Limnological parameters and phytoplakton in fishponds with tambaqui, *Colossoma macropomum* (Cuvier, 1816) in the semi-arid region

Parâmetros limnológicos e fitoplancton em açudes com tambaqui, *Colossoma macropomum,* (Cuvier, 1816) no semi-árido

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Abstract: Aim: It was evaluated the limnological parameters in rain fed ponds. **Methods:** In Manga Nova and Federação ponds, that belong to agrarian settled families, 1,800 and 1,000 tambaqui fingerlings where put (initial weight ± 11 g) in April/07. Water samples were taken to evaluate: orthophosphate, total ammonia nitrogen, nitrite, alkalinity and hardness, oxygen, pH, salinity, conductivity and depth measurements were taken. Water was collected and analyzed each 15 days, as well as the water bodies' morph metric measurements to follow the water surface seasonal evolution. **Results:** Water parameter analyses results showed that Manga Nova had better limnological conditions. A final fish measurement was done in October. In Manga Nova the fingerling growth average was 113 g and in Federação was 22 g. The results also indicated that Federação lost 89.35% of its initial area. Manga Nova lost 86.36%. Phytoplankton community from Federação was represented by 15 species distributed in the groups Cyanobacteria (3 sp.), Bacillariophyceae (4 sp.) and Chlorophyceae (8 sp.). It was observed that two dominant species *Hyalodiscus scoticus* (Kütz.) Grunow (96.5%) and *Oscillatoria splendida* Kützing (71.4%). *Oscillatoria splendida* Kützing (100%) and *Ulothrix subtilissima* Rabh (83.3%) were considered "very frequently". Manga Nova was represented by 36 species distributed in the groups Cyanobacteria (10 sp.), Bacillariophyceae (12 sp.) and Chlorophyceae (14 sp.). *Hyalodiscus scoticus* (Kütz.) Grunow with 78% was the dominant specie. It was considered very frequent for be present in more than 70% of the samples in Manga Nova: *Arthrospira maxima* (Stiz.) Geitl., *Aulacoseira* sp., *Eunotia* sp., *Hyalodiscus scoticus* (Kütz.) Grunow, *Micrasterias mahabuleswarensis* Hobson, *Oscillatoria chlorina* Kützing, *Spirulina* sp. e *Ulothrix subtilissima* Rabh. Bacillariophyceae was present in the largest density of cells observed in both sites. **Conclusions:** This research concludes that only Manga Nova has the minimum characteristics for fish survival and growth.

Keywords: rain dependent, tambaqui, algae, water quality.

Resumo: Objetivo: avaliar parametros limnológicos em açudes dependentes de água da chuva. **Métodos:** Os açudes Manga Nova e Federação, pertencentes a assentamentos agrários, foram povoados, respectivamente, com 1.800 e 1.000 alevinos de tambaqui (peso inicial ± 11g). Foram retiradas da água para avaliação dos teores de: ortofosfato, N-amoniacal, nitrito, alcalinidade total e dureza total. Foram realizadas medidas de oxigênio, pH, salinidade, condutividade e profundidade. Coletas e análises dos parâmetros da qualidade de água foram realizadas a cada quinze (15) dias, bem como medidas morfométricas dos açudes, para acompanhar a evolução temporal da lâmina d'água. Resultados mostram que Manga Nova apresenta melhores condições limonológicas. **Resultados:** No Manga Nova o crescimento médio foi de 113 g, em Federação foi de 22 g. Os resultados indicam também, que Federação perdeu 89,35% de sua lâmina d'água inicial. Manga Nova perdeu 86,36%. A comunidade fitoplanctônica da Federação esteve representada por 15 espécies, distribuídos nos grupos Cyanobacteria (3 sp.), Bacillariophyceae (4 sp.) e Chlorophyceae (8 spp.). Foi observado apenas duas espécies classificadas como "dominante" a diatomácea *Hyalodiscus scoticus* (Kütz.) Grunow (96,5%) e a cianobactéria *Oscillatoria splendida* Kützing (71,4%). *Oscillatoria splendida* Kützing (100%) e *Ulothrix subtilissima* Rabh (83,3%) foram consideradas "muito freqüentes". Manga Nova esteve representada por 36 espécies distribuídas nos groups Cyanobacteria (10 sp.), Bacillariophyceae (12 sp.) e Chlorophyceae (14 sp.) sendo observada apenas uma espécie "dominante" *Hyalodiscus scoticus* (Kütz.) Grunow com 78%. Foram consideradas muito freqüentes, por estarem presentes em mais de 70%

das amostras analisadas em Manga Nova: *Arthrospira máxima* (Stiz.) Geitl., *Aulacoseira* sp., *Eunotia* sp., *Hyalodiscus scoticus* (Kütz.) Grunow, *Micrasterias mahabuleswarensis* Hobson, *Oscillatoria chlorina* Kützing, *Spirulina* sp. e *Ulothrix subtilissima* Rabh. Bacillariophyceae apresentou as maiores densidade de células, fato este observado nos dois locais de coleta estudado **Conclusões**: Este estudo concluiu que somente Manga Nova tem as características mínimas para a sobrevivência e o crescimento de peixe.

Palavras-chave: dependência da chuva, tambaqui, algas, qualidade da água.

1. Introduction

Fisheries activity in the Brazilian semi-arid water bodies has become a constant practice by the Companhia de Desenvolvimento do Vale do São Francisco (CODEVASF) and by the Departamento Nacional de Obras Contra a Seca (DNOCS) since the 1960 decade (Guerra, 1980). It has contributed for the mitigation of high nutritional value lack of food in the region. The majority of those fish stocking are not done every year and when it is done there is not a control of the fish population or water quality parameters. Historical notes show that those actions led to the increase of the fish productivity in the Brazilian semi-arid (Mota, 1979). Although few were the research to evaluate the chemical and biological water characteristics during the production period as well as the study to evaluate the water surface regression during the dry season and its impacts in the ponds water characteristics (Sodré-Neto and Araújo, 2008; Paggi and Sipaúba-Tavares, 2007; Chellapa et al., 2008).

The study of the lacustrine phytoplankton constitutes basic information on the structure of the biological production of a natural lake or reservoir (Lachi and Sipaúba-Tavares, 2008). Although other plants like macrophytes can contribute to total organic carbon fixed by photosynthesis in the aquatic ecosystem and other forms of primary production can occur, it is the phytoplankton study what provides important information on the ecosystem (Paggi and Sipaúba-Tavares, 2007). It is of extreme importance for the understanding of the water body, once inside each environment there is a set of phytoplankton forms whose variety, abundance and distribution are unique and depend on the adaptation to the abiotic characteristics (Borduquie et al., 2008; Chellapa et al., 2008). Considering the capacity of the phytoplankton organisms to take place in almost any type of environment of fresh water constituting to base of the food chain, besides responding to the changes that take place in the water body and of participating actively of the nutrient cycles, it constitutes an important element to water quality evaluation (Margalef, 1983; Nogueira and Matsumura-Tundisi, 1996; Rojas et al., 2004; Macedo and Sipaúba-Tavares, 2005).

The aim of the research was to monitor the water quality, phytoplankton abundance and species composition, the decrease on water body area and the tambaqui (*Colossoma macropomum* (Cuvier,1816)- Characidae) growth to optimize the extensive fish production in those areas.

2. Material and Methods

2.1. Study area

Two small rain-fed ponds were selected, Manga Nova (MN) and Federação (FED), where 25 agrarian settled families live in each area. They depend on that water for domestic and animal consume. The access to the water bodies is restricted to the community and the own families watch over it. The areas are 4 km distant from each other in a straight line.

Tambaqui juvenile (*C. macropomum*) were used in the research because of the specie characteristics to support the water bodies conditions. Both ponds were stocked in the same day (April, 10th, 2007) with the average of 1,800juveniles in MN and 1,000 in FED, with the initial weight of ± 11 g. At the same time, water and sediment samples were taken to laboratory analyses and limnological parameters were measured with portable equipments. Fish didn't receive any additional food during the study period other than it was available in the pond. A final fish biometry was done in FED and in MN where a 60 m fish net was used in the capture. The net was passed over twice each time and all fish captured were used as sample. After the capture fish were put into buckets with water and weighted in digital portable field scale.

Water quality and pond morphometric studies were realized each fifteen days until October/07 in triplicate. Limnological parameters analyzed were: orthophosphate (mg.L^{-1}), total ammonia nitrogen (mg.L^{-1}), nitrite (mg.L^{-1}), alkalinity (mmol/EDTA) and hardness [Ca^{+2} (mL H_2SO_4)], following procedures described by Golterman et al. (1978). In the local area portable automatic monitors WTW were used to obtain: dissolved oxygen, temperature, pH and conductivity; transparency was measured using a Secchi disk.

For quantitative phytoplankton analyzes samples were obtained with a 25 µm plankton net and then preserved in a 4% formalin. Six samples from FED were taken from April 27 through July 13, 2007, and nine samples from MN from April 10 through August 17, 2007. Phytoplankton was counted in a Sedgwick Rafter Cell and examined under binocular Olympus microscope. Density data were expressed in percentage. The identification was done at the Phycology Laboratory at the Universidade Federal de Alagoas. For the qualitative study, 1 mL samples were analyzed using a optical microscope Olympus and for the identification the following references were used: Mizuno (1968), Bourrelly (1968; 1970; 1972), Silva-Cunha and Eskinazi-Leça (1990), Parra and Bicudo (1995) and Thomas (1997).

For the phytoplankton analyzes 2 biological index were measured. Relative Abundance was estimate for total phytoplankton organism, divided in four classes: class 4 (dominant = >50%), class 3 (abundant = 50% > 30%), class 2 (few abundant = 30% > 10%), and class 1 (rare = <10%) (Lobo and Leighton, 1986). Frequency occurrence was also estimate for total phytoplankton organisms, divided in four classes: class 4 (very frequent > 70%), class 3 (frequent between 41 and 69%), class 2 (moderately frequently, between 21 and 40%), and class 1 (low frequency, between 1 and 20) (Mateucci and Colma, 1982).

Monthly precipitaion, relative air humidity, air temperature, evaportion, solar radiation and bright sunshine data were supplied by EMBRAPA Semi-Arido, Petrolina-PE, Brazil and compared to datas from 1965 and 2005 described by Moura et al. (2007). To measure water surface decrease in the ponds a GPS was used fallowing the margins.

3. Results

A total of 1,407 tambaqui in a total weight of 175 kg was harvested in MN. In FED a total of 532 tambaqui in a total weight of 18 kilograms was harvested. In MN fish growth was of 113 g and in FED it was of 22 g.

Limnological parameters from Manga Nova (MN) and Federação (FED) are presented in Table 1. The pH had slight change during the period and ranged from 7.48 (April) to 8.01 (October) in MN and from 7.19 (May) to 7.61 (August) in FED. Temperature ranged from 22.55 °C (August) to 27.67 °C (April) in MN and from 21.70 to 27.17 °C (April) in FED. In both ponds the temperature was within the comfort range for tambaqui. Conductivity increased in both ponds, ranging from 198.30 μS.cm^{-1} (April) to 394.33 μS.cm^{-1} (October) in MN and from 82.70 μS.cm^{-1} (April) to 149.35 μS.cm^{-1} (October) in FED. Dissolved Oxygen (D.O.) ranged from 5.23 mg.L^{-1} (May) to 10.90 mg.L^{-1} (July) in FED and from 5.00 mg.L^{-1} (May) to 11.03 mg.L^{-1} (August) in MN. Transparency was decreasing during the study period in both ponds. In May it was 45.67 cm in MN and in October it was 30.67 cm. In FED the value was 11.17 cm and 0.00 cm in the same months. Alkalinity kept stable in FED with minimum value of 34.33 mg.L^{-1} (April) and maximum of 48.16 mg.L^{-1} (July). In MN alkalinity variation was higher. The values ranged from 78.67 mg.L^{-1} to 140.00 mg.L^{-1}. In this area, alkalinity value had linear increase during the study period. Ca + Mg concentrations showed the same pattern for alkalinity, ranging in FED, from 37.90 (April) to 83.50 (August), and in MN, from 79.58 (April) to 153.72 (August). Nitrate ranged from 0.022 mg.L^{-1} (June) to 0.146 mg.L^{-1} (August) in FED and from 0.010 mg.L^{-1} (May) to 0.09 mg.L^{-1} (June) in MN. Total ammonia nitrogen ranged from 0.066 mg.L^{-1} (June) to 0.386 mg.L^{-1} (September) in FED and from 0.023 mg.L^{-1} (October) to 0.178 mg.L^{-1} (May) in MN. Orthophosphate ranged from 0.070 mg.L^{-1} (June) to 0.186 mg.L^{-1} (September) in FED and from 0.037 mg.L^{-1} (August) to 0.46 mg.L^{-1} (June) in MN.

The phytoplankton community in FED was represented by 15 species, distributed in the phylum Cyanobacteria (3 species), Bacillariophyta (4 species) e Chlorophyta (8 species). During the period of study it was observed 2 species classified as dominant: the diatom *Hyalodiscus scoticus* (96.5%) in July 13th and the cyanobacteria *Oscillatoria splendida* (71.4%) in May 15th. *Oscillatoria splendida* (100%) and *Ulothrix subtilissima* (83.3%) were considered very frequent. MN was represented by 36 species distributed in the phyla Cyanobacteria (10 species), Bacillariophyta (12 species) and Chlorophyta (14 species), but only one specie was dominant, *Hyalodiscus scoticus* with 78%. It was considered very frequent for being in more than 70% of the samples analyzed in MN: *Arthrospira maxima*, *Aulacoseira* sp., *Eunotia* sp., *Hyalodiscus scoticus*, *Micrasterias mahabuleswarensis*, *Oscillatoria chlorina*, *Spirulina* sp. e *Ulothrix subtilissima*. The phylum Bacillariophyta showed the major densities in cells, fact that was observed in both water bodies. Considering the contribution of each phylum for the species abundance in the present study, Chlorophyta was the most representative in both water bodies analyzed in the different period. The second phyla most representative in abundance was Bacillariophyta. Through the results obtained it was possible to observe that the lower abundance was observed in May 15th and 29th, June 14th and July 13th with four species in FED. The highest abundance was observed in MN with 21 species identified in the sample from July 13th. In FED it was observed in April (Tables 3 and 4).

Climate variation for the parameters studied were: precipitation (accumulated in the year: 268.4 mm; average: 36.85; min/max: 0-145.9), evaporation (accumulated in the year: 100.1 mm; average: 8.3; min/max: 5.7-11mm), bright sunshine (accumulated in the year: 83 hr; average: 7.9 hr/month; min/max:5.7-8.5), radiation (accumulated in the year: 5,302.9l y; average: 490.85ly/month; min/max: 369.2-554.3 ly/day), relative air humidity (average/year: 53.5%; min/max: 49-76%) and air temperature (average/year: 28.15; min/max:24.1-28.4). In March/ 2007, after the rain season MN and FED had the following areas: 79,660.70 m^2 and 11,195.80 m^2. In October, when the last measurement was taken, water surface regression for MN was of 10,862.37 m^2. It had a total loss of 86.36% of the initial area. FED total water surface regression was of 10,004.36 m^2 with a loss of 89.35% of its initial area (Table 2). In Table 3, it can be seen an estimative of the water volume lost, considering only the daily evaporation (pan evaporation) times the daily water surface regression, not taking into account the human use and the influence of the evaporation process. MN lost about 650,127.00 L of water and FED lost 81,176.55 L during the study.

Table 1. Limnological variables (mean ± SD) of Manga Nova (MN) and Federação (FED) ponds, during dry period.

Variables	Pond	April	May	June	July	August	September	October
pH	MN	7,49 (± 0,30)	7,91 (± 0,24)	7,78 (± 0,08)	7,86 (± 0,33)	7,87 (± 0,14)	8,00 (± 0,14)	8,01 (± 0,27)
	FED	7,33 (± 0,15)	7,19 (± 0,28)	7,32 (± 0,03)	7,50 (± 0,19)	7,61 (± 0,28)	7,54 (± 0,10)	7,30 (± 0,13)
Conductivity (µS.cm^{-1})	MN	198,30 (± 11,25)	211,33 (± 1,21)	247,00 (± 0,00)	222,30 (± 12,06)	304,83 (± 1,15)	343,84 (± 16,25)	394,33 (± 0,58)
	FED	82,70 (± 10,98)	84,65 (± 2,40)	95,13 (± 1,40)	105,40 (± 12,86)	107,32 (± 0,46)	122,09 (± 8,86)	149,35 (± 0,92)
Dissolved Oxygen (mg.L^{-1})	MN	5,01 (± 1,07)	5,00 (± 1,21)	9,10 (± 0,27)	10,12 (± 0,78)	11,03 (± 0,59)	7,64 (± 1,03)	8,60 (± 0,78)
	FED	5,78 (± 0,87)	5,23 (± 0,93)	10,03 (± 1,08)	10,90 (± 0,81)	10,45 (± 0,67)	7,20 (± 0,68)	10,10 (± 0,11)
O_2 Saturation (%)	MN	60,30 (± 14,6)	59,15 (± 10,53)	85,33 (± 2,08)	82,32 (± 9,14)	83,07 (± 2,19)	59,77 (± 12,36)	79,70 (± 7,75)
	FED	75,97 (± 13,23)	61,17 (± 6,93)	83,83 (± 8,79)	84,62 (± 5,71)	86,27 (± 0,55)	60,50 (± 8,9)	73,50 (± 1,84)
Temperature (°C)	MN	27,67 (± 0,90)	24,95 (± 0,68)	23,17 (± 0,00)	22,67 (± 0,59)	22,55 (± 0,15)	22,93 (± 0,05)	25,73 (± 0,38)
	FED	27,17 (± 0,74)	24,49 (± 0,50)	22,37 (± 0,06)	21,87 (± 0,60)	21,70 (± 0,12)	22,08 (± 0,31)	24,85 (± 0,35)
Transparency (cm)	MN	45,67 (± 12,66)	55,00 (± 19,21)	45,67 (± 3,79)	31,84 (± 4,22)	27,84 (± 6,08)	33,00 (± 6,87)	30,67 (± 0,58)
	FED	11,17 (± 1,17)	10,84 (± 1,33)	10,00 (± 0,00)	6,84 (± 3,49)	4,50 (± 0,00)	1,17 (± 1,83)	0,00 (± 0,00)
Alkalinity (mg.L^{-1})	MN	78,67 (± 2,31)	87,27 (± 42,93)	94,16 (± 15,01)	109,83 (± 6,85)	129,92 (± 8,39)	135,75 (± 4,42)	140,00 (± 7,94)
	FED	34,33 (± 1,53)	36,57 (± 12,31)	42,00 (± 8,50)	48,16 (± 4,07)	46,33 (± 1,40)	46,42 (± 3,53)	44,50 (± 7,78)
Ca + Mg	MN	79,58 (± 1,50)	93,46 (± 12,43)	89,65 (± 19,75)	112,60 (± 4,56)	153,72 (± 5,89)	138,04 (± 9,76)	134,80 (± 11,39)
	FED	37,90 (± 4,21)	92,90 (± 30,44)	59,74 (± 12,90)	54,84 (± 5,73)	83,50 (±8,98)	72,20 (± 25,83)	62,66 (± 3,54)
Nitrite (mg.L^{-1})	MN	0,046 (± 0,00)	0,010 (± 0,00)	0,090 (± 0,003)	0,010 (± 0,002)	0,010 (± 0,003)	0,014 (± 0,004)	0,012 (± 0,001)
	FED	0,073 (± 0,012)	0,027 (± 0,03)	0,022 (± 0,024)	0,085 (± 0,013)	0,146 (± 0,021)	0,122 (± 0,12)	0,039 (± 0,008)
Total ammonia (mg.L^{-1})	MN	0,149 (± 0,03)	0,178 (± 0,23)	0,033 (± 0,01)	0,088 (± 0,12)	0,070 (± 0,09)	0,039 (± 0,01)	0,023 (± 0,006)
	FED	0,273 (± 0,18)	0,085 (± 0,04)	0,066 (± 0,078)	0,170 (± 0,01)	0,216 (± 0,071)	0,386 (± 0,037)	0,085 (± 0,007)
Orthophosphate (mg.L^{-1})	MN	0,046 (± 0,00)	0,045 (± 0,00)	0,046 (± 0,001)	0,040 (± 0,019)	0,037 (± 0,018)	0,039 (± 0,02)	0,033 (± 0,03)
	FED	0,093 (± 0,012)	0,148 (± 0,03)	0,070 (± 0,023)	0,097 (± 0,013)	0,108 (± 0,036)	0,186 (± 0,095)	0,079 (± 0,016)

4. Discussion

Tambaqui growth in MN was considered good considering the pond limnological characteristics. The low fish development in FED was expected as the water parameter values were examined. Fish development researchers are interested in fast growth for intensive culture, and any research for fish development in the same situation was found. Although the growth in MN can be considered good (Ituassu et al., 2004; Chagas et al., 2005; Guimarães and Sertoli-Filho, 2004).

The difference in water quality parameters in the ponds were also interfering in the optimal tambaqui development, once the water quality parameters found in both rain-fed pounds were lower than the ones found in other natural fed water bodies with fish (Lachi and Sipaúba-Tavares, 2007; Chagas et al., 2005). This is due the small area of the ponds studied and its fast and continuously process of decreasing area. Although the water parameters found in the beginning were within the optimal values for aquatic life in accord to Arana (2004).

Table 2. Water surface regression (m²) and water volume regression estimate (L).

	Manga Nova		*Federação*	
	Area (m²) (Area reduction m²)	Water volume reduction (L)	Area (m²) (Area reduction m²)	Water volume reduction (L)
March	79.660,70 (24.694,80)	180.272,04	11,195.80 (3.694,61)	26.970,00
April	54.965,90 (19.787,72)	284.943,16	7.501,19 (2.775,44)	19.980,00
June	35.178,18 (10.201,67)	72.431,85	4.725,75 (1.039,66)	14.973,12
July	24.976,15 (7.167,89)	50.892,01	3.686,09 (1.687,15)	11.981,25
August	17.808,62 (4.347,61)	35.871,80	1.998,94 (445,94)	3.656,70
September	13.434,01 (2.571,64)	25.716,40	1.553,00 (361,56)	3.615,60
October	10.862,37	-	1.191,44	-
Total reduction	68.798,33 m²	650.127,26 L	10.004,36 m²	81.176,55 L

Table 3. Phytoplankton species distribution in Feração. Legend: (RA): relative abundance (%). (D) density (cel.L^{-1}). (F) frequency (%); (C) Categories: (VF) very frequent. (F) frequent. (FF) few frequent. (S) sporadic.

PHYLUM / SPECIES	Period													
	April/27		May/15		May/ 29		June/14		June/28		July/13		F	C
	RA	D	RA	D	RA	D	RA	D	RA	D	RA	D		
CYANOBACTERIA														
Nostoc sp. Vaucher	1.60	3000	-	-	-	-	1.80	1000	1.40	1000	-	-	50.0	F
Oscillatoria splendida Greville	33.00	61000	71.40	15000	37.80	42000	43.60	24000	26.30	19000	2.50	5000	100.0	MF
Spirulina abbreviata Lemmermann	3.20	6000	-	-	-	-	-	-	-	-	-	-	16.7	E
BACILLARIOPHYTA														
Coscinodiscus argus Ehrenberg	2.20	4000	4.80	1000	-	-	-	-	-	-	-	-	33.3	PF
Gyrosigma kuetzingii (Grun.) Cl.	0.50	1000	-	-	-	-	-	-	-	-	-	-	16.7	E
Hyalodiscus scoticus (Kutz.) Grun.	-	-	-	-	60.40	67000	47.30	26000	66.70	48000	96.50	196000	66.7	F
Nitzschia vermicularis (Kutz.) Hantz.	1.20	2000	-	-	-	-	-	-	1.40	1000	0.50	1000	50.0	F
CHLOROPHYTA														
Cosmarium denticulatum Borge	0.50	1000	-	-	-	-	-	-	-	-	-	-	16.7	E
Cylindrocystis brebisonii Menegh.	0.50	1000	-	-	-	-	-	-	-	-	-	-	16.7	E
Euastrum spinulosum Delp.	4.30	8000	-	-	-	-	-	-	-	-	-	-	16.7	E
Micrasterias mahabulechswarensi Hobson	2.20	4000	-	-	-	-	-	-	-	-	-	-	16.7	E
Oedogonium longiarticulatum Hansgrig	2.70	5000	-	-	-	-	-	-	-	-	0.50	1000	33.3	PF
Oedogonium sp.	28.10	52000	4.80	1000	-	-	-	-	-	-	-	-	33.3	PF
Pediastrum duplex Meyen	-	-	-	-	0.90	1000	-	-	-	-	-	-	33.3	PF
Ulothrix subtilissima Rabh.	20.00	37000	19.00	4000	0.90	1000	7.30	4000	4.20	3000	-	-	83.3	MF
Total	100.00	185000	100.00	21000	100.00	111000	100.00	55000	100.00	72000	100.00	203000		
Species richeness	13.00	-	4.00	-	4.00	-	4.00	-	5.00	-	4.00	-		
Specific diversity (bits.cel^{-1})	2.53	-	1.22	-	1.09	-	1.41	-	1.26	-	0.26	-		
Equitability	0.70	-	0.61	-	0.54	-	0.68	-	0.54	-	0.12	-		

Table 4. Phytoplankton species distribution in Manga Nova-MN. Legend: (RA): relative abundance (%), (D) density (cel.L^{-1}), (F) frequency (%); (Categories: (VF) very frequent, (F) frequent, (FF) few frequent, (S) sporadic.

PHYLUM / SPECIES	PERIOD																		F	C
	Apr/10		Apr/27		May/15		May/29		June/14		June/28		July/13		July/31		Ago/17			
	RA	D	RA	D	RA	D	RA	D	RA	D	RA	D	RA	D	RA	D	RA	D		
CYANOBACTERIA																				
Anabaena menderi O. Agardhi	-	-	-	-	-	-	-	-	1.7	4000	-	-	-	-	-	-	-	-	11.1	E
Anabaena spiroides Klebahn	1.4	1000	8.2	9000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22.2	PF
Arthrospira maxima (Stiz.) Geitl.	22.9	16000	3.6	4000	3.9	10000	2.3	11000	0.9	2000	1.7	6000	1.3	4000	3.5	12000	2.4	6000	100.0	MF
Cyanothece aeruginosa (Nägeli) Komárek	7.1	5000	-	-	-	-	25.5	120000	43.6	102000	24.7	85000	5.2	15000	0.6	2000	-	-	66.7	F
Nostoc paludosun Kützing	-	-	-	-	-	-	-	-	-	-	-	-	0.7	2000	1.7	6000	2.0	5000	33.3	PF
Oscillatoria chlorina Kützing	2.9	2000	10.0	1000	2.0	5000	3.4	16000	10.7	25000	3.0	10000	1.7	5000	3.5	12000	-	-	88.9	MF
Oscillatoria splendida Kutzing	-	-	-	-	-	-	1.5	7000	6.8	16000	-	-	1.0	3000	0.3	1000	-	-	44.4	F
Spirulina sp.	15.7	11000	11.8	13000	3.1	8000	4.7	22000	4.3	10000	2.3	8000	2.4	7000	7.3	25000	0.8	2000	100.0	MF
BACILLARIOPHYTA																				
Aulacoseira sp.	-	-	21.0	23000	3.9	10000	1.7	8000	2.1	5000	3.2	11000	1.7	5000	0.3	1000	-	-	77.8	MF
Bacteriastrum elongatum Cleve	-	-	-	-	0.8	2000	-	-	-	-	-	-	-	-	-	-	-	-	11.1	E
Chaetoceros decipiens Cleve	-	-	-	-	0.8	2000	-	-	-	-	-	-	-	-	-	-	-	-	11.1	E
Coscinodiscus argus Ehrenberg	1.4	1000	7.3	8000	3.1	8000	0.2	1000	-	-	-	-	-	-	-	-	-	-	44.4	F
Delphineis sp.	4.3	3000	1.8	2000	-	-	0.4	2000	-	-	-	-	-	-	0.9	3000	-	-	44.4	F
Eunotia sp.	-	-	1.8	2000	-	-	0.2	1000	-	-	0.6	2000	0.3	1000	0.9	3000	2.8	7000	66.7	MF
Fragilaria sp.	15.7	11000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.1	E
Gyrosigma sp.	-	-	-	-	-	-	-	-	-	-	-	-	0.3	1000	-	-	-	-	11.1	E
Hyalodiscus scoticus (Kütz.) Grunow	-	-	10.9	12000	76.0	193000	45.6	215000	11.1	26000	46.5	160000	60.6	180000	53.9	185000	78.0	193000	88.9	MF
Navicula sp.	2.9	2000	-	-	-	-	-	-	1.7	4000	1.5	5000	2.0	6000	3.5	12000	2.4	6000	66.7	F
Pinnularia sp.	2.9	2000	-	-	-	-	-	-	-	-	-	-	-	-	0.6	2000	-	-	22.2	PF
Surirella sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.7	16000	0.8	2000	22.2	PF
Treubaria triapendiculata Bernard	-	-	-	-	0.4	1000	0.2	1000	-	-	-	-	0.7	2000	0.9	3000	-	-	44.4	F
CHLOROPHYTA																				
Arthrodesmus furcatospermus Scot. & Presc.	-	-	-	-	-	-	-	-	-	-	-	-	0.3	1000	-	-	-	-	11.1	E
Closterium turgidum Ehrenb.	-	-	-	-	-	-	-	-	-	-	-	-	0.3	1000	2.9	10000	-	-	22.2	PF
Cosmarium pseudodecoratum Schmidle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.8	2000	11.1	E
Cosmarium quadrum Lundell	1.4	1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.1	E
Cosmarium reniforme (Ralfs) Archer	4.3	3000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.1	E
Cosmarium subcrenatum Hantzsch	1.4	1000	-	-	-	-	-	-	-	-	-	-	0.7	2000	-	-	-	-	22.2	PF
Eudorina unicocca G.M. Smith	-	-	2.7	3000	-	-	4.9	23000	2.6	6000	10.2	35000	13.5	40000	-	-	-	-	55.6	F
Micrasterias mahabuleswarensis Hobson	15.7	11000	6.4	7000	2.4	6000	1.1	5000	7.7	18000	2.0	7000	3.0	9000	5.8	20000	4.4	11000	100.0	MF
Oedogonium sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	1000	11.1	E
Pediastrum duplex Meyen	-	-	-	-	1.6	4000	-	-	-	-	2.0	7000	2.0	6000	5.5	19000	2.4	6000	55.6	F
Scenedesmus westii (G.M. Sm) Chod	-	-	-	-	-	-	0.2	1000	-	-	-	-	-	-	-	-	-	-	11.1	E
Sphaerocystis sp.	-	-	2.7	3000	-	-	-	-	-	-	0.3	1000	0.3	1000	0.3	1000	-	-	44.4	F
Spirogyra sp.	-	-	1.8	2000	-	-	1.7	8000	-	-	-	-	0.3	1000	0.3	1000	0.8	2000	55.6	F
Ulothrix subtilissima Rabh	-	-	10.0	11000	2.0	5000	6.4	30000	6.8	16000	2.0	7000	1.7	5000	2.6	9000	-	-	77.8	MF
Total	100	70000	100	100000	100	254000	100	471000	100	234000	100	344000	100	297000	100	343000	100	243000		
Species richeness	14	-	14	-	12	-	16	-	12	-	13	-	21	-	20	-	13	-		
Specific diversity (bits.cel^{-1})	3.20	-	3.45	-	1.57	-	2.45	-	2.74	-	2.38	-	2.31	-	2.69	-	1.50	-		
Equitability	0.84	-	0.90	-	0.44	-	0.61	-	0.77	-	0.64	-	0.53	-	0.62	-	0.41	-		

Others reservoirs had similar pH values, than the ones found in this research (Leitão et al., 2006; Cavenaghi et al., 2003; Cutrofello and Durant, 2007; Paggi and Sipaúba-Tavares, 2007). Not all of these reservoirs were in the semi-arid, which proves that this region had no influence in this parameter. Although a lower pH value of 6.7 was found in an exclusive fish culture pond (Lachi and Sipaúba-Tavares, 2008). Temperature difference from the reservoirs might be because of the seasonal wind or because of the localization. This parameter had the same season behavior than in others reservoirs (Leitão et al., 2006; Granado and Henry, 2008). The decrease in the size of the reservoir was not promoting the increase of the temperature (Paggi and Sipaúba-Tavares, 2007).

Conductivity increased in both ponds during the research period. This behavior is due to the increase of local temperature that leads to an increase in water evaporation and consequently the increase and concentration of ions in the water (Willians, 1987; Esteves, 1988). Chellapa et al. (2008) affirm that high conductivity is a peculiar characteristic in semi-arid reservoirs. This can be observed in this study. High conductivity values was also noticed by Chellapa et al. (2008) and Leitão et al. (2006) during the end of the dry season, which had the same pattern in MN and FED.

Dissolved oxygen (D.O.) was considered above the minimum for best fish development (Boyd, 1990). Similar values of D.O. was found in different reservoirs which were used for different purpose (Leitão et al., 2006; Cavenaghi et al., 2003; Rojas et al., 2004; Granado and Henry, 2008). There was a decrease in the D.O. levels in both water bodies in September and October, which is due to the slight temperature increase concomitant to the strong decrease in the water body surface, to the biomass increase and the organic matter decomposition increase in the water bodies. The highest D.O. concentration in MN can be related to the highest primary production due to the water transparency characteristic where the active photosynthetic light reaches greater depth. The lowest value for FED is due to the highest suspended solid amount, where the water has mud color. Transparency was decreasing during the study period in both ponds. This constant decreasing was expected due to the water surface decrease in both ponds and also due to the high sediment leaching in FED (Chellapa et al., 2008 ; Sodré-Neto and Araújo, 2008).

Relation among alkalinity and other water parameters has great importance in the aquatic ecosystems' global productivity, for its roles in important chemistry and physiological process (Rojas et al., 2004). Alkalinity values found in MN and FED were above to the optimal value for fingerlings growth, and higher than the ones found in culture areas (Lachi and Sipaúba-Tavares, 2008; Paggi and Sipaúna-Tavares, 2007). It was increasing as the areas of reservoirs were decreasing. According to Boyd (1990), alkalinity values are typical from as soft (until 75 $mg.L^{-1}$) to moderate hard waters (until 150 $mg.L^{-1}$), but without limitation for fish growth. The variation among water chemical parameters in both water bodies is probably due to the different soil types in the water catchments area. In the Pacajus and Gavião reservoirs, the total alkalinity during the dry season was 78.11 mg $CaCO_{3.}L^{-1}$ and 68.50 mg $CaCO_{3.}L^{-1}$, respectively (Leitão et al., 2006).

Primary production limitation is established by amount of nitrogen and phosphorus available in the environment (Esteves, 1998). Both nutrients influence plankton community growth and structure, which are linked to the biomass (Lachi and Sipaúba-Tavares, 2008). Higher concentration of N and P was found in FED during the study period. It confirms the statement above once the quantity and diversity of plankton found in MN was higher than in FED. Higher levels of N compounds are found in natural reservoirs than in fish ponds (Cavenaghi et al., 2003; Rojas et al., 2004; Chellapa et al., 2008; Granado and Henry, 2008; Lachi and Sipaúba-Tavares, 2008; Paggi and Sipaúba-Tavares, 2008). According to Ismiño-Orbe et al. (2003), ammonia excretion in tambaqui is directly related to fish mass and not to the water temperature. This same statement cannot be affirmed in this study because there were too many variables influencing the environment which is open. In tropical lakes temperature increase leads to metabolism increase and consequently the orthophosphate is assimilated faster and incorporated into the biomass (Esteves, 1988).

Despite the fact that data related to the nutritional water parameters has showed more than the double value of variation, the concentrations are typical of an oligotrophic lake (Esteves, 1988) and the value are in the comfort physiological zone for fish (Arana, 2004). On the other hand, Leitão et al. (2006) refers, in their study to the reservoirs located in the semi-arid as eutrophic and hypereutophic. All these concentrations related above are in the optimal zone established for fish survival and growth (Kubtza, 2000; Arana, 2004). The few variation in some water parameters, like oxygen and temperature, is due to the wind action inducing mixture in the small water bodies due to pond depth during the period.

Cyanobacteria is potencially invasive and, is considered a major problem for water quality management and to eutrophication. Also, Cyanobacteria has a negative influence in phytoplankton diversity in small lakes (Chellapa et al., 2007). The same was obseverd in FED when Cyanobacteria were dominant, there were a great decrease in the species diversity of Chlorophyceae. According to Jayatissa et al. (2006), the fluctuation capacity, the resistance to high luminosity and, the atmospheric nitrogen fixation through heterocysts (?), also contributes to the greater Cyanobacteria resistance. Considering the contribution of each group for the species abundance in the present study, Chlorophyceae was the most representative in both water bodies in the different periods, what agrees with other authors (Tucci 2002; Alvain et al., 2005; Ferrier et al., 2005; Filho, 2005; Nabout et al., 2006) that studied Brazilian ponds for fish production.

The second group most representative in abundance was Bacillariophyceae, similarly to other studies that also related the important contribution of diatoms for the species composition in shallow water in tropical environment (Huszar et al., 1994; Komárek, 2005; Shubert, 2003).Some authors (Alvain et al., 2005; Ferrier et al., 2005) has observed that Chlorophyceae are more demanding in light intensity than Bacillariophyceae. This fact was also observed in both ponds. It is possible that it has influenced phytoplankton decrease in the environment once Bacillariophyceae and Cyanobacteria increased in the rainy season and, water moves and sediment comes to surface (Sipaúba-Tavares et al., 2003).

The species dominance in the ponds, was possibly associated to extrinsic (wind, air temperature and precipitation) and intrinsic (fish species) factors. Phytoplankton composition ranged in accord to the environment condition (Avault, 2003; Sipaúba-Tavares et al., 2003).

Climate variation showed to be regular within seasonality for the studied periods: low water precipitation, high bright sunshine, solar radiation, evaporation and temperature. The same pattern was found by Moura et al. (2007), for a 40 years studying period (1965-2005). Also, the decreasing may be is due to infiltration, animal and domestic use. The use of rain fed water bodies for fish culture in the Brazilian semi-arid is recommended for some authors (Maltchik, 2000; Albinati, 2006).

In Table 3, it can be seen an estimation of the water volume lost, considering only the daily evaporation (pan evaporation) times the daily water surface regression, not taking into account the human use and the influence of the evaporation process. These kinds of pond and, behavior related to the evaporation and use in the Brazilian semi-arid has an influence in the decrease of water quality (Suassuna, 1996). More recently, similar conclusions were reported by Fontes et al. (2003), in studied ponds evaporation in the Brazilian semi-arid; by Gomes and Filho (2001), in the Brazilian northeast, and Meireles et al. (2007), in Edson Queiroz dam, Acaraú basin, in the semiarid of Ceará and by Molle (1989) in 11 stations distributed in the Brazilian semi-arid and in a series from 8 through 25 years.

5. Conclusion

Water quality and phytoplankton community followed the pattern found in the literature for reservoirs with the characteristics of Manga Nova and Federação. Manga Nova has limnological characteristics for optimal tambaqui growth. Rain water dependent ponds are useful to the benefit of food production in communities of the Brazilian northeastern semi-arid.

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