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Qualitative analysis of phytoplankton from a fish farm in Alvorada d´Oeste, Rondônia, Brazil

Análise qualitativa da comunidade fitoplanctônica de uma piscicultura em Alvorada d´Oeste, Rondônia, Brasil

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Abstract

Aquaculture is one of the segments for animal production with the fastest growth worldwide. The survey of the phytoplankton community in these environments allows establishing more efficient forms of management. The objective of this research was to perform a qualitative analysis of phytoplankton aimed at understanding the aquatic ecological dynamics to support management measurements for fish production. The study was conducted at the fish farm Helena, km 14, TN 13, 4 GB, in the town of Alvorada d'Oeste, Rondônia, Brazil, where three acres of water depth are used to grow *Colossoma macropomum.* The dam supply and three ponds were chosen for analysis. The samples were collected bimonthly between August, 2013 and May, 2014. 74 taxa were identified. The class with the largest representation (23 taxa) and occurrence in nurseries (43%) was the Chlorophyceae, the dam where the supply is uncultivated *Colossoma macropomum* had no monospecific dominance of the phytoplankton community. The cyanobacteria, despite not being the class of the greatest diversity of taxa, proved to be influential in the phytoplankton community, with high densities of the genus Microcystis and Planktotrix which together with the genus Euglena (Euglenophyceae) caused occasional blooms in October, 2013 and February, 2014.

Key words: *Colossoma macropomum*, water quality, fish production, Chlorophyceae, Cyanophyceae.

Resumen

A piscicultura é um dos segmentos da produção animal que mais cresce no cenário mundial. O levantamento da comunidade fitoplanctônica nestes ambientes permite estabelecer formas de manejo mais eficientes. Objetivou–se com esta pesquisa realizar a análise qualitativa da comunidade fitoplanctônica visando a compreensão da dinâmica ecológica aquática para subsidiar medidas de manejo para a produção piscícola. O estudo foi desenvolvido na Piscicultura Santa Helena, km 14, TN 13, GB 4, no município de Alvorada d´Oeste, Rondônia, Brasil, onde três hectares de lâmina d´água são destinados ao cultivo de *Colossoma macropomum.* A represa de abastecimento e três viveiros foram escolhidos para as análises. As coletas ocorreram bimestralmente entre agosto–2013 à maio–2014. Foram identificados 74 táxons. A classe com maior representatividade (23 táxons) e de ocorrência nos viveiros (43%) foi a Chlorophyceae, na represa de abastecimento onde não é cultivado *Colossoma macropomum* não houve dominância monoespecífica da comunidade fitoplanctônica. As Cianofíceas apesar de não terem sido a classe de maior diversidade de táxons se mostraram influentes na comunidade fitoplanctônica, com altas densidades do gênero *Microcystis* e *Planktotrix* que juntamente com o gênero*Euglena* (Euglenophyceae) ocasionaram florações pontuais em outubro–2013 e fevereiro–2014.

Palabras claves: *Colossoma macropomum*, qualidade de água, produção piscícola, Chlorophyceae, Cyanophyceae.

Introduction

Aquaculture destined for fish farming is the segment of livestock of the fastest growing in the current world scenario, surpassing the growth rates of cattle, poultry and swine. Therefore, the water quality is a constant concern in fish nurseries, as when it is of poor quality, declines in growth performance and fish mortality can happen, decreasing production and profitability (Ono and Kubitza, 2003).

Fish nurseries work as an artificial ecosystem where the abiotic and biotic conditions can be partially manipulated (Martins, 2007), this comprises a highly diversifies biotic community, from primary producers to secondary producers and decomposers (Osti, 2009). Among this the plankton is found and composed by animals (zooplankton) and plants (phytoplankton) (Kubitza, 1998).

The phytoplankton community is characterized by a diverse group of photosynthetic organisms, or not, found in marine, freshwater, brackish, soil, etc. (Corrêa, 2011). Phytoplankton plays an important role in primary production of the aquatic environment, covers a number of diverse organisms at the taxonomic, morphological and physiological level, which have different requirements and responses to the physical and chemical variables such as light, temperature, alkalinity, concentration of nutrients, pH, oxygen, etc. (Luís, 2011). This produces 50 to 95% of the oxygen in aquaculture systems, however, plankton may consume about 50 to 80% of the dissolved oxygen in the respiratory process during periods of low solar radiation. A balance between photosynthesis and respiration is a prerequisite for maintaining a constant chemical composition of water (Kubitza, 2003).

The artificial enrichment of water bodies promotes excessive growth of algae and aquatic plants, often causing fish mortality due to deficit of dissolved oxygen in water (Osti, 2009). The assimilation of ammonia, nitrate and phosphorus by phytoplankton may lead to an uncontrolled growth of the community causing blooms of algae on the environment, which are caused by certain species of cyanobacteria that are capable of delivering potentially toxic compounds in water and can lead to difficulties in their treatment (Muller *et al.*, 2012).

Overall, aquatic community of the phytoplankton respond quickly to changing environmental conditions, either by reducing species or by the occurrence of blooms (Muller, 2012). The monitoring of physical, chemical and biological conditions is important, but the classification of algae, with their fluctuations in space and time, are fundamental to the identification of good times for blooms and accumulation of toxins in water (Tundisi, 2003).

In inland waters can be found representatives of almost all algal groups, the predominance of either group in a particular ecosystem is due mainly to the prevailing characteristics of the medium, as a rule, predominantly Chlorophyta algae, represented by Desmidiaceae, and the main groups with representatives in freshwater plankton are: Cyanophyta, Chlorophyta, Euglenophyta, Chrysophyta and Pyrrophyta (Esteves, 2011).

According to Vicente *et al.* (2005) the composition and abundance of phytoplankton in lakes and reservoirs depends on the following factors: physical and hydrological conditions (light, temperature, turbulence/plankton stability); chemical composition of water (nutrients and organic matter mineralization (proportionality constant in compounds) and pH, trace elements, biological factors (predation by filter feeders planktophagous (zooplankton and fish) and the relationships between species (allelopathic effects and toxicity induced by some species) and parasitic fungi (yeast infections and heterotrophic chromist flagellates able to reduce dense populations of phytoplankton).The inadequate conditions of water quality affect the growth, reproduction, health, survival and even the quality of the fish, thus the ability of producers and technicians to monitor and correct water quality is a decisive factor in the success of aquaculture businesses for the water in ponds and culture tanks (Kubitza, 2003).

Generally, the use of the maximum support in fish farming happens, which are mesotrophic to eutrophic, and, any change no matter how small, can lead to adverse conditions in the medium (Sipaúba–Tavares *et al.*, 2002). Depending on the trophic level of fish ponds, which are dynamic environments, different planktonic species with short reproductive cycles and well adapted to these changing systems can appear in high abundance (Macedo and Sipaúba–Tavares, 2010).

In fish breeding tanks excessive proliferation of phytoplankton can cause decreased dissolved oxygen at night and supersaturation during the day, may cause clogging of the gills of fish by filaments and inhibit the growth of the most digestible algae, in addition to the production of products from the secondary metabolism of cyanobacteria that cause unpleasant taste in fish (Datta and Jana, 1998).

A deficiency of basic knowledge on water quality causes that fish farmers by themselves contribute to the decline in the quality of the water because, in tanks and ponds with low water renewal, the accumulation of organic and metabolic waste generated is inevitable during the production process. The challenge of the producer, however, is to minimize the accumulation of waste during cultivation, thus preventing rapid degradation of water quality in order to get better performance and greater productivity of fish (Kubitza, 2003).

Thus studies that focus on the dynamics of ecosystems and water quality are of great importance in fish farming, since all factors act in an interconnected manner, so that the record of the species of phytoplankton in these environments makes it possible to know in advance critical periods for cultivation, allowing more efficient ways to provide management for each situation either by increasing or decreasing the flow of water renovation, change in the supply system and flow of the cultivation, use of aerators in low periods and/or absence of photosynthesis, among others. However, there are few studies that address the phytoplankton community in aquaculture systems, and also in this sense the Brazilian Society of Limnology, highlights the lack of studies on the tropical phytoplankton and the need for progress on the representativeness of the samples, for the recognition of spatial and temporal patterns (Bozelli and Huszar, 2003). The objective of this research was to qualitatively identify the phytoplankton flora that represents the reservoir supply and the nursery ponds for the breeding of *Colossoma macropomum* with renewal and continuous water flux in the fish farm Santa Helena, Alvorada d' Oeste, RO.

Materials and methods

Location of the study

The fish farm Santa Helena is located at the Km 14, TN 13, gleba 4, in the municipality of Alvorada d´Oeste, Rondônia, Brazil. The area of the fish farm is 3 hectares of water lamina distributed in nurseries with a mean deep of 1. 80 m, being destined for the fattening of tambaqui (*Colossoma macropomum*).

Sample collection

The samples were collected bisemestrally between August, 2013 and May, 2014, in the nursery 1, 3 and 5 and also in the supply dam. All the samples were collected at 36 cm depth, for a total of 7 samplings per bisemester. To select two points for sampling

For selecting sampling points it was taken into account that the supply of nurseries is connected as 'cascade type' where the supply dam gives water to the first nursery and from there the water from a nursery supplies the other, so that the water contained in the last nursery passed all the previous ones. In this context, the samplings were done in alternate nurseries, being one point the turbulence place in the supply and other the Near the supply pipe and the other in the flow pipe, except in the supply reservoir sampled where only the exit point.. The choice of sing to samples in each nursery was based on literature by Bicudo (2004), which states that in shallow environments (about to 2 m) it could be sampled the surface and bottom or only the surface, assuming the absence of vertical structure, therefore if this is not considered the sampling effort may be greater than the needed.

Analysis of water physicochemical parameters

The physicochemical analysis of water were performed at 36 cm depth and measured *in situ*, the variables were: temperature (T °C), dissolved oxygen (mg/l), pH (multiparameter probe YSI 6820 V2) and transparency with Secchi disk (cm).

Qualitative analysis of the phytoplankton

The samples for qualitative analysis of phytoplankton were collected at 36 cm depth in amber glass flasks, identified and stored refrigerated for preservation (Brandão *et al.*, 2011).

Five slides per sample were analyzed (one supernatants drop placed between slide and cover slip). Identification of organisms was performed using a binocular optical microscope (Bioval), up to 400 times and subsequently compared with illustrations and descriptions of organisms found in specialized literature (Bicudo and Menezes, 2006; Franceschini *et al.*, 2010) and materials available at specialized sites in the internet. The organisms were identified up to genera, occurrence frequency of the taxa was calculated according to Mateucci and Colma (1982) cited by Sousa *et al.* (2009) using the rate between the number of samples, in which each taxon occurred, and the total number of samples analyzed, the following categories were established: very frequent (> 75%), frequent (<75% and> 50%) uncommon (<50% and> 25%) and sporadic (<25%).

Statistical analysis

To compare the obtained results the statistical software BIOESTAT 5 was used with the Tukey´s test at 1% significance level.

Results and discussion

Physicochemical parameters

The analysis of the physicochemical parameters of water is an important tool to monitor the quality of the water in the system (Matsuzaki *et al.*, 2004). Knowledge of the optimal range of physical and chemical parameters is a crucial factor for success in the fish farming as a major concern for the aquatic environment is eutrophication, in fish farming this is caused mostly by excessive feeding, by poor or inadequate nutrient balancing rations, resulting in nutritional deficiencies and consequent water eutrophication. This leads to an imbalance of the aquatic environment, causing stress, fish developmental difficulties, or even fish death in extreme conditions, as well as compromising quality of water bodies downstream (Macedo and Sipaúba–Tavares, 2010).

The values of the limnological variables (dissolved oxygen -OD-, hydrogen potential -pH- and transparency) towards the last nurseries were influenced by the amount of organic matter and nutrients from the food introduced in the first nurseries that flow in subsequent nurseries, similar to results found by Macedo (2004).

The water temperature varied seasonally, with a difference of 3.5 °C between the highest and lowest temperature. The average for the dam supply and nurseries in the collection periods had no significant differences, indicating that the temperature did not vary importantly between the summer and winter amazon periods (Table 1). As the winter and summer are not well defined in the regions close to the Equator, which is a positive feature for fish activity, because fish do not have the capacity to maintain constant body temperature, in this sense the water is having a direct influence in the physiological processes, like respiration rate, food assimilation, growth, reproduction and behavior (Faria *et al.*, 2013). In lakes of tropical regions it observed that the periodicity of phytoplankton is not uniform and there are few evidences of fluctuations according to the season of the year (stationary fluctuations) (Esteves, 2011). Therefore the fish farming tanks have short stationary time and high interference of climatic factors favoring the emergence of cyanobacteria, which are abundant in these systems, due to their fluctuation capacity and high resistance to light (Saadoun *et al.*, 2001).

Table 1. Average and standard deviation of the physicochemical parameters of water in the sampling sites in the Fish farm Santa Helena for the period between August 2013 to May 2014.

Parameters	Supply dam	Nursery 1	Nursery 3	Nursery 5
	Average ± SD	Average ± SD	Average ± SD	Average ± SD
Temperature (°C)	27.40 ± 0.89	28.50 ± 1.08	28.40 ± 0.84	28.50 ± 0.84
Dissolved oxygen (mg/lt)	2.20 ± 0.84 ab*	2.90 ± 1.10	3.50 ± 1.96 a	4.5 ± 1.43 ab
pH	6.60 ± 0.55 c	7.00 ± 0.66	7.10 ± 0.57	7.30 ± 0.48 c
Transparency (cm)	30.80 ± 10.0 5 d	29.00 ± 3.62 e	23.80 ± 7.10d e	24.00 ± 7.09 de

* Parameters followed by the same letter do not differ statistically by Tukey´s test at 1% probability.

In relation to the OD values the minimum values were observed in October, 2013 in the supply dam (1 mg/l) that was correlated with a flood that caused the overflow of ponds at the dawn previous to sampling (report provided by the fish farmer) and also the cloudy sky, which led to decreased photosynthetic production by phytoplankton. The maximum values was obtained in August, 2013 in the 3 and 5 nurseries, both values were 7.5 mg/l, with differences ($P < 0.05$) between the sample means of the samples from the supply dam and the 3 and 5 nurseries and, between the nursery 1 and 5, these differences are consequence of the supply in cascade type, which results on high accumulation of nutrients in the subsequent nurseries and consequently there is an increase in the phytoplankton community producing a higher OD in the medium (Macedo and Sipaúba–Tavares, 2010).

The results for pH varied from acidic to alkaline (6.4 to 9.4). The minimum value was registered in May, 2014 as 9.4, there is statistical difference between the means of the samples at the supply dam and the nursery 5. According to Copatti and Amaral (2009) the neutral or slightly alkaline pH values are recommended as suitable to culture commercial spices of fresh water.

The transparency varied between 13 and 40 cm. lower transparency was recorded in October, 2013, in the nursery 3 being the values for all the nurseries the lowest during that month, this is attributed to the bloom of algae found in the sampling date, caused by the species *Microcystis aeruginosa* (Figure 4) belonging to the Cyanophyceae class associated to *Euglena sanguínea* (Figure 4) of the Euglenophyceae class. The highest value obtained in the supply dam in May, 2014 with a value of 40 cm, there was significant difference between the means of the supply dam and the nurseries 3 and 5 and between the nursery 1 and the nurseries 3 and 5, which was due to rainfall of May, 2014 in the region, increasing the renewal of the water flux in the nurseries and dissolving the nutrients and, therefore, reducing the phytoplankton density/l, this is also associated to the significant decrease of *Microcystis aeruginosa* that is predominant in density in the previous months, mainly in the ones of low renewal of water (August to October, 2013).

According to Faria *et al.* (2013) the ideal for fish farming is a transparency between 30 and 60 cm of depth, indicating the existence of a suitable amount of plankton (water slightly green), since low transparency (transparency lower than 30 cm) is an indicator of excess on organic matter, plankton or inorganic matter in suspension that comes from the rain of movement in the bottom that avoids the light penetration, reduces the oxygen production by the phytoplankton; in the same manner, according to this author, a high transparency (transparency higher than 60 cm) indicates lack of plankton which can cause large variations in pH along the day bring damaging consequences to the fish farming, favoring the development of filamentous algae and aquatic plants that difficult the management at the fishing time.

Phytoplankton

The analysis of the samples yielded the identification of 74 species, 33 families, 21 orders and 10 taxonomical classes as shown in Figure 1 to 4.

In general, the class with the highest representability, at the level of specific richness of 43% of occurrence in the nursery was Chlorophyceae, with a significant predominant density of the *Coelastrum* genera in May, 2014, that predominated in density in the nursery 1 in all the samplings, as well as in the nurseries 3 and 5 in the rainy season samplings (December, 2013, February and May, 2014). In this sense, the re-

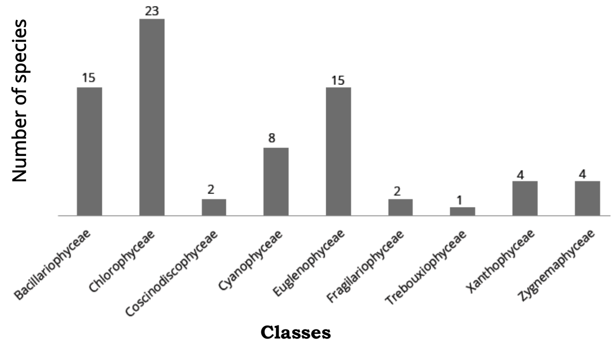

Figure 1. Number of species by phytoplankton class.

sults confirmed that the species from the Chlorophyta division are a predominant group in the fresh water phytoplankton. According to Bortolucci and Pedroso–de–Moraes (2014) in some lakes, the chloroficeae can be 90% in the occurring plankton, showing a wide distribution and are considered cosmopolites. These play a fundamental role in the maintenance of the aquatic life, since they are capable of conversion and availability of the light energy for the other organisms of the trophic chain.

The supply dam showed diversity with a trend to homogeneous dominance among the species of the phytoplankton community from the classes Euglenophyceae, Chlorophyceae and

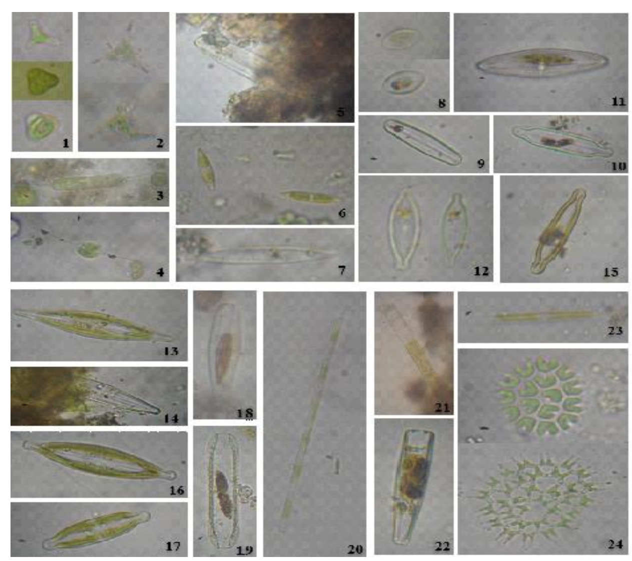

Figure 2. Identified species from Xanthophyceae, Bacillariophyceae, Coscinodiscophyceae, Fragilariophyceae and Chlorophyceae genera.

Where: XANTHOPHYCEAE: 1 – *Goniochloris sp*, 2 – *Pseudogoniochloris sp*, 3 – *Centritractus sp1*, 4 – *Centritractus sp2*. BACILLARIOPHYCEAE: 5 – *Achnanthes sp*, 6 – *Nitzschia palea*, 7 – *Nitzschia sp2*, 8 – *Diploneis sp*, 9 – *Frustulia sp1*, 10 – *Frustulia sp2*, 11 – *Navicula sp1*, 12 – *Navicula sp2*, 13 – *Navicula sp3*, 14 – *Navicula sp4*, 15 – *Nupela sp*, 16 – *Stauroneis sp1*, 17 – *Stauroneis sp2*, 18 – *Surirella sp1*, 19 – *Surirella sp2*. COSCINODISCOPHYCEAE: 20 – *Aulacoseira sp1*, 21 – *Aulacoseira sp2*. FRAGILARIOPHYCEAE: 22 – *Meridion sp*, 23 – *Ctenophora sp*. CHLOROPHYCEAE: 24 – *Pediastrum duplex*.

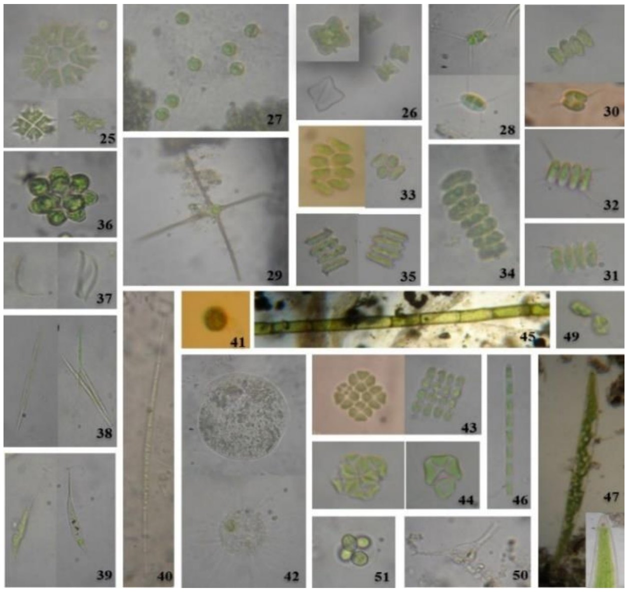

Figure 3. Identified species of the Chlorophyceae, Zygnemaphyceae and Trebouxiophyceae genera.

Where: CHLOROPHYCEAE: 25 – *Pediastrum tetras*, 26 – *Tetraedron minimum*, 27 – *Chlorococcum sp*, 28 – *Lagerheimia sp*, 29 – *Treubaria sp*, 30 – *Desmodesmus sp1*, 31 – *Desmodesmus sp2*, 32 – *Desmodesmus sp3*, 33 – *Scenedesmus disciformis*, 34 – *Scenedesmus linearis*, 35 – *Scenedesmus lefevrii*, 36 – *Coelastrum microporum*, 37 – *Monoraphidium sp1*, 38 – *Monoraphidium sp2*, 39 – *Schroederia sp*, 40 – *Closteriopsis acicularis var. acicularis*, 41 – *Chlamydomonas sp*, 42 – *Volvox sp*, 43 – *Crucigenia quadrata*, 44 – *Crucigenia tetrapedia*, 45 – *Oedogonium sp*, 46 – *Planktonema sp*. ZYGNEMAPHYCEAE: 47 – *Closterium sp1*, 48 – *Closterium sp2* (próxima págian), 49 – *Cosmarium pseudarctoum*, 50 – *Staurastrum sp*. TREBOUXIOPHYCEAE: 51 – *Oocystis sp*.

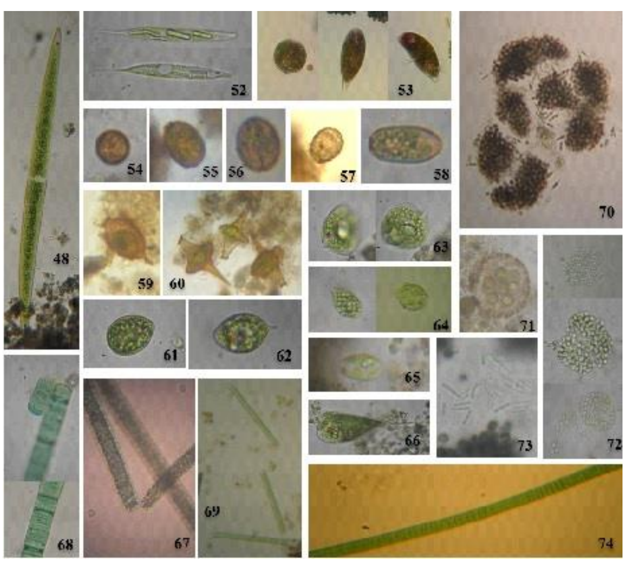

Figure 4. Identified species of the Euglenophycea and Cyanophyceae genera.

where: EUGLENOPHYCEAE: 52 – *Euglena sp1*, 53 – *Euglena sanguinea*, 54 – *Trachelomonas oblonga*, 55 – *Trachelomonas hispida*, 56 – *Trachelomonas sp3*, 57 – *Trachelomonas acanthostoma var. Minor*, 58 – *Trachelomonas cylindrica*, 59 – *Strombomonas sp1*, 60 – *Strombomonas sp2*, 61 – *Lepocinclis sp1*, 62 – *Lepocinclis sp2*, 63 – *Phacus sp1*, 64 – *Phacus sp2*, 65 – *Phacus sp3*, 66 – *Phacus sp4*. CYANOPHYCEAE: 67 – *Planktothrix sp*, 68 – *Oscillatoria sp1*, 69 – *Oscillatoria sp2*, 70 – *Microcystis aeruginosa*, 71 – *Asterocapsa submersa*, 72 – *Aphanocapsa sp*, 73 – *Pseudanabaena mucicola*, 74 – *Geitlerinema sp*.

Bacillariophyceae in the samples, except for August, 2013 that has a larger diversity of the Cyanophyceae class an in May, 2014 for Euglenophyceae.

The blooming in October, 2013 (Figure 5) showed water of an intense green color, despite the significant presence of *Microcystis aeruginosa* (Cyanophyceae), in density *Euglenas sanguinea* (Euglenophyceae) was predominant and in the blooming of February, 2014 *Microcystis aeruginosa* (Cyanophyceae) was predominant. According to Alves–da–Silva and Tamanaha (2008) *Euglena sanguinea* have been cited by several authors as a species that, at blooming, can give a reddish color to the water and this color is due to the presence of hematochrome grains in the algae cells that are increasing rapidly under stress conditions like high temperature and light.

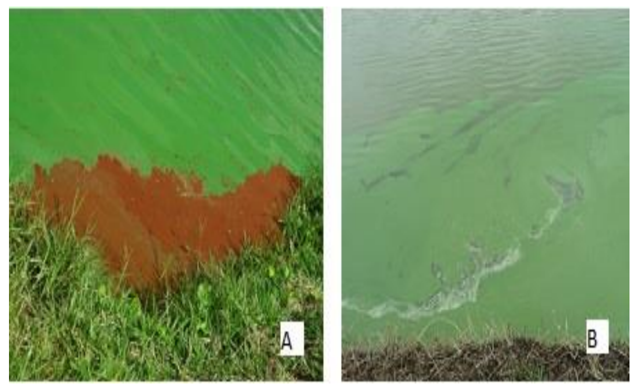

Figure 5. Blooming of algae, (A) October 2013: blooming of *Microcystis aeruginosa* and *Euglena sanguinea* at the nursery 3. (B) February 2014: blooming of *Microcystis aeruginosa* at nursery 5 of the fish farm

The cyanobacteria, despite not being the class with greater diversity of taxa of phytoplankton, was present in all samples collected, and with gradual increase in the nurseries 3 and 5, which may be related to the supply of nurseries by cascade type, which increases of N and P in them. This class showed to be also quantitatively representative, being the genera *Planktotrix* and *Mycrocistis* the dominant ones in density (Figure 6), mainly in August, 2013 (except for the nursery 1). The Cyanophyta division, according to Esteves (2011), can be autotrophic (assimilate CO_2 by using sun light) or mixotrophic (assimilate organic compounds), which allow them to live at depth places in lakes in the absence of light. This large adaptive capacity allows their distribution in all the biotopes of the lake ecosystem: water-air interface,

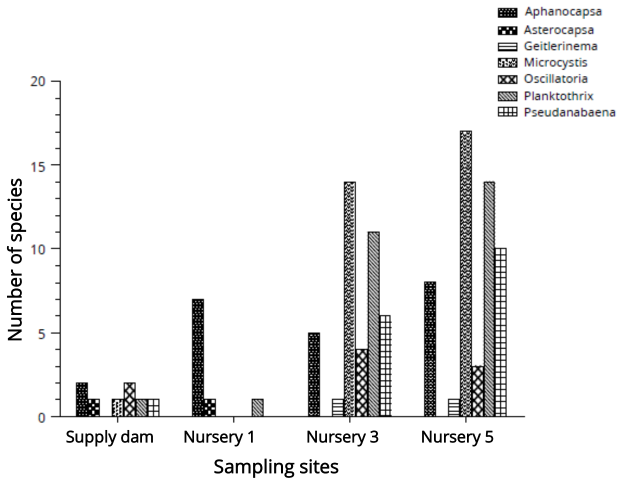

Figure 6. Phytoplankton genera identified for the Cyanophyceae class.

the entire water column, sediment, on aquatic weeds.

The most frequent genera in the sampling period in the dam supply were: Trachelomonas 14%, Strombomonas 11%, Phacus 7%; nursery 1: Crucigenia 29%, Trachelomonas 25%, Desmodesmus 24%; nursery 3: Nitzschia 19%, Crucigenia 18%, Mycrocistis 14% and; nursery 5: Desmodesmus 18%, Mycrocistis 17%, Trachelomonas 16%, Crucigenia 16%. According to the frequency levels stablished by Mateucci and Colma (1982) cited by Sousa *et al.* (2009), the occurrence percentages in the fish farm nurseries of Santa Helena are in the category of less frequent microorganisms (< 50% e $\geq$ 25%) or less frequent to sporadic (< 25%), therefore, the possibility of large blooming is small and do not affect the fish farming activities.

In relation to the density of the phytoplankton genera, it was evidenced that the Microcystis genera, when is present in the medium, predominates in density over the other taxon, mainly in the nurseries 3 and 5, which is correlated to the increase in nutrient concentration due to the water supply in cascade. According to Brandão (2011), in general, clean and nutrient poor waters have a less abundant phytoplankton community and with high diversity, whereas rich nutrient waters have large number of microorganisms that belong to few species.

Conclusions

The seasons for rainfall in the north region of Brazil and the managing of the nurseries of Santa Helena fish farm, influenced directly or indirectly the variation of the studied limnology parameters associated with the negative influence of the supply by cascade type with overlapping nutrients in nurseries.

The supply dam where the *Colossoma macropomum* is cultured was the only one not showing monospecific dominance in the phytoplankton community.

Cyanobacteria, despite not being the class with the largest taxa diversity, have a large influence on the phytoplankton community, with high densities for the *Microcystis* and *Planktotrix* genera, mainly in the periods of drought and large accumulation of nutrients in the nurseries.

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