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# CYANOBACTERIAL COMMUNITY IN RESERVOIRS OF NORTHEASTERN BRAZIL

## COMUNIDADE DE CIANOBACTÉRIAS EM RESERVATÓRIOS DO NORDESTE DO BRASIL

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**Abstract**

This paper contributes to the inventory of cyanobacteria in freshwater environments in Northeastern Brazil. Forty-two samples were collected from 19 reservoirs between February 2009 and January 2010. Twenty-three species of cyanobacteria distributed among the orders Chroococcales (10), Oscillatoriales (8) and Nostocales (5) were identified, 12 of which constitute new records for the state of Pernambuco. The greatest degrees of species richness were recorded in three ecosystems (Alagoinha, Carpina and Ingazeira reservoirs). Microcystis was the most representative genus, with the greatest number of species (*Microcystis novacekii* (Komárek) Compère, *Microcystis panniformis* J. Komárek, J. Komárková-Legnerová, C. L. Sant'Anna, M. T. P. Azevedo & P. A. C, Senna, *Microcystis protocystis* W. B. Crow and *Microcystis sp.*). *Cylindrospermopsis raciborskii* (Woloszynska) Seenaya and Subba Raju (straight morphotype) had the greatest distribution (considered very frequent) was present in 16 reservoirs (84.25%). Only four of the 42 samples did not have cyanobacteria.

*Keywords: Cyanophyta; phytogeographic distribution; species richness; taxonomy.*

**Resumo**

Este trabalho contribui para o inventário das cianobactérias de ambientes de água doce do Nordeste do Brasil. 42 amostras foram coletadas em 19 reservatórios entre fevereiro de 2009 e janeiro de 2010. Foram identificadas 23 espécies de cianobactérias distribuídas nas ordens Chroococcales (10), Oscillatoriales (8) e Nostocales (5), 12 destas constituem em novas citações para o estado de Pernambuco. A maior riqueza

de espécies foi registrada em três ecossistemas (Reservatórios de Alagoinha, Carpina e Ingazeira). Microcystis foi o gênero mais representativo, com maior número de espécies (*Microcystis novacekii* (Komárek) Compère, *Microcystis panniformis* J. Komárek, J. Komárková-Legnerová, C. L. Sant'Anna, M. T. P. Azevedo & P. A. C, Senna, *Microcystis protocystis* W. B. Crow and *Microcystis sp.*). *Cylindrospermopsis raciborskii* (Woloszynska) Seenaya e Subba Raju (morfotipo reto) apresentou maior distribuição (considerado muito frequente), esteve presente em 16 reservatórios (84.25%). Apenas quatro das 42 amostras não apresentaram cianobactérias.

*Palavras-chaves: Cyanophyta; Distribuição fitogeográfica; Riqueza de espécies; Taxonomia.*

**Introdution**

Cyanobacteria are cosmopolitan organisms considered to be the first photosynthesizers with chlorophyll and primary producers to release oxygen into the atmosphere (Carmichael, 1994). These organisms exhibit broad ecological tolerance, which contributes to their competitive success. One of the striking characteristics of this group is the ability to grow in the most varied environments – from hot springs to cold oceans as well as in terrestrial environments (Domitrovic & Forastier, 2005). However, freshwater ecosystems are the most suitable environments for the development of cyanobacteria, especially in tropical regions, which have the most favorable conditions for cyanobacterial blooms – a phenomenon characterized by the intensive growth of these microorganisms in water (Chorus & Barthram, 1999). The following aspects favor this growth: high temperatures (Padisák, 1997), alkaline pH (Reynolds & Walsby, 1975), low luminosity (Niklisch & Kohl, 1989), water column stability (Paerl, 1988), high concentrations of nutrients (Chorus & Bartram, 1999) – especially phosphorus (Watson et al., 1997) –, and a low N:P ratio (Smith, 1983). Cyanobacterial also exhibit adaptive strategies, such as the storage of phosphorus (Pettersson et al., 1993) and floatability (Reynolds & Walsby, 1975). Reservoirs in Northeastern Brazil offer these conditions and therefore favor the occurrence of cyanobacterial populations (Moura et al., 2011).

The extensive morphological plasticity and overlapping measures in species of cyanobacteria have caused problems in the correct identification of taxa, and therefore, according Bittencourt-Oliveira, Oliveira, & Bolch (2001), this can lead to a false understanding of the toxic potential of various species. Due to these problems, there are few works that aim as the primary focus aspects of taxonomic group, and thus, only about 5-10% of this diversity is known (Komárek, 2003).

In Pernambuco, studies on cyanobacteria began with Carvalho-De-La-Mora (1986; 1991) and were intensified after the "syndrome of Hemodialysis". Jochimsen et al. (1998) reported the occurrence of microcystin in the hemodialysis equipment of the Institute of kidney diseases in Caruaru, the place where the contamination and death of humans by cyanotoxins. Then, Domingos, Rubim, Molica, Azevedo & Carmichael (1999) confirmed the production of microcystin by picoplankton cyanobacteria isolated from material collected in two reservoirs in the state of Pernambuco (Tabocas and Sr. José Maria), used to supply the city of Caruaru, suggesting that these organisms may have contributed to human poisoning in hemodialysis clinic of the municipality.

Carmichael et al. (2001) observed that the Tabocas reservoir in the city of Caruaru, cyanobacteria were dominant and recorded the presence of microcystin-LR,-YR and-AR in the ecosystem. Falcão et al. (2002) reporting for monitoring four years in 82 reservoirs and dams in the state of Pernambuco noting the occurrence of cyanobacterial blooms. Couté & Bouvy (2004) described a new species of

*Cylindrospermopsis* (*C. acuminato crispa* A. Couté & M. Bouvy) to the Ingazeira reservoir.

The frequent occurrence and high densities of *Cylindrospermopsis raciborskii* (Woloszynska) Seenaya and Subba Raju were recorded in many reservoirs in the state (Bouvy et al., 1999; Bouvy et al., 2000; Bouvy et al., 2001; Huszar et al., 2000).

In the Carpina reservoir various studies were done on the cyanobacteria, with distinct approaches (ecology, taxonomy, distribution, seasonal and spatial), were carried out by Aragão et al. (2007), Moura et al. (2007a), Costa et al. (2010), Lira et al. (2010), Moura et al. (2010). In the Mundaú reservoir used for public supply in the city of Garanhuns-PE work has been done by Moura et al. (2007b), Dantas, Moura, Bittencourt-Oliveira, Neto & Cavalcanti (2008), Dantas, Bittencourt-Oliveira & Moura (2010) and Lira, Moura, Bittencourt-Oliveira & Araújo (2010). In Tapacurá, reservoir located in the state of the forest, cyanobacteria were studied by Bouvy et al. (2003), Molica et al. (2005) and Andrade et al. (2009). In Jucazinho, rugged region of the reservoir state, Travassos-Júnior, Moura, Bittencourt-Oliveira, Lira & Mendonça (2005) showed a floristic survey of phytoplankton, including cyanobacteria.

Given the need for wider knowledge of these organisms the aim of the present study was to broaden knowledge on the diversity of cyanobacteria in freshwater environments in Northeastern Brazil.

## Material and Methods

### *Study Area and Sampling*

Forty-two samples were taken from 19 reservoirs located in different phytogeographic regions in the state of Pernambuco, used mainly for the public water supply and fishing activities (figure 1) (table 1). Sampling was carried out at a single point at the subsurface near the bank between February 2009 and January 2010. The taxonomic study was performed based on semi-permanent slides with samples of living matter analyzed immediately after collection and complemented with samples preserved in formalin and Transeau solution. Analyses were performed with the aid of a ZEISS optical microscope (Jenaval model) with a measurement ocular (magnification: 400X and 1000X).

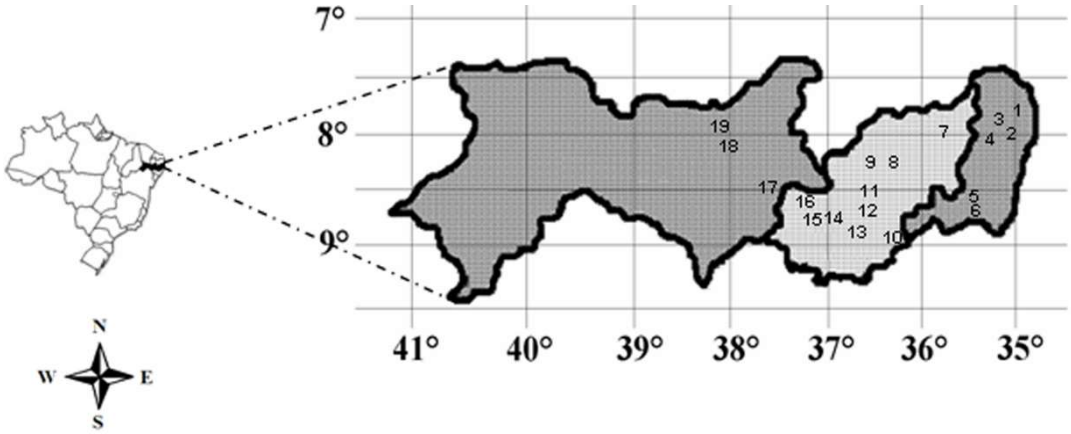


**Figure 1.** Map of location of the reservoirs in the state of Pernambuco. 1- Botafogo, 2- Duas Unas, 3- Tapacurá, 4- Carpina, 5- Pastora, 6- Santo Antônio dos Palmares, 7- Jucazinho, 8- Bitury, 9- Ipojuca, 10- Mundaú, 11- Alagoinha, 12- Venturosa, 13- Ingazeira, 14- Pedra, 15- Arcoverde, 16- Buíque, 17- Poço da Cruz, 18- Jazigo, 19- Saco I.

Morphological taxonomic characteristics of the organisms were analyzed, such as shape and dimensions of the heterocyst, akinetes, trichomes and cells as well as the presence of aerotopes and coloration. Identification was carried out to the smallest possible taxonomic level using the specialized literature (Komárek & Anagnostidis, 1986; 2005; Anagnostidis & Komárek, 1988; Cronberg & Annadotter, 2006; Komárek & Zapomělová, 2007; Moustaka-Gouni et al., 2009).

Frequency of occurrence was calculated based on the system proposed by Mateucci & Colma (1982), considering the following categories: > 70% = very frequent (VF); ≤ 70% and > 40% = frequent (F); ≤ 40% and > 10% = occasional (O); and ≤ 10% = sporadic or rare (S).

## Results and Discussion

Cyanobacteria were recorded in 38 of the 42 samples analyzed. Twenty-three species were identified in the 19 ecosystems, distributed among the orders Oscillatoriales, (10 spp.), Chroococcales (8 spp.) and Nostocales (5 spp.) (table 2). The greatest degrees of species richness were recorded in the Alagoinha, Carpina and Ingazeira reservoirs (10 spp.). *C. raciborskii* and *Sphaerospermopsis aphanizomenoides* (Forti) Zapomelová, Jezberová, Hrouzek, Hisem, Reháková & Komárková were present in all samples from these reservoirs.

**Table 1.** Location of the reservoirs, sampling dates, phytogeographical region of reservoirs and coordenates.

| Reservoirs (City) | Sampling dates | Phytogeographical region | Coordenates |
|---|---|---|---|
| Alagoinha (Alagoinha) | 04/2009, 10/2009 | *Agreste* | 8°27'31,9" S, 6°46'33,5" W |
| Arcoverde (Buíque) | 05/2009, 11/2009 | *Agreste* | 8°33'32,5" S, 6°59'07,5" W |
| Bitury (Belo Jardim) | 02/2009, 04/2009 | *Agreste* | 08°18'35" S, 36°25'36" W |
| Botafogo (Igarassu) | 05/2009, 10/2009 | *Litorânea* | 7°50'11,8" S, 35°02'0,8" W |

| | | | |
|---|---|---|---|
| Buíque (Buíque) | 06/2009, 11/2009 | *Agreste* | 8°37'52,7" S, 7°07'53,5" W |
| Carpina (Lagoa do carro) | 04/2009, 10/2009 | *Zona da Mata* | 7°53'03,8" S, 5°20'37,8" W |
| Duas Unas (Jaboatão dos Guararapes) | 05/2009, 10/2009 | *Zona da Mata* | 8°05'02" S, 35°30,6" W |
| Ingazeira (Venturosa) | 04/2009, 10/2009 | *Agreste* | 8°36'41,2" S, 6°54'23,7" W |
| Ipojuca (Belo Jardim) | 04/2009, 11/2009 | *Agreste* | 8°20'43,7" S, 36°22'31,5" W |
| Jazigo (Serra Talhada) | 05/2009, 01/2010 | *Sertão* | 8°00'08,2" S, 38°12'38,5" W |
| Jucazinho (Surubim) | 03/2009, 10/2009 | *Agreste* | 7°59'03" S, 35°48'36,7" W |
| Mundaú (Garanhuns) | 03/2009, 11/2009 | *Agreste* | 8°56'42,8" S, 36°29'27,4" W |
| Pastora (Palmares) | 06/2009 | *Zona da Mata* | 08°41'28,5" S, 5°36'53,8" W |
| Pedra (Pedra) | 06/2009, 11/2009 | *Agreste* | 8°29'37" S, 36°56'40" W |
| Poço da Cruz (Ibimirim) | 05/2009, 02/2010 | *Sertão* | 8°30'31,5" S, 37°42'17,9" W |
| Saco I (Serra Talhada) | 05/2009, 01/2010 | *Sertão* | 7°56'49,3" S, 38°17'13,1" W |
| Santo Antônio dos Palmares (Palmares) | 06/2009 | *Zona da Mata* | 08°41'35,7" S, 5°39'24,6" W |
| Tapacurá (São Lourenço da Mata) | 03/2009, 10/2009 | *Litorânea* | 8°02'31,9" S, 35°11'46,5" W |
| Venturosa (Venturosa) | 04/2009, 10/2009 | *Agreste* | 8°34'43,6" S, 36°52'47,3" W |

Fonte: Elaborado pelos autores.

The total number of species identified was relatively smaller than that recorded in previous studies with emphasis at cyanobacteria community at Northeastern of Brazil (Aragão et al., 2007; Moura et al., 2007a; Costa et al., 2009; Lira et al., 2010; Dantas et al., 2011; Lira et al., 2011) who recorded greater cyanobacterial richness. The lower number of taxa in the present study is likely due to the occurrence of blooms dominated by one or more species of cyanobacteria in the majority of reservoirs studied. The genus Microcystis was the most representative, represented by four species (*M. novacekii* (Komárek) Compère, *M. panniformis* J. Komárek, J. Komárková-Legnerová, C.L. Sant'Anna, M.T.P. Azevedo & P.A.C, Senna, *M. protocystis* W.B. Crow and *Microcystis sp.*). These same species were recorded by Costa et al. (2006) forming blooms in the Armando Ribeiro Gonçalves reservoir in the state of Rio Grande do Norte (Northeastern Brazil).

Twelve new records are recorded for the state of Pernambuco: *Chroococcus obliteratus* Richter, Merismopedia glauca (Ehrenberg) Kützing¸ *M. tenuissima* Lemmermann, *Microcystis novacekii*, *M. protocystis*, Lyngbya cf. ceylanica Wille¸ *Planktothrix isothrix* (Skuja) Komárek & Komárková, *Pseudanabaena papillaterminata* (Kiselev) Kukk¸ *Spirulina major* Kützing ex Gomont,

*Dolichospermum maximum* (Cronberg et Komárek) Wacklin, D. torques-reginae (Komárek) Wacklin and *S. aphanizomenoides*. These species are described for the first time, as most studies on cyanobacteria in the state of Pernambuco have mainly addressed floristic and ecological factors of this group. Moreover, the genera Dolichospermum and Sphaerospermopsis were renamed, as previous studies have described these genera as Anabaena and Aphanizomenon, respectively (Wacklin et al., 2009; Zapomelová et al., 2009; 2010).

*C. raciborskii* is one of cyanobacteria bloom-forming species in Brazilian ecosystems and populations with straight and coiled trichomes have been observed in Northeastern Brazil (Bittencourt-Oliveira et al., 2011). The straight morphotype of *C. raciborskii* and *G. amphibium* (Agardh ex Gomont) Anagnostidis were very frequent species with 84.25% and 73.68% of occurrence, followed by the coiled morphotype of *C. raciborskii*, *M. tenuissima*, *Microcystis sp.*, *Planktothrix agardhii* (Gomont) Anagnostidis & Komárek, *Pseudanabaena catenata* Lauterborn and *S. aphanizomenoides*, which were considered frequent. D. maximum, Lyngbya cf. ceylanica and S. major, each with a single record (5.26%) were considered sporadic species (table 2).

**Table 2.** Taxa of Cyanobacteria and frequence of occurrence (F.O.- %) in 19 reservoirs of semiarid region of state of Pernambuco.

| **Taxa/Reservoirs** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **F.O. (%)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Chroococcaceae** | | | | | | | | | | | | | | | | | | | | |
| *Chroococcus obliteratus* | - | - | - | - | - | - | - | + | - | - | + | - | - | - | - | - | - | - | - | 10.52(O) |
| *Chroococcus* sp. | + | - | - | - | - | + | - | - | - | - | - | - | - | + | + | - | - | - | + | 26.31(O) |
| *Merismopedia glauca* | - | + | - | - | + | - | - | + | - | - | - | - | + | - | - | + | - | - | - | 26.31(O) |
| *M. tenuissima* | + | + | - | + | - | - | - | + | - | - | - | + | - | + | - | - | - | + | + | 42.10(F) |
| **Microcystaceae** | | | | | | | | | | | | | | | | | | | | |
| *Microcystis novacekii* | + | - | - | - | - | - | + | - | - | - | - | + | - | + | - | - | - | - | - | 21.05(O) |
| *M. panniformis* | + | + | - | - | - | + | + | - | - | - | - | + | - | + | - | - | - | + | - | 36.84(O) |
| *M. protocystis* | + | - | - | - | - | - | - | + | - | - | - | + | - | - | - | - | - | + | - | 21.05(O) |
| *Microcystis* sp. | + | - | - | + | + | - | + | - | + | - | + | + | - | - | - | - | - | + | - | 42.10(F) |
| **Oscillatoriaceae** | | | | | | | | | | | | | | | | | | | | |
| *Lyngbya* cf. *ceylanica* | - | - | - | - | - | - | - | - | + | - | - | - | - | - | - | - | - | - | - | 5.26(S) |
| *Oscillatoria princeps* | - | + | - | - | - | - | - | - | - | - | - | - | + | - | - | - | - | - | - | 10.52(O) |
| *Oscillatoria* sp. | - | - | - | - | - | + | - | - | - | + | + | - | - | + | - | - | - | + | - | 26.31(O) |
| **Phormidiaceae** | | | | | | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Planktothrix* .. .. | + | + | - | - | - | + | + | + | + | - | + | - | - | - | - | - | + | + | - | 47.36(F) |
| *P. isothrix* | - | - | - | - | - | + | - | - | + | - | + | - | - | + | - | - | - | - | - | 21.05(O) |
| *Planktothrix* sp. | - | - | - | + | - | - | - | - | - | + | - | - | - | - | + | + | + | - | - | 26.31(O) |
| **Pseudanabaena** | | | | | | | | | | | | | | | | | | | | |
| *Geitlerinema amphibium* | + | + | + | - | + | + | + | + | + | - | + | + | - | + | + | + | - | + | - | 73.68(VF) |
| *Pseudanabaena catenata* | + | + | + | + | + | + | - | + | + | - | + | + | - | + | - | - | - | + | - | 63.15(F) |
| *P.* | - | + | - | - | - | - | - | - | - | - | + | - | - | - | + | - | - | + | - | 21.05(O) |
| *Spirulina major* | - | - | - | - | - | + | - | - | - | - | - | - | - | - | - | - | - | - | - | 5.26(S) |
| **Nostocaceae** | | | | | | | | | | | | | | | | | | | | |
| *Cylindrospermopsis raciborskii* | + | + | + | - | + | + | + | + | + | - | + | + | - | + | + | + | + | + | + | 84.25(VF) |
| *Cylindrospermopsis raciborskii* | + | - | + | - | + | + | + | + | + | - | + | + | - | + | + | + | - | + | - | 68.42(F) |
| *Dolichospermum maximum* | - | - | - | - | - | - | + | - | - | - | - | - | - | - | - | - | - | - | - | 5.26(S) |
| *D. torques-reginae* | - | - | - | - | - | + | - | - | - | - | - | - | - | - | - | - | - | + | - | 10.52(O) |
| *Dolichospermum* | + | - | + | - | - | + | - | + | + | - | + | - | - | - | - | - | - | + | - | 36.84(O) |
| *Sphaerospermopsis* | + | + | + | + | + | + | + | + | + | - | + | - | - | - | - | + | - | + | - | 63.15(F) |

Reservoir: 1-Alagoinha, 2- Arcoverde, 3- Bitury, 4- Botafogo, 5- Buíque, 6- Carpina, 7- Duas Unas, 8- Ingazeira, 9- Ipojuca, 10- Jazigo, 11- Jucazinho, 12- Mundaú, 13- Pastora, 14- Pedra, 15- Poço da Cruz, 16- Saco I, 17- Santo Antônio dos Palmares, 18- Tapacurá and 19- Venturosa. Species: *Chroococcus obliteratus* Richter, *Merismopedia glauca* (Ehrenberg) Kützing, *Merismopedia tenuissima* Lemmermann, *Microcystis novacekii* (Komárek) Compère, *Microcystis panniformis* J. Komárek, J. Komárková-Legnerová, C. L. Sant'Anna, M. T. P. Azevedo & P. A. C, Senna, *Microcystis protocystis* W. B. Crow, Lyngbya cf. ceylanica Wille, *Oscillatoria princeps* Vaucher ex Gomont, *Planktothrix agardhii* (Gomont) Anagnostidis & Komárek, *Planktothrix isothrix* (Skuja) Komárek & Komárková, *Geitlerinema amphibium* (Agardh ex Gomont) Anagnostidis, *Pseudanabaena catenata* Lauterborn, *Pseudanabaena papillaterminata* (Kiselev) Kukk, *Spirulina major* Kützing ex Gomont, *Cylindrospermopsis raciborskii* (Woloszynska) Seenaya & Subba Raju, *Dolichospermum maximum* (Cronberg et Komárek) Wacklin, *Dolichospermum torques-reginae* (Komárek) Wacklin, *Sphaerospermopsis aphanizomenoides* (Forti) Zapomelová, Jezberová, Hrouzek, Hisem, Reháková & Komárková.

***** Very Frequent (VF); Frequent (F); Occasional (O); Sporadic or rare (S).

Among the organisms identified, *C. raciborskii*, *G. amphibium*, Planktothrix agardhii and Pseudanabaena catenata had the broadest distribution, occurring in approximately 63 and 84% of the reservoirs. Some studies have reported the frequent occurrence of *C. raciborskii* in others Brazilian ecosystems (Bouvy et al., 1999; Bouvy et al., 2000; Bouvy et al., 2001; Bittencourt-Oliveira & Molica, 2003; Costa et al., 2006; Aragão et al., 2007; Moura et al., 2007a; Panosso et al., 2007;

Chellappa et al., 2008a; Chellappa et al., 2008b; Von Sperling et al., 2008; Andrade et al., 2009; Bittencourt-Oliveira et al., 2011; Dantas et al., 2011; Lira et al., 2011; Moura et al., 2011). The frequency of this species in semiarid ecosystems occurred, in general, when the ecosystem is stratified with a high degree of intermittence in availability of nutrients (Bouvy et al., 2000; Marinho & Huszar, 2002; Bormans et al., 2005; Dantas et al., 2011).

The frequency, persistence and high density or biomass of one or multispecies of cyanobacteria in drinking reservoir are a greatest problem from the fact of some species, like: *C. raciborskii*, *Microcystis sp.*, *P. agardhii* and *S. aphanizomenoides* are potentially toxic.

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