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Submerged Macrophytes, Phytoplankton and Zooplankton in Tropical Reservoir

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RESUMO

O conhecimento sobre a ecologia e influência da macrófitas submersas, zooplâncton e fitoplâncton na qualidade da água ainda é insipiente em reservatórios da América Latina. O controle da formação de biomassa, crescimento algal, baixa carga de nutrientes, e a diversidade são pontos-chave. Investigamos evidências do papel das macrófitas submersas na qualidade da água e assembleias planctônicas em duas baías formadas de um reservatório. Amostragem para análises da transparência da água, nutrientes (fósforo e nitrogênio mg / L⁻¹), fitoplâncton e zooplâncton (riqueza e densidades) foram coletadas entre áreas litorâneas com macrófitas e na limnética. Análises foram realizadas com protocolos padrão para comparações desses parâmetros entre as baías. A transparência foi alta (médias de 3.8 e 3.9 m), baixa concentração do fósforo (médias = 0.03 e 0.05 mg / L⁻¹) e nitrogênio (0.4 e 0.9 mg / L⁻¹), ambas as baías estão eutrofizadas. A Chlorofila-*a* teve alta biomassa (49 e 61 µg/ L⁻¹). *Egeria densa* cobre amplas áreas no litoral (66% e 40%), a riqueza do fitoplâncton incluiu 13 espécies, das quais Cyanophyta (5,292 a 717 células / mL⁻¹) em altas densidades. O zooplâncton incluiu espécies Rotífera, Cladocera e Copepoda (77; 18; 03). As densidades do zooplâncton foram altas (3,711 e 2,232 org.m⁻³) no litoral. A oligotrofia e restauração das baías podem ser adquiridas combinando conhecimento sobre métodos biológicos e experimentação técnica. Novas abordagens e medidas de manejo para avançar nas pesquisas da água em reservatórios são o futuro e consiste no próximo passo no Nordeste do Brasil.

Palavras-chave: Qualidade da água, interações tróficas, Brasil, Semi-árido, Rio São Francisco.

Macrófitas submersas, Fitoplâncton e Zooplâncton em Reservatório Tropical

ABSTRACT

Submerged macrophytes, zooplankton and phytoplankton surround reservoirs are still need knowledge about ecology and influence in water quality in reservoirs of America Latina. The control of the biomass formation, low nutrient loadings, algal growth and diversity are key points to acquire water quality. We investigated evidences of submerged macrophytes enhance water quality and planktonic assemblages in two bays surround reservoir. Samples for water transparency, nutrients (phosphorus and nitrogen mg/L⁻¹), phytoplankton, and zooplankton were collected inside macrophytes between littoral and limnetic areas. Analyses with Standard Protocols were applied to make comparisons of these parameters. In the study areas the water bodies were Super and Eutrophic, the Secchi disk was high (3.8 and 3.9 m), low concentration of phosphorus (means= 0.03 and 0.05 mg/L⁻¹) and nitrogen (0.4 and 0.9 mg/L⁻¹). Chlorophyll-*a* exhibited high biomass formation during the dry period (49 and 61 µg/ L⁻¹). *Egeria densa* cover a wide range in littoral areas (66% and 40%). Phytoplankton was represented by 13 species, including Cyanophyta (5,292 to 717 cell/mL⁻¹) in high densities. Zooplankton comprised 77 species of Rotífera, 18 of Cladocera and three Copepoda, and densities varied between 3,711 and 2232 org.m⁻³ in the littoral areas. The Re-oligotrophication and restoration of these bays can be used combining biological methods knowledge and technical experimentation. New approaches to aadapted management measures to advance research and to improve water quality is a next step in a near future of reservoirs from Northeast Brazil.

Keywords: Water quality, trophic interactions, Brazil, Semi-arid, São Francisco River.

Introduction

Aquatic macrophytes develop and colonize a wide range of natural freshwater environments worldwide, and have high biodiversity in Neotropics (Murphy et al., 2019). In lakes, submerged forms enhance ecosystem processes reducing suspended solids, nutrient uptake and cycling from water column (Carpenter and Lodge 1986). Across latitudes the effects of macrophytes on water quality are recognized (Song et al., 2019). The morphological traits of submerged plants play specific positive feedbacks to water clarity in freshwater ecosystems in the combat of eutrophication (Su et al., 2019). The potential algicide producing allelopathic substances, became submerged forms a promising management tool to reduce cyanobacteria blooms in lakes-reservoirs (Tazart et al., 2019). Submerged macrophytes are the key point to restore eutrophicated shallow warm freshwater environments and the increased bottom-up effects have significant effects on water clarity (Liu et al., 2018).

Alternative equilibria in shallow lakes theory predicts clear water state when submerged macrophytes are dominant, which establish bottom-up effect on phytoplankton and interacting simultaneously with zooplankton through top-down control (Scheffer et al., 1993). Zooplankton are recognized top-predator in aquatic food webs and are able to control phytoplankton by herbivory (Carpenter et al., 1985). Studies demonstrate that zooplankton as an indicator of trophic conditions in large reservoirs in Brazil and an indicator of phytoplankton control by herbivory (Brito et al., 2011). Evidences of biomanipulation of food webs in natural ponds and lakes demonstrate that macrophytes influenced the zooplankton community increasing species richness, influence predator-prey interactions (Santos et al., 2020). Mesocosm experiments suggest that submerged macrophyte meadows can establish ecological networks, crucial to determining habitat and interactions for large zooplankton herbivores (Puche et al., 2019). Besides these contributions, is still few evidences about the influence of submerged macrophytes enhance zooplanktonic assemblages, their influence on the water quality and phytoplankton assemblages in Brazilian reservoirs (Rocha et al., 2019). In this context, in cooperation between Brazilian and German institutions, INNOVATE, a trans-disciplinary research projects, emerged to find

solutions and strategies, improving knowledge for a more sustainable watershed management of reservoirs in the São Francisco River Basin (Siegmond-Schultze, 2017).

The expert and satisfactory water governance requires as a priority water security for the humans survivorship and ecosystem functioning (Tundisi and Tundisi, 2016). In semi arid northeast Brazil, reservoirs series are built for multiple purposes, but the high anthropogenic pressure on these systems enhance eutrophication processes, which in turn hamper the various water uses (Gunkel and Sobral, 2013). In such cases, suitable management measures for water quality improvement must be implemented. For that, it is first necessary to study the mechanisms underlying trophic interactions responsible for the water quality maintenance. Such background knowledge on food chain mechanisms of freshwater systems is crucial for the development of appropriate rehabilitation measures of eutrophicated waterbodies.

In this study it was explored the potential role of submerged macrophytes on promoting water quality (transparency, chlorophyll-a, and low nutrients), zooplanktonic assemblages and low phytoplankton in two shallow bays surround reservoir series in the semi-arid areas from Brazil. We hypothesized, that submerged macrophytes play an important role in determining water clarity, is a factor that shapes and influencing zooplankton and phytoplankton assemblages. In this context, we expect to observe in littoral areas the contribution of submerged plants coverage on improving transparency of the water, low concentrations of nutrients, richness and densities to zooplankton, and low phytoplankton.

Material and Methods

Study Area

The São Francisco River is the largest and the most important perennial river of the Northeastern of Brazil, has a length of 3160 km stretching the rainy southwest from Minas Gerais to the dry zone of a Seasonal Dry Tropical Forest in the Caatinga Biome (Maria et al., 2017). The São Francisco River basin covers 640 000 km² and along the water course eight reservoirs have been constructed for hydroelectric power generation (Hydroelectric Company of the São Francisco River [CHESF 2015]). Itaparica reservoir was constructed

in 1988 and is positioned in the middle course of the São Francisco River, between Bahia and Pernambuco states, 290 km upstream from the Atlantic Ocean (Hydroelectric Company of the São Francisco River [CHESF 2015]).

Rainy season (less than 400 mm per year) at Itaparica Reservoir region is generally from January to April with partly heavy rain events (Andrade et al., 2017). This reservoir brings many opportunities for the regional economies, and the water serves multiple sources like power generation, human water supply, recreation, agriculture, aquaculture and artisanal fisheries. The management of water quality in urbanized areas are in need of serious considerations, especially because many external load sources from the land such agriculture, soil erosion, aquaculture, sewage, waste and rainfall (Selge et al., 2016). In the last 20 years, the high pressure on water and land use in those area has been contributing to quality impoverishment due to intensive agriculture and aquaculture fomenting eutrophication processes (Günkel et al., 2013).

The main water abstraction of this reservoir is for irrigation purposes (Selge, 2016). Besides that, artisanal fishery and net cage aquaculture also constitute very important economic activities in the region, although aquaculture leads to severe eutrophication of the water body (Silva et al., 2018). The heterogeneous and dendritic morphometry of Itaparica reservoir shape extensive shallow areas promoting favorable conditions to development of submerged macrophytes that are normally less affected by water currents (Selge et al., 2016). Petrolândia (8°59'22.89"S / 38°13'15.91"W) and Icó-Mandantes (8°47'56.54"S / 38°23'17.68"W) bays are the study areas surround Itaparica dam. These environments are shallow, are very vulnerable to eutrophication processes, because the proximity to urban and rural areas which also serve extensive agriculture irrigation and fishery purposes.

Sampling

In this study, were collected samples of water for physical-chemical analyses, of submerged macrophytes (*Egeria densa* Planch. and *Chara guairensis* R. M. T. Bicudo), of phytoplankton and of zooplankton in the littoral and the limnetic zones (bay channel) in Petrolândia and Icó-Mandantes bays. Sampling took place in September 2014, January, March and August 2015 in the morning (0900–1200). In each field campaign, the samplings

were collected randomly in littoral and limnetic areas of both bays, in depths ranging from 1.5 to 8 m.

Water Quality

Water physical-chemical analyses were conducted at 12 sampling points during the study period. The following abiotic parameters were measured using portable digital equipment (Oakton): water temperature (°C), conductivity ($\mu\text{S}/\text{cm}^{-1}$) and pH. The transparency of water was measured with a Secchi disk. Dissolved oxygen (mg/L^{-1}) was determined using the Winkler method (Standard Methods for The Examination of Water and Wastewater [APHA 2005]). Nitrogen concentration ($\text{TN mg}/\text{L}^{-1}$) was analyzed by Kjeldahl, phosphorous concentration by persulphate digestion method ($\text{TP mg}/\text{L}^{-1}$) (Standard Methods for The Examination of Water and Wastewater [APHA 2005, 2005b, 2005c]). The Trophic State Index-TSI was calculated according to Carlson (1977) modified by Companhia Ambiental do Estado de São Paulo (CETESB 2004) to classify the water quality of each bay.

Submerged macrophytes

Submerged macrophytes coverage (%) was estimated visually at 12 sampling points distant 500 m each in each bay, which were established parallel to the littoral and in the bay main channel. A vertical rake method (about 5 m^2) was used according to Johnson and Newman (2011). The coverage (%) was analyzed through the presence-absence (mi) of species (xi) in each point (MT all points sampled). The coverage was calculated by the following equation $xi = (mi/MT) \times 100$ (Matteucci and Colma, 1982).

Phytoplankton

Samples (250 mL bottle) were collected at 12 sampling points manually in each bay at the subsurface (ca. 0.5 m). The samples for species identification were fixed and preserved with Lugol's solution (Brandão et al., 2011). Abundance evaluation was carried out using inverted microscopy (sensu Utermöhl) at a magnification of $400\times$ for quantification (Standard Methods for The Examination of Water and Wastewater [APHA 2005a]). Density ($\text{cell.}/\text{mL}^{-1}$) was calculated counting at least 100 organisms per sample. Specific literature was used for phytoplankton taxonomical

analyses (Anagnostidis and Komárek 1988; Buchheim et al., 2001; Cavalier-Smith 2004; Komárek and Anagnostidis 1998; Medlin and Kaczmarek, 2004). To quantify phytoplankton biomass as Chlorophyll-*a* (CHL-*a* $\mu\text{g.L}^{-1}$), 12 water samples (1 L) were filtered with glass-fibre membranes (Whatman GF/F), acetone was conducted and quantification performed with a fluorometer (Companhia Ambiental do Estado de São Paulo [CETESB 2014]).

Zooplankton

Zooplanktonic assemblages were determined based on an integrated sample, through vertical and horizontal hauls with a plankton standard net (68 μm), totaling 48 samples (24 in each bay). The samples were fixed immediately in formaldehyde solution (4 %) buffered with Sodium Tetraborate (Brandão et al., 2011). The filtered volume was calculated by the following equation (Pinto-Coelho, 2004): $VF = \pi r^2 d$; where VF is the volume filtered by the net, r is the radius of the net aperture (0.15 m), and d is the distance traveled by the net, from depth to the surface of the water column. Organisms were identified to the lowest taxonomic level using specialized literature (Elmoor-Loureiro 1997; Koste 1978a, 1978b; Perbiche-Neves et al., 2015; Reid 1985; Segers 2002). Zooplankton richness and density (org. / m^{-3}) was estimated by counting the organisms in three 1-mL replicates in a Sedgwick-Rafter-type chamber, using an optical microscope at $400 \times$ magnification (Companhia Ambiental do Estado de São Paulo [CETESB 2000]). The samples with a low number of organisms ($N < 200$) were fully analysed.

Data Analysis

In order to investigate how submerged macrophytes enhance ecosystem processes in shallow environments, we compared areas with and without plants (littoral and limnetic, respectively) in both bays. A factorial analysis of variance (ANOVA Two-way and One-way Kruskal–Wallis) was conducted to compare transparency of water (Secchi disk), Chlorophyll-*a* (CHL-*a*), richness and density of zooplankton (org. / m^{-3}) in the study areas. The assumption of normality and homocedasticity was previously verified, and were tested with Shapiro–Wilk and Tukey tests respectively, a posteriori (p

< 0.05) (Zar, 2010). The analyses were developed with R software version 3.5.1 (2019).

Results

Water Quality

In the bays of Icó-Mandantes and Petrolândia the mean water temperature, dissolved oxygen and electrical conductivity in the sampling periods were similar in both environments. Mean Nitrogen (TN mg.L^{-1}) and Phosphorus (TP mg.L^{-1}) were present in low concentrations in both bays (Table 1). Water transparency (Secchi disk depth) was generally higher in Icó-Mandantes bay (mean of 4m) than in Petrolândia (mean of 3m). Besides that, the difference between both areas was not statistically significant ($H = 1.15$, $df = 1$, $p = 0.28$) (Figure 1). Moreover, the TSI of both bays was 65 and 63 for Icó-Mandantes and Petrolândia respectively, which corresponds to Supereutrophic and Eutrophic water quality conditions (Table 1).

Figure 1. Secchi depth (m (mean)) during sampling campaigns in Icó-Mandantes (Ico) and Petrolândia (Pe) surround Itaparica reservoir, in the São Francisco River (between September 2014 and August 2015)

Table 1. Mean values and standard deviation (SD) of limnological parameters during sampling campaigns in Icó-Mandantes and Petrolândia in Itaparica reservoir, in the São Francisco River (between September 2014 and August 2015, respectively).

Limnological parameters	Icó-Mandantes	Petrolândia
Area (km ²)	13	6.5
T°C	27.25 (± 1.76)	25.8 (± 0.99)
pH	7.3 (±0.39)	7.2 (±0.57)
Dissolved Oxygen (mg/L ⁻¹)	8.25 (±1.05)	7.68 (±2.0)
Conductivity (µS/cm ⁻¹)	76.5 (±2.1)	75.54 (±4.66)
Total Nitrogen (mg/L ⁻¹)	0.916 (±0.86)	1.2 (±1.04)
Total Phosphorus (mg/L ⁻¹)	0.07 (±0.07)	0.05 (±0.04)
Chlorophyll- <i>a</i> (µg/L ⁻¹)	9.2 (±15.2)	12.4 (±20.5)
Trophic Index	65	63
State- TSI	(Supereutrophic)	(Eutrophic)

Macrophytes

Egeria densa Planch., was the dominant aquatic plant identified covering the large littoral area of Icó-Mandantes (shallower than 7 m water depth). In this bay, *Chara guairensis* R. M. T. Bicudo was identified covering only shallow sandy areas (< 1.0 m water depth). The highest percentage of coverage of *E. densa* (< 3 m depth) in Icó-Mandantes was observed in the littoral areas (66%), different from the limnetic zone (16%). In Petrolândia *E. densa* was had low coverage areas in the littoral (40%) and limnetic zone (8%). *E. densa* offers shelter for aquatic invertebrates like shrimps and mollusks (*Biomphalaria glabatra*, Say, 1818) that were observed to be attached to stems and leaves of this plant in both bays (pers. obs.). With this background, it was then established that the limnetic zone are areas of these bays with at least 6m water depth, and littoral zone are the regions shallower than 6 m water depth, where *Egeria densa* or *Chara guairensis* were constantly present.

Phytoplankton

The phytoplanktonic communities of Icó-Mandantes (09 species) and Petrolândia (08 species) bays are similar in CHL-*a* (Table 1,) richness and density (Figure 2). The higher CHL-*a* observed in limnetic area of both bays was however not statistically different than that concentration found in littoral region (ANOVA one-way, $F=0.10$, $df=1$, $P=0.74$). During the study period, Cyanophyta and

Bacillariophyta were the most diverse groups (N=05; 05 species).

Figure 2. Density (cell /mL⁻¹) of phytoplanktonic assemblages identified in the littoral and limnetic areas of Icó-Mandantes and Petrolândia surround Itaparica reservoir, in the São Francisco River (between September 2014 and August 2015).

Cyanobacteria species were regularly found in Itaparica reservoir during the field campaign (Figure 2). Icó-Mandantes exhibited a great dominance of recorded (N= 9 species) than Petrolândia (N= 8 species). Total densities ranged from 5 292 (cell /mL⁻¹), with *Aphanocapsa delicatissima*, W. and G. S. West 1912 (3 775 cell /mL⁻¹) and *Pseudanabaena* sp. (1 093 cell/mL⁻¹). *Cylindrospermopsis raciborskii* (Woloszynska) Seenayya & Subba Raju 1972, was recorded in lower densities (84 cell /mL⁻¹), during all sample period. Moreover, Chlorophyta like *Scenedesmus longus* Meyen, 1829 was recorded in low density (79 cell /mL⁻¹) just during the first campaign. Bacillariophyta was represented by *Eunotia camelus* Ehrenberg 1843 and *Fragilaria crotonensis* Kitton 1869, showed the same little density (20 cell /mL⁻¹) respectively. Phytoplankton assemblages of Petrolândia included more 04 different Taxa than Icó-Mandantes. Bacillariophyta was the most representative group in the bay areas (717 cell /mL⁻¹), represented by *F. crotonensis* (642 cell /mL⁻¹) and *Ulnaria ulna* (Nitzsch) P. Comperè 2001 (38 cell /mL⁻¹). Other phytoplanktonic groups also Chlorophyceae *Sphaerocystis schroeteri* Chodat 1897 (4 cell /mL⁻¹),

Dynophyceae *Gymnodinium* sp. (95 cell. mL⁻¹), and Cyanophyta *C. raciborskii* (74 cell / mL⁻¹) were recorded in low densities.

Zooplankton

Zooplankton community comprised 98 species in Petrolândia (74 species) and in Icó-Mandantes (69 species), including some sub-specific varieties distributed among 49 genera and 28 families (Suppl. Mat.). Rotifera group included the most rich Taxa (N= 77 species) among all zooplankton groups. Rotiferans was more widespread in Petrolândia and Icó-Mandantes than the other three groups of microcrustaceans such as Cladocera (N= 18 species) and Copepoda (N= 3 species) (Suppl. Mat.). Rotiferans families included Brachionidae (N=15 species), Lecanidae (N=10 species), sessile and colonial Flosculariidae (N= 6 species) and Conochilidae (N= 3 species). With respect to the main species of Cladocera, the smaller-bodied *Bosminopsis deitersi* Richard, 1895, *Bosmina freyi* (Elmoor-Loureiro, et. al, 2004) and, the larger-bodied species of daphniids such *Daphnia ambigua* Scourfield, 1947, *Daphnia gessneri* Herbst, 1967 and *Simocephalus mixtus*, Sars, 1903; occurred similarly in the littoral inside macrophytes (Suppl. Mat.). Large bodied, Copepods were sampled in all bay zones and periods, including in the earlier stages (copepodites, Nauplius) (Suppl. Mat.). *Notodiaptomus isabelae* (Wright S., 1936), *Microcyclops anceps*, and *Thermocyclops decipiens* (Kiefer, 1929) (Richard, 1897) were distributed similarly in all sample periods, and in both the littoral and limnetic zones (Suppl. Mat.).

In the littoral zone of Petrolândia a highest species richness was found in the littoral (63 species), also in Icó-Mandantes (62 species) (Figure 3). In the limnetic zone of the same areas was found in lower number correspondingly (34; 30 species). The mean richness was significantly associated with submerged macrophytes in the littoral zones ($H= 11.31$; $P = 0.01$) of both bays (Figure 3).

Figure 3 – Richness of zooplanktonic assemblages (Rotifera, Cladocera and Copepoda) surveyed in Icó-Mandantes and Petrolândia (ILt/PLt-littoral, ILm/PLm-limnetic) surround Itaparica reservoir, in the São Francisco River during the study period (between September 2014 and August 2015).

The number of species recorded per sample in the littoral zones, showed a significant effect of macrophytes coverage on zooplanktonic densities (org. /m³) among littoral areas (Two-way ANOVA, $F= 13.59$; $P < 0.0001$) and between Petrolândia and Icó-Mandantes (Two-way ANOVA, $F= 3.55$; $P < 0.01$) (Figure 4). The density of zooplanktonic organisms varied with strongly difference during the study period in the littoral Icó-Mandantes (min-max= 2 227 and 3 711 org. /m³) and Petrolândia (min-max= 230 and 2 232 org. /m³). In limnetic zones, densities showed little differences of Icó-Mandantes (min-max= 880 and 1 898 org. /m³) and Petrolândia (min-max= 1 139 and 1 732 org. /m³). During the field campaign the most densities was observed for Rotifera (min-max= 1 532 and 360 org. / m³) and for microcrustaceans (min-max= 1357 and 141 org. / m³) in littoral areas of Petrolândia and Icó-Mandantes respectively.

Figure 4. Density of zooplanktonic assemblages (Rotifera, Cladocera and Copepoda) surveyed in Icó-Mandantes and Petrolândia (ILt/PLt-littoral, ILm/PLm-limnetic), in the São Francisco River during the study period (between September 2014 and August 2015).

Discussion

Our study brings new ecologic and taxonomic data from São Francisco River in Brazil. Few studies have focused reservoirs in the semiarid area of Brazil to address the role of submerged plants on the water quality, and the influence of zooplanktonic and phytoplankton (Rocha et al., 2019). Itaparica reservoir is under a very high anthropogenic pressure and that was observed on both bays, which revealed a high trophic index, correspondent to eutrophic waterbodies. Such index values were corroborated by the massive development of the submerged macrophyte *Egeria densa* in both bays, which is known for its pioneer and rapid growth behavior. The eutrophic state was also disclosed by the prevalence of mostly Cyanobacteria species in the phytoplankton community of these bays. Despite the low macrophytes richness in the study areas, the potential of submerged forms on improving zooplankton assemblages was nonetheless confirmed in this study. The species richness and densities of zooplankton observed in littoral regions shows the importance of submerged macrophytes beds in tropical freshwater systems. This information is of crucial value for future rehabilitation measures of these systems.

A dense coverage of submerged macrophytes congregate large microcrustaceans such *Daphnia* and calanoids in the littoral of the study areas. Cladocerans like Bosminidae and Daphnids were identified, and constitute an important group of algae consumers, which can feed on and reduce phytoplankton growth. Diaptomidae and Cyclopidae are omnivorous and are known to feed on microphytoplankton (Brito et al., 2011). Corroborating this evidences, a multi-interaction network models proposed suggest macrophyte-dominated lakes are the key element to provide habitat to large herbivores (such as Cladocera or Copepoda) (Puche et al., 2019). Macrophytes induce positive changes in water quality, and influenced the zooplankton by contributing to increased species richness, especially to small- and medium-sized littoral cladocerans (Santos et al., 2020). In spite of the poor richness of copepods, the high densities of Calanoida, Cyclopoida and nauplii in Petrolândia (2 203-org. /m³) probably is a good bioindicator by maintaining low algae biomass.

Low densities of Chlorophyta were observed, corroborate the bottom-up effect of *Egeria densa* and the grazing pressure on the edible algae by the smallest rotiferans filter feeders such *Brachionus*, *Keratella* and *Synchaeta*. Submerged form competing with light, nutrients and allelopathy with phytoplankton in natural and manipulated lakes (Scheffer et al., 1993; Liu et al., 2018; Tazart et al., 2019). Besides that, inedible Cyanobacteria showed great density on phytoplankton assemblages in both bays. On the one hand, this can be explained by eutrophication process of these bays (Günkel et al., 2013). On the other hand, a higher abundance of inedible cyanobacteria or species which can form large colonies (ex. *Fragilaria crotonensis*) also indicates that a high grazing pressure from zooplankton on smaller species is probably taking place in these waterbodies.

Itaparica was constructed to generate power hydroelectricity, but the water body serves multiple purposes to supply urban areas, such as food production and economy development. Studies on Itaparica reservoir have evidenced the necessity to manage littoral areas, which discharges and nutrients from the lands brings high eutrophication risks (Günkel et al., 2013; Selge et al., 2016). The high coverage of submerged macrophytes is a key point for the management of these bays. The removal of massive monospecied macrophytes beds is a practical current tool to manage eutrophic freshwater

environments (Selge et al., 2016). Maintenance or restoration to guaranty water quality assessment in reservoirs with proper allocation to natural needs for the human uses and their economies is a next step and key initiative for the future water governance (Tundisi and Tundisi, 2016).

New aquatic ecology techniques to combat eutrophication process, though manipulate food webs and submerged macrophytes, are gap to scientific and Technical experiments in Semi-arid areas from Brazil (Rocha et al., 2019). Icó-Mandantes and Petrolândia are good potential systems for restoration and the background knowledge of the trophic interactions techniques is urgent, and a promise tool to improve new approaches to guaranty water quality supply for million people. In the Northeast region with extreme water scarcity needed, knowledge for well-founded and adapted management measures for the numerous reservoirs the São Francisco River Basin.

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