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PLANKTONIC MICROALGAE IN RECREATIONAL FISHPONDS OF THE CRATO MUNICIPALITY, CEARÁ STATE/BRAZIL

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ABSTRACT: This study aimed to evaluate the occurring phytoplankton composition in the two recreational fishponds in Crato municipality, south of Ceará. Samples for the study were collected monthly, from June 2012 to March 2013, using plankton net and glass separator (20 μm), fixed with 4% formalin and deposited in the Botany Laboratory of the assets of Regional University of Cariri, where were made analysis and taxonomic identification. The phytoplankton community proved to be represented by 100 taxa belonging to five divisions: Chlorophyta which contributed 56% of total taxa, followed by Euglenophyta (18%), Cyanobacteria (16%), Bacillariophyta (7%) and Dinophyta (3%). The Scenedesmaceae family presented the highest number of taxa (19) and *Scenedesmus* and *Desmodesmus* genres presented greater number of species. *Desmodesmus comunis* (Hegewald) Hegewald and *Desmodesmus opoliensis* (P. Hichter) Hegewald (Chlorophyta) and *Aphanocapsa* sp. (Cyanobacteria) were classified as dominant and other two named species of Chlorophyta abundant *Desmodesmus armatus* (R. Chodat) E. Hegewald and *Scenedesmus producto-capitatus* Schumula. As the frequency 10% were classified as very frequent, 14% frequent and the others too infrequent. 75% had average diversity and the community with equitable distribution of taxa. The set of information made in relation to the phytoplankton community characterized the ecosystems studied from meso to eutrophic.

KEY WORDS: Phytoplankton; Diversity; Cyanobacteria.

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MICROALGAS PLANCTÔNICAS DE PESQUEIROS DO MUNICÍPIO DO CRATO, CEARÁ, BRASIL

RESUMO: O presente estudo teve como objetivo avaliar a composição fitoplanctônica ocorrente em dois pesqueiros do município do Crato, Sul do Estado do Ceará. As amostras para o estudo foram coletadas mensalmente, no período de junho de 2012 a março de 2013, utilizando rede e copo separador de plâncton (20μm), fixadas com formol a 4% e depositadas no acervo do Laboratório de Botânica da Universidade Regional do Cariri, onde foram efetuadas análise e identificação taxonômica. A comunidade fitoplanctônica mostrou-se representada por 100 táxons distribuídos em cinco divisões: Chlorophyta, que contribuiu com 56% do total de táxons, seguida de Euglenophyta (18%), Cyanobacteria (16%), Bacillariophyta (7%) e Dinophyta (3%). A família Scenedesmaceae foi a que apresentou maior número de táxons (19) e os gêneros *Desmodesmus* e *Scenedesmus* apresentaram maior número de espécies. *Desmodesmus comunis* (Hegewald) Hegewald e *Desmodesmus opoliensis* (P. Hichter) Hegewald (Chlorophyta) e *Aphanocapsa* sp. (Cyanobacteria) foram classificadas como dominantes e outras duas espécies de Chlorophyta denominadas abundantes *Desmodesmus armatus* (R. Chodat) E. Hegewald e *Scenedesmus producto-capitatus* Schumula. Quanto à freqüência, 10% foram classificadas como muito frequentes, 14% frequentes e as demais pouco frequentes. 75% apresentaram média diversidade e a comunidade com distribuição equitativa dos táxons. O conjunto de informações levantadas em relação à comunidade fitoplanctônica caracterizou os ecossistemas estudados de meso a eutrófico.

PALAVRAS-CHAVE: Cyanobacteria; Diversidade; Fitoplâncton.

INTRODUCTION

Phytoplankton consists of a wide variety of organisms belonging to different taxonomic groups and which live suspended in well-lit surface waters (PROENÇA et al., 2011). They are microscopic organisms that float freely in water and play an essential role in any water environment, given that phytoplankton consists of organisms that contain chlorophyll and are therefore primary producers at the bottom of the food chain, and also represent the main source of oxygen for water ecosystems (SANT'ANNA; GENTIL; SILVA, 2006).

Microalgae are among the oldest organisms in the world, are found in all water masses, and are excellent bioindicators of water quality and trophic condition. They take part in the cycling, retention and transformation of organic carbon dissolved in water, are part of the diet of a wide range of organisms as fishes and invertebrates, and have a role in the oxygenation of water and accumulation of polluting substances. Their presence or absence these organisms are also a strong indicator of environmental alterations (POMPÊO, 2003).

Recreational fishponds are leisure endeavors involving a modality of sport fishing. They are located near urban centers, not only to serve fish selling systems but also to meet the demand for leisure services in natural environments and for multiple alternative uses of water bodies (MERCANTE et al., 2011). One tool to help understand the ecological dynamics of these ecosystems is the floristic survey of phytoplankton, as it is a bioindicator of the trophic conditions of a given aquatic environment and helps in the evaluation and research involving the conservation of these environments (CORDEIRO-ARAÚJO et al., 2010).

There is little data on the phytoplankton community and water quality in recreational fishponds, as this is a recent activity in Brazil (GENTIL, 2007; ROSINI, 2010), concentrated mainly in the southeast region of the country.

Therefore, the objective was to assess the composition of planktonic microalgae in two recreational fishponds located in the Cariri region, southern Ceará State, Brazil, and determine their relationship to water quality, in order to contribute to knowledge on the diversity of these organisms in these ecosystems.

2 MATERIAL AND METHODS

The Cariri region, comprising southern Ceará, northeastern Pernambuco and eastern Piauí states, is situated on a sedimentary basin (Araripe basin) nearly 12,000 km^2 in size – the largest in Northeastern Brazil. Surrounded by Brazil's semi-arid region, the Cariri is a true oasis, due to a rich and dense rainforest located on top of the Araripe Highlands. Due to the porosity of its rocks, rainwater is absorbed in the forest highlands and retained in the subsoil, reemerging as crystalline water springs on hillsides (LUCENA et al., 2012). In this region, underground hydric resources are the most important sources of drinking water for public and private supplies, as well as farming, industrial and leisure activities (OLIVEIRA, 2003).

The recreational fishponds in which the study was carried out are located in the district of Belmonte, municipality of Crato, Cariri region. Fishpond 1 (Pp 1) (7º 15' 31" S and 39º 26' 41" W) and Fishpond 2 (Pp 2) (7° 15' 30" S and 39° 26' 42") are situated at altitudes of 628 m and 622 m, respectively. They were built about three years ago, are about 470 m^2 to 1.276 m^2 in area, 2,3 m at the deepest point, and water is provided to them by a deep well (Figure 1).

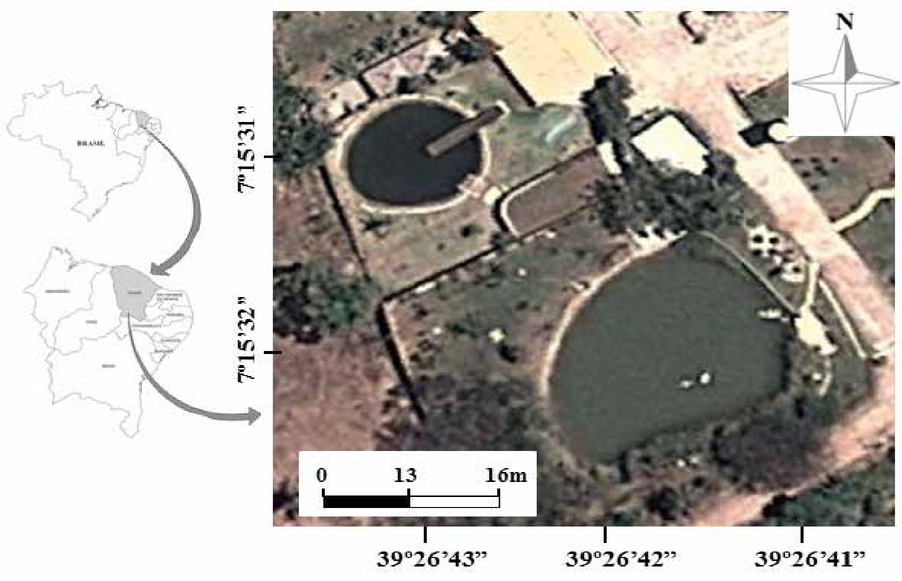

Figure 1. Aerial photo of the fishponds. Source: Google Earth, 2014.

After authorization from the owner, samples of the phytoplankton community were collected monthly between June 2012 to March 2013. Collections were made using a net and plankton separator (20 μm mesh size) by filtering approximately 50L of water. The net was cast several times over the water surface, and towed horizontally for approximately five meters from the middle towards the edge of the pond.

The samples were next placed in proper flasks, labeled and fixed in 4% formaldehyde (NEWELL; NEWELL, 1963) and then stored in the collection of the Botanic Laboratory at Cariri Regional University (URCA). The quantitative floristic composition analysis consisted of identifying the different taxa, using a BIOVAL $L2000_A$ optical microscope. To identify and systematize the taxa, specialized sources were consulted, such as: Desikachary (1959), Prescott (1962) Mizuno (1968), Prescott (1975), Compére (1976), Parra et al. (1983), Sant'Anna (1984), Anagnostidis; Komárek (1988), Komárek; Anagnostidis (1989), Round et al. (1992), Bicudo; Menezes (2005) Bicudo and Menezes (2006), Reviers (2006), Sant'Anna et al. (2006), Franceschini et al. (2010), Sant'Anna et al. (2012), among others.

Quantitative analysis consisted of calculating the relative abundance values for each taxon in the sample, using the formula proposed by Lobo and Leighton (1986), with the different taxa distributed in the following hierarchy: Dominant > 50%; Abundant > 30 ≤ 50%; Little abundant ≤ 30 > 10% and Rare ≤ 10. The frequency of occurrence was calculated according to the methodology proposed by Mateucci and Colma (1982), with the taxa classified into the following categories: Very frequent > 70%; Frequent ≤ 70% > 40%; Little frequent ≤ 40% > 10% and Sporadic ≤ 10%.

Specific diversity was calculated as per Shannon (1948), expressed in bits. cel^1, with values fitting into the following classification: < 1.0 very low diversity, < 2.0 ≥ 1 low diversity, <3.0 ≥ 2.0 medium diversity, ≥ 3.0 $bits.cel^{-1}$ high diversity. Equitability was calculated according to Pielou (1977), with values ranging between 0 and 1, in which equitability is considered low whenever the value nears zero while values above 0.50 are considered high or equitable, representing a uniform distribution of the taxa in the sample under analysis. The Ecology (Measures of Community and Measures of Community Similarity) statistical program was used for these calculations.

3 RESULTS AND DISCUSSION

A total of 100 phytoplankton taxa were inventoried in the two recreational fishponds. Of this total, 76 were found in Pp1 and 54 in Pp2, distributed into five divisions: Chlorophyta, which contributed 56% (56 species) of the total number of taxa, followed by Euglenophyta 18% (18 species), Cyanobacteria 16% (16 species), Bacillariophyta 7% (seven species) and Dinophyta 3% (three species), and represented by six taxonomic classes: Chlorophyceae, Zygnemaphyceae, Euglenophyceae, Cyanophyceae, Bacillariophyceae and Dinophyceae (Table 1).

Table 1. Planctonic Microalgae Species Registered in the Two Fishponds in the Period of June 2012 to March 2013 (continua)

		SECO		CHUVOSO	
		Pp1	Pp2	Pp1	Pp2
	Cyanobacteria/ Cyanophyceae				
1	*Anabaena* sp.	x		x	x
2	*Aphanocapsa anulata* G.B. Mc Gregor	x			
3	*Aphanocapsa delicatissima* West & G.S.West	x			
4	*Aphanocapsa incerta (Lemmannmer) Komárek*				x
5	*Aphanocapsa* sp.	x	x	x	x
6	*Chroococcus dispersus* (Keissler) Lemmermann				x
7	*Chroococcus turgidus (Kützing)* Nägeli	x	x	x	x
8	*Dactylococcopsis rhaphidioides* Hansgirg		x		
9	*Limnococcus* sp.			x	
10	*Merismopedia* sp.	x	x	x	
11	*Microcistis* sp.			x	
12	*Nostoc* sp.	x			x
13	*Rabdoderma* sp.				x
14	*Radiocystis* sp.			x	
15	*Synechococcus* sp.			x	
16	*Synechocystis* sp.		x	x	
	Subtotal	7	5	9	7
	Chlorophyta/ Chlorophyceae				
17	*Ankistrodesmus* sp.	x		x	
18	*Chlorella fusca* Shihira & R. W. Krauss	x	x	x	x
19	*Chlorella vulgaris* Beyerinck [Beijerinck]	x	x	x	x
20	*Chlorococcum* sp.	x	x		x

(continua)

21	*Chodatella* sp.	x			
22	*Closteriopsis* sp.	x			
23	*Coelastrum microporum* Nägeli		x		
24	*Crucigenia quadrata* Morren	x			
25	*Crucigenia* sp.	x	x		x
26	*Crucigenia tetrapedia* (Kirchner) Kuntze	x	x	x	
27	*Desmodesmus opoliensis* (P. Richter) Hegewald	x	x	x	x
28	*Desmodesmus* armatus (R. Chodat) E. Hegewald	x	x		x
29	*Desmodesmus bicaudatus* (Dedusenko) PMT satenko		x		
30	*Desmodesmus communis* (E. Hegewald) Hegewald	x	x	x	x
31	*Desmodesmus maximus* (W.West & G.S.West) Hegewald		x		
32	*Desmodesmus subspicatus* (Chodat) E. Hegewald & H. Schmidt	x		x	
33	*Dicellula geminata* (Printz) Korshikov	x	x		x
34	*Dictyosphaerium ehrenbergianum* Nägeli	x	x	x	x
35	*Elakatothrix gelatinosa* Wille		x		
36	*Eutetramorus globosus* Walton	x		x	
37	*Franceia* sp.		x	x	
38	*Gloeocystis* sp.		x		x
39	*Golenkinia radiata* Chodat		x		
40	*Golenkiniopsis* (Korshikov) Korshikov				x
41	*Kirchneriella lunaris* (Kirchner) K.Möbius	x	x		
42	*Lagerheimia* sp.				x
43	*Monoraphidium contortum* (Thuret) Komárková-Legnerová	x	x	x	x
44	*Monoraphidium griffithii* (Berkeley) Komárková-Legnerová	x	x	x	
45	*Monoraphidium* sp.	x		x	
46	*Monoraphidium tortile* (West & G.S. West) Komárková-Legnorová	x		x	
47	*Mucidosphaerium pulchellum* (H. C. Wood) C. Bock		x		x
48	*Nephrochlamys* sp.	x		x	x
49	*Nephrocytium* sp.	x			
50	*Oocystis borgei* J.W.Snow	x	x	x	
51	*Oocystis solitaria* Wittrock				x
52	*Oocystis* sp.		x		

(continua)

53	*Pediastrum tetras* (Ehrenberg) Ralfs	x		x	
54	*Scenedesmus arcuatus* (Lemmermann) Lemmermann	x		x	
55	*Scenedesmus bernardi* Smith	x		x	x
56	*Scenedesmus producto-capitatus* Schumula	x	x	x	
57	*Scenedesmus javanensis* Chodat		x		x
58	*Scenedesmus* sp.		x		
59	*Schroederia indica* Philipose		x		
60	*Tetradesmus* sp.	x			
61	*Tetraëdron caudatum* (Corda) Hansgirg	x	x	x	x
62	*Tetraëdron minimum* (A.Braun) Hansgirg	x			x
63	*Tetraëdron* sp.				x
64	*tetrastrum elegans* Playfair		x		
65	*Tetrastrum heteracanthum* (Nordstedt) Chodat				x
	Subtotal	31	29	21	22
	Chlorophyta / Zygnemaphyceae				
66	*Cosmarium contractum* O. Kirchner		x		x
67	*Cosmarium depressum (*Nägeli) P.Lundell		x		
68	*Cosmarium majae* Strøm	x	x		
69	*Cosmarium* sp.			x	
70	*Staurastrum volans* W.West & G.S.West	x			
71	*Staurastrum* sp.	x			
72	*Euastrum* sp.	x	x		
	Subtotal	4	4	1	1
	Euglenophyta/ Euglenophyceae				
73	*Euglena caudata* K. Hubner			x	
74	*Euglena oxiuris* Schmarda			x	
75	*Euglena proxima* Dangeard			x	x
76	*Euglena* sp.1	x		x	x
77	*Euglena* sp.2			x	
78	*Euglena texta* (Dujardin) Hubner			x	
79	*Hyalophacus ocelatus* Pringsheim		x		
80	*Lepocinclis globulus* Perty			x	

(conclusão)

81	*Lepocinclis ovum* (Ehrenberg) Lemmermann	x	x	x	x
82	*Lepocinclis texta* (Dujardin) Lemmermann			x	
83	*Lepocinclis* sp.	x		x	x
84	*Phacus caudatus* Hubner				x
85	*Phacus longicauda* (Ehrenberg) Dujardin		x		x
86	*Phacus minutus* (Playfair) Pochmann		x		x
87	*Phacus* sp.				x
88	*Phacus tortus* Lemmermann		x		x
89	*Trachelomonas volvocina* (Ehrenberg) Ehrenberg	x		x	
90	*Trachelomonas* sp.		x		
	Subtotal	4	6	11	9
	Dinophyta/Dinophyceae				
91	*Gymnodinium* sp.	x	x		
92	*Peridinium umbonatum* Stein		x		x
93	*Peridinium* sp.		x	x	x
	Subtotal	1	3	1	2
	Bacillariophyta/ Bacillariophyceae				
94	*Cymbella* sp.		x		x
95	*Frustulia* sp.			x	
96	*Gomphonema* sp.		x		
97	*Navicula* sp.	x	x		
98	*Nitzschia* sp.		x		x
99	*Pinnularia* sp.		x		
100	*Pleurosigma* sp.		x		
	Subtotal	1	6	1	2

With regard to seasonal variation, the divisions were present in both periods of the year – rainy and dry – for both analyzed fishponds. Chlorophyta contributed with the greatest species richness in both periods, followed by Euglenophyta and Cyanobacteria (Figure 2).

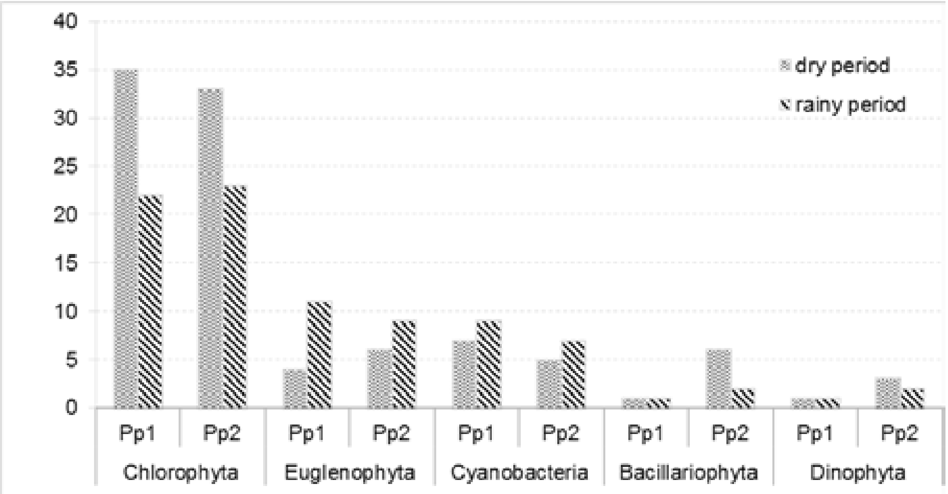

Figure 2. Distribution of taxa according to division during the dry and rainy periods

Studies conducted in different ecosystems, such as the planktonic community in rearing fishponds located in Jaboticabal- SP (MACEDO; SIPAÚBA-TAVARES, 2005) and studies on phytoplankton in fishponds located in the São Paulo metropolitan area (MATSUZAKI; MUCCI; ROCHA, 2004; SANT'ANNA; GENTIL; SILVA, 2006; GENTIL, 2007; ROSINI, 2010) found Chlorophyta to be the most representative division, corroborating the data found in this study.

Chlorophyta is one the most common divisions, frequently found in almost every water body (BICUDO; MENEZES, 2005). Most of them preferably inhabit mesotrophic to eutrophic lakes, and are cosmopolitan (ESTEVES, 2011).

Among the Chlorophyta identified in the two fishponds under study, family Scenedesmaceae showed the highest number of taxa (19), and the most representative genera were *Desmodesmus* and *Scenedesmus*, with six and five taxa, respectively; *Crucigenia* (three taxa); *Tetrastrum* (two taxa); and *Coelastrum, Dicellula* and *Tetradesmus* (one taxon). According to Hentschke and Torgan (2010) the first two genres are common occurrence in continental waters, especially rich in nutrients, a fact that probably occurred in this study considering the introduction of feed and the lack of monitoring. Also they are considered important components of the phytoplankton community, as they are very representative in its composition. Similar results were found in studies on Chlorococcales in ten fishponds in the São

Paulo metropolitan area, as recorded by Rosini et al. (2012); family Scenedesmaceae showed the highest number of taxa (26), while genera *Desmodesmus* and *Scenedesmus* had the largest number of species.

Among the identified taxa, *Desmodesmus comunis* (Hegewald) Hegewald and *Desmodesmus opoliensis* (P. Hichter) Hegewald (Chlorophyta), and *Aphanocapsa* sp. (Cyanobacteria) were classified as dominant, while two other species of Chlorophyta were named as abundant: *Desmodesmus armatus* (R. Chodat) E. Hegewald and *Scenedesmus producto-capitatus* Schumula. All others were classified as little abundant or rare. Characterizing, of this way, the environment studied as meso to eutrophic.

Genera *Desmodesmus* and *Scenedesmus* are of great importance in characterizing eutrophic environments and for the development of the trophic chain of ecosystems. These species are known to be the first to colonize aquatic environments, providing large amounts of nutrients, thus making them essential for the ecology of the environment (SANTIAGO, 2010). They can be considered the most common and cosmopolitan within the green algae genus (BICUDO; MENEZES, 2005).

Euglenophyta was the second most diverse division in the floristic survey of the two studied fishponds, contributing 18 taxa. According to Matsuzaki, Mucci e Rocha (2004), in a study performed with planktonic algae and their relationship to the water quality of a recreational fishpond in the south side of the city of São Paulo, these organisms are favored in low-transparency environments because of their flagella, allowing them to move to locations with better lighting in the water column. According to the authors, this added number of flagellates may have benefited from high water turbidity and low transparency. Euglenophyta are frequently found in freshwater, especially in waters rich in organic matter (ESTEVES, 2011).

Division Cyanobacteria was classified as having the third highest species richness, represented by 16 taxa. Similar data were reported by Matsuzaki, Mucci e Rocha (2004) in a study evaluating the water quality and phytoplankton community in a recreational fishpond system, in which 15 taxa of Cyanobacteria were identified. According to Sant'Anna et al. (2006), most species in this division are freshwater species, and live in plankton or periphyton. They can alter the balance of aquatic ecosystems, causing changes to the transparency and deoxygenation of water, in addition to releasing foul-tasting and smelling substances that affect the use of reservoirs even in recreational areas, thus compromising water quality (BRANDÃO; DOMINGOS, 2006). Moreover, several species of cyanobacteria that form blooms produce toxins called cyanotoxins (CALIJURI et al., 2006). These toxins can accumulate themselves in the food chain causing aquatic and terrestrial mortality of animals as well as acute human poisoning (Azevedo, 1998).

With regard to this division, it is worth mentioning the presence of genera *Microcystis* (December 2012, little frequent) and *Anabaena* (August/September/December 2012, frequent), which are mentioned in the literature as producers of cyanotoxins and blooms.

Genus *Aphanocapsa* was dominant during the month of July 2012 (dry period), as also observed by Sant'Anna, Gentil e Silva (2006) in studies performed in 30 fishponds located in the São Paulo metropolitan area, where one of the factors attributed to this observation was the introduction of fish rations, which may have increased turbidity and reduced water transparency, promoting the development of Cyanobacteria.

With regard to the frequency of occurrence of the identified taxa, 10% were classified as very frequent in the sampling period, with highlight to division Chlorophyta represented by *Cosmarium* sp., *Chlorella vulgaris* Beyerinck [Beijerinck], *Monoraphidium contortum* (Thuret) Komárková-Legnerová, *Pediastrum tetras* (Ehrenberg) Ralfs, *Oocystis* sp., *Desmodesmus opoliensis* (P. Hichter) Hegewald and *Scenedesmus acuminatus* (Lagerheim) Chodat. *Aphanocapsa* sp., *Chroococcus turgidus* (Kutzing) Nageli (Cianobactéria) and *Lepocinclis ovum* (Ehrenberg) Lemmermann (Euglenophyta), 14% were frequent; the rest were little frequent. Taniguchi; Rocha and Senna (2003), studying the phytoplankton community of a tropical lake located in southeastern Brazil, found only 10% of surveyed taxa to be considered frequent or very frequent.

The rates of specific diversity in both fishponds ranged between 1.51 bits.cel^{1} and 3.02 bits.cel^{-1}, in which 75% of samples showed medium diversity ranging between 2.13 and 2.85 bits.cel^{-1} in Feb/2013 and Aug/2012, 12.5% had low diversity, and another 12.5% showed high diversity. Equitability rates showed equitable distribution, in which 100% of analyzed values were above 0.50, thus determining a uniform distribution of species.

Although the equitability and diversity indicated a balanced environment, the data obtained herein suggest the maintenance of mesotrophic to eutrophic waters, and the trophic level did not impede high species richness, as reported in other fishponds.

4 CONCLUSION

They were classified in the two fishponds, 100 taxa phytoplankton. The Chlorophyta divisions, Euglenophyta and Cyanobacteria, showed higher species richness. The presence of producing cyanobacterial blooms and cyanotoxins leaders, underscore the importance of monitoring of phytoplankton and water quality of these fishponds.

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