lemmermann (1898)	+	+	+	-
Microcystis aeruginosa (Kützing) Kützing (1846)	0.4	0.4	1.2	-
Nostocales				
Cylindrospermopsis raciborskii (Woloszynska) Seenaya and Suba Raju (1972)	3.0	5.7	2.3	1.5
Aphanizomenon gracile (Lemmermann) Lemmermann (1907)	2.0	0.2	0.3	0.3
Raphidiopsis mediterranea Skuja (1937)	0.2	1.0	-	-
Anabaenopsis elenkinii V. V. Miller (1923)	+	+	-	-
Dolichospermum sp.	1.9	1.8	-	0.3
Pseudonabaenales				
Planktolynbya sp.	+	+	+	+

The results of the Redundancy Analysis (RDA) are illustrated in Figure 1. The Monte Carlo test proved significant ($p < 0.01$). There were relationships between environmental variables and biological factors. Eigenvalues of Axis 1 and 2 explained 55.3% of the variance in biological data. The correlation of species biomass with environmental conditions was high in both axes.

RDA Axis 1 separated the reservoirs. The sampling units in Jucazinho Reservoir were positively related to this axis, whereas those in the Carpina Reservoir were negatively related. Regarding to the intra-set correlation, the variables associated positively to Axis 1 were nitrite and ammonia and a group of sampling units of the Jucazinho Reservoir was observed. Calcium, alkalinity, sulfate, chloride and conductivity were negatively associated with Axis 1 and a group of sampling units of the Carpina reservoir was verified. *Cylindrospermopsis raciborskii* (Woloszynska) Seenaya and Suba Raju (1972), *P. agardhii* and *Geitlerinema amphibium* (C. Agardh) Anagnostidis (1989) were inversely related with Axis 1 and were the most abundant taxa in the Carpina Reservoir. *C. raciborskii* was also associated with higher conductivity and lower values of nitrite and ammonia. *P. agardhii* and *G. amphibium* were associated with higher values of calcium, sulfate, chloride and alkalinity. These three species were abundant under the same conditions (Figure1).

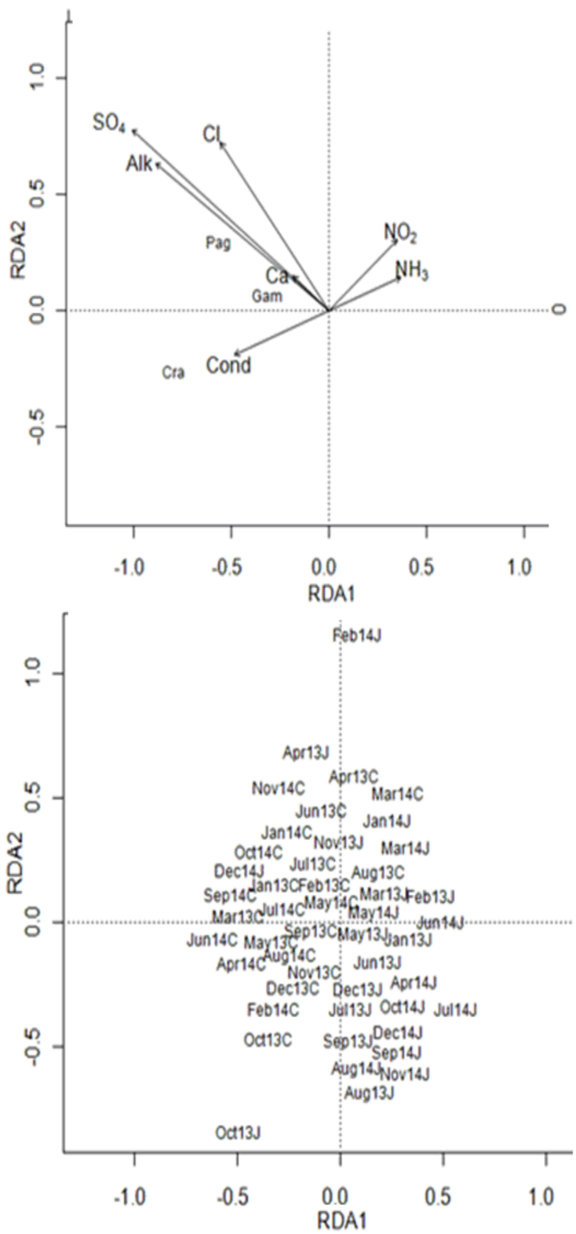

Figure 1. RDA plots for the main species of cyanobacteria and significant abiotic variables in the Jucazinho and Carpina reservoirs, Pernambuco State, Brazil; Cra: *Cylindrospermopsis raciborskii*; Gam: *Geitlerinema amphibium*; Pag: *Planktothrix agardhii*; NO_2: nitrite; NH_3: ammonia; Cl: chlorides; SO_4: sulfate; Alk: alkalinity; Ca: calcium; Cond: conductivity. Sampling units are identified with the first letter of the season (D: Dry; R: Rainy), two last numbers of the year (13: 2013; 14: 2014) and the first letter of the reservoir (J: Jucazinho; C: Carpina)

The second axis showed temporal variations between years (2012 and 2013) and seasons (dry and rainy) both in Jucazinho and Carpina reservoirs. *C. raciborskii, P. agardhii* and *G. amphibium* were mostly associated with sampling units of the Carpina Reservoir. Non-N-fixing species (*P. agardhii* and *G. amphibium)* were positively related to this axis, whereas the N-fixing species (*C. raciborskii)* was negatively related. The variables positively associated to Axis 2 were chloride, sulfate, alkalinity and calcium and conductivity was negatively associated with this axis. As observed in the Carpina Reservoir, *P. agardhii*, *C. raciborskii* and *G. amphibium* were also abundant in the Jucazinho reservoir.

Discussion

Most limnological parameters analyzed, both biotic and abiotic, showed higher concentrations in the Carpina Reservoir, than Jucazinho. It was possibly because the Carpina reservoir is downstream of Jucazinho, and receives the load of organic matter from the stretch between the two reservoirs.

Both reservoirs showed high TSI, classifying the reservoirs as eutrophic (Jucazinho) and hypereutrophic (Carpina). Moura et al. (2007b), and Lira et al. (2011), studying Brazilian reservoirs, observed that these environments remained eutrophic or hypereutrophic throughout the year, mainly in the drier months.

The electrical conductivity showed high levels in both reservoirs throughout the study period, ranging from 1,146 to 1,961 μS cm^{-1}. This parameter is considered a good indicator of water quality, since high values may indicate eutrophication, possibly due to the decay of organic matter that release large amount of ions in the water body. This report is supported by studies in eutrophic reservoirs performed by Gemelgo et al. (2009), Lira et al. (2011), Teixeira de Oliveira et al. (2011), Daruich et al. (2014) and Oliveira et al. (2014).

Alkaline pH values were registered throughout the study in both reservoirs, as well as in studies carried out in eutrophic reservoirs in northeastern Brazil (MOURA et al., 2007b, OLIVEIRA et al., 2014). The aquatic communities can interfere with pH and algae can raise the pH through photosynthesis. The preference of Cyanobacteria from neutral to alkaline environments is due to their ability to use bicarbonate as a form of inorganic carbon and their limited ability to regulate and maintain neutral the internal pH in acidic ecosystems (LEE, 2008).

High concentrations of phosphorus and nitrogen forms were verified in all samples, corroborating studies in eutrophic ecosystems undertaken by Moura et al. (2007a), Gemelgo et al. (2009), Teixeira de Oliveira et al.(2011), Dantas et al., 2012, Piccin-Santos and Bittencourt-Oliveira (2012) and Oliveira et al. (2014). However, seasonality has some influence on these macronutrient concentrations. The phosphorous showed the highest concentration in the dry season, a result also found by Oliveira et al. (2014) in studies in eutrophic reservoirs. Nevertheless, higher concentrations of this macronutrient and nitrogen forms were found in the rainy season, confirming Moura et al. (2007b), Teixeira de Oliveira et al. (2011), Dantas et al. (2012) and Bezerra et al. (2014). The profile for nitrogen was confirmed in this study and may be due to the input of sediments and nutrients from the reservoir margins. Finally, studies performed by Moura et al. (2007a) and Dellamano-Oliveira et al. (2008) detected smaller concentrations of both nutrients during the rainy season, possibly as a result of the dilution effect of rainfall.

The characterization of the studied areas shows that the upstream stretch of Carpina and Jucazinho reservoirs is subjected to intense human activities, considering the agglomeration of several municipalities along the banks of the Capibaribe River. Both regions lack sewage treatment in urban and rural areas, which contribute with the input of undesirable chemicals in the reservoir water, as well as accelerate eutrophication process.

Although phosphorus is frequently considered as the most important limiting factor for algal growth (DELAZARI-BARROSO et al., 2007), nitrogen limitation is recognized as the ideal condition for the occurrence of cyanobacterial blooms, reported in several studies in eutrophic ecosystems, highlighting the predominance of heterocystous species (MOURA et al., 2007a, 2007b, DELAZARI-BARROSO et al., 2007, FONSECA; BICUDO, 2008, DANTAS et al., 2012, BEZERRA et al., 2014, COSTA et al., 2014), including reservoirs of Northeastern Brazil, probably due the high availability of phosphorous (DANTAS et al., 2008, 2011). Nevertheless, studies also demonstrated the predominance of cyanobacteria under phosphorus limiting conditions (CHELLAPPA et al., 2008, FIGUEREDO; GIANI, 2009) or found no relationship between cyanobacterial dominance and TN: TP ratio in eutrophic reservoirs (SANTOS et al., 2012).

Analyzing the RDA (Figure 1), it was observed that the nitrogen forms NO_2 and NH_3 were negatively correlated with *C. raciborskii* (N-fixing species), *P. agardhii* and *G. amphibium* (non-N-fixing species). This result was similar to that reported by Fonseca and Bicudo (2008), considering negative correlation with cyanobacteria total density and Willame et al. (2008), who considered negative correlation with cyanobacteria efficient in competing for N. This result suggests that these filamentous species preferred the oxidized form of nitrogen (nitrate). However, studies highlighted that *C. raciborskii* abundance decreases with the decreasing inorganic nitrogen (TONETTA et al., 2014).

With respect to conductivity, there was a positive correlation with the cyanobacteria species identified, corroborating a study carried out in the same reservoir by Lira et al. (2011). As shown in Figure 1, *P. agardhii, C. raciborskii* and *G. amphibium* had positive correlation, meaning that the same environmental conditions are favorable for the growth of these three taxa. Fonseca and Bicudo (2008) pointed out that species of Nostocales were positively correlated with conductivity values.

Despite high throughout the year, higher cyanobacteria biomass values were found during the dry season in the Jucazinho Reservoir and in the rainy season in the Carpina Reservoir. Permanent cyanobacterial dominance is regarded as the ultimate phase of eutrophication (DOKULIL; TEUBNER, 2000). The results found for the Carpina Reservoir are in accordance to Lira et al. (2011), in a study carried out in the same reservoir. Teixeira de Oliveira et al. (2011), Lira et al. (2011), Dantas et al. (2012) and Oliveira et al. (2011) showed a predominance of cyanobacteria during the rainy season, due to the displacement of allochthonous nutrients, which enriched the ecosystem. Nevertheless, higher biomass, mainly of filamentous species, was found during the dry season in many reservoirs (MOURA et al., 2007b, DANTAS et al., 2008, DELLAMANO-OLIVEIRA et al., 2008, TUNDISI et al., 2008, OLIVEIRA et al., 2011, MOURA et al., 2011, DANTAS et al., 2012). Reduced biomass in the rainy season can occur due to the hydrological instability caused by the intense rainfall events, characteristic of the onset of the rainy season in tropical regions.

The influence of seasonality on cyanobacteria biomass may occur by the regulation of light penetration into water bodies. In the present study, cyanobacteria biomass had negative correlation with turbidity in both reservoirs. Although with low values, the turbidity was higher in the dry season in the Carpina Reservoir, and in the rainy season in the Jucazinho Reservoir; some studies indicate that greater values of turbidity can be more advantageous to Oscillatoriales and Nostocales (FIGUEREDO; GIANI, 2009). Moura et al. (2007a) found higher turbidity values in the rainy season in a reservoir of the Pernambuco State, corroborating the results found in Jucazinho Reservoir.

Blooms and coexistence of *P. agardhii* and *C. raciborskii* have been frequently reported in tropical eutrophic reservoirs (FIGUEREDO; GIANI, 2009) and occurred throughout the study period in both reservoirs. They are associated with the highest values of turbidity (R-strategist species), temperature, conductivity, pH and phosphorous (GEMELGO et al., 2009).

In the present study, there were higher values of Oscillatoriales biomass (*P. agardhii* and *G. amphibium*), followed by Nostocales (*C. raciborskii*). According to Moura et al. (2007a), in the Carpina Reservoir, higher densities of Oscillatoriales than Nostocales were verified. In eutrophic ecosystems in northeastern Brazil, the dominance of a single species throughout the year has been recorded (MOURA et al., 2007b).

C. raciborskii may dominate some eutrophic reservoirs for long periods, especially under nitrogen limiting conditions (DANTAS et al., 2011, BITTENCOURT-OLIVEIRA et al., 2012). *C. raciborskii* blooms have been reported (DOKULIL; TEUBNER, 2000, TONETTA et al., 2014), including in the Pernambuco State (BITTENCOURT-OLIVEIRA et al., 2012). Studies in eutrophic reservoirs have registered *P. agardhii* blooms (DOKULIL; TEUBNER, 2000, MOURA et al., 2007b, GEMELGO et al., 2009, FIGUEREDO; GIANI, 2009, DANTAS et al., 2012). In agreement with Reynolds (2002), this species is classified as a S1 functional group, characterized by inhabiting turbid and mixed environments with low light penetration. Furthermore, it was shown that *Planktothrix* compete well under N-limitation and is able to survive long periods of nitrogen deficiency (WILLAME et al., 2008). The conditions in the Jucazinho Reservoir were conducive to the occurrence of S1 associations often accompanied by *C. raciborskii* (Sn functional group) and *Aphanizomenon gracile* (Lemmermann) Lemmermann (H1 group) (DANTAS et al., 2012).

The persistence of cyanobacteria is probably favored by the high nutrient concentrations in eutrophic systems (DELLAMANO-OLIVEIRA et al., 2008) or due to the synergism of several factors (BORGES et al., 2008, FIGUEREDO; GIANI, 2009, DANTAS et al., 2011).

Long hydraulic retention times, allied to the other physical and chemical parameters, may have favored the development of cyanobacteria, resulting in high densities in the reservoirs, as observed by Gemelgo et al. (2009). For Jucazinho and Carpina reservoirs, the theoretical hydraulic retention time is about 401 days and 109 days, respectively. Short residence times cause biomass loss by hydraulic washout and mechanical shock in phytoplankton cells (TEIXEIRA DE OLIVEIRA et al., 2011).

Seasonal models for many physical and chemical parameters are common in tropical reservoirs, which are basically defined by the strong influence of rainfall. It should be stressed that the majority of species that coexist in cyanobacterial blooms also form part of this group and are capable of living in adverse conditions and grow competitively when conditions are favorable (LIRA et al., 2011).

In the present study, in the Carpina Reservoir, the rainy season provided conditions of competitive equality among the opportunistic species, leading to a reduction in *P. raciborskii* dominance by 5%. *A. gracile* was sensitive to the increased rainfall, but is opportunists and establishes rapid growth under situations of increased light penetration. Although relatively low, the change in the dominance of *P. agardhii* in the rainy season was sufficient for the establishment of opportunistic species, which began to coexist. Nevertheless, in Jucazinho Reservoir, the transition from dry to the rainy season increased the dominance of *P. agardhii* in the cyanobacteria community about 4%, due to the disappearance of *Microcystis aeruginosa* (Kützing) Kützing (1846) and *Merismopedia tenuissima* Lemmermann (1898), which were sensitive to the increased rainfall in the reservoir.

The cyanobacteria community in the reservoirs is strongly influenced by biotic and abiotic factors, undergoing the effects of seasonality. This study represents a significant contribution to the determination of ecology of cyanobacteria in eutrophic aquatic ecosystems, used for multiple purposes, taking into account the effect of seasonality.

Conclusion

This study showed higher values of cyanobacteria biomass in the dry (9.9 $mm^3\ L^{-1}$) and rainy (19.0 $mm^3\ L^{-1}$) seasons in Jucazinho and Carpina reservoirs, respectively, especially *P. agardhii*, *C. raciborskii* and *G. amphibium*, which occurred in 100% of the samples. RDA analysis revealed that the variables nitrite, ammonia, conductivity, calcium, sulfate, chlorides and alkalinity influenced most the Cyanobacteria community in both reservoirs. Seasonality affected both biotic and abiotic variables.

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