he role of Charophytes primary production in a coastal agoon subjected to human impacts (RJ, Brazil).

PALMA-SILVA[1], C; ALBERTONI[1], E.F. & ESTEVES[2], F.A.

'undação Universidade Federal do Rio Grande, Departamento de Ciências Morfo-biológicas, aboratório de Ecologia, CEP: 96201-900, Rio Grande, RS, Brasil. - e-mail: dmbcps@furg.br

Universidade Federal do Rio de Janeiro, Instituto de Biologia, Depto de Ecologia, Laboratório de Limnologia

RESUMO: A importância da produção primária da comunidade de Carófitas em uma lagoa costei- ı tropical sujeita a impactos antrópicos (RJ, Brasil). Esta pesquisa foi realizada na lagoa nboassica, localizada na cidade de Macaé (22°24'S e 42°42'W), (RJ, Brasil), com bjetivo de estimar a produção primária da comunidade de carófitas, e discutir seu apel sobre a manutenção de águas claras durante seu crescimento. A lagoa sofre npactos de entrada de poluição orgânica e também com grande freqüência ocorre rtificialmente uma variação drástica de nível de água para controle de enchentes. ι estimativa da produção primária da macroalga foi avaliada após uma variação rusca do nível de água da lagoa, e através de dois métodos: o primeiro por incuba- ;ões em frascos claros e escuros, em montagens com água filtrada e não filtrada, :om determinação da variação de oxigênio dissolvido, e o segundo pela variação la biomassa total. Combinando os valores da variação de biomassa com dados da :oncentração de nutrientes presentes nas plantas foi estimada também a quantida- le de nutrientes absorvida durante cada intervalo de coleta. As coletas foram men- ıais entre Março/97 à Julho/97, período de recomposição da coluna de água e gran- le crescimento das Carófitas, após uma abertura artificial da barra da lagoa ocorri- la em Janeiro/97. Os resultados das incubações indicaram que não ocorre uma liferença significativa entre a situação com água filtrada e não filtrada, o que de- nonstra uma pequena contribuição do fitoplâncton para a produção final. Os valo- res de PPL determinados pela variação de oxigênio dissolvido variaram entre 0,91 à 2,53 $mgC.mg^{-1} PS.h^{-1}$. O pico máximo de PPL calculado pela variação de biomassa foi de 5,9 $gPS.m^{-2}.d^{-1}$, o que significa incorporar neste período em sua biomassa diariamente 210 $gP.ha^{-1}$ e 1 $KgN.ha^{-1}$. Esta absorção, quando comparado a entrada de nutrientes na lagoa, mantém as concentrações baixas na coluna de água. Isto deve ser um fator importante para o pequeno crescimento fitoplanctônico, representado por uma alta transparência da água e uma baixa concentração de clorofila-*a*.

Palavras-chave: Macrófitas aquáticas, Carófitas, Produção primária, Poluição.

ABSTRACT: The role of Charophytes primary production in a coastal lagoon subjected to human impacts (RJ, Brazil). This research was done at Imboassica lagoon, in the city of Macaé (22°24'S and 42°42'W), (RJ, Brazil), aiming to estimate the primary production of the Charophytes community, analyzing their role in the maintenance of clear water during their growth. This lagoon receives input of organic pollution and the sandbar is frequently breached to control shoreline flooding with an artificial drastic water level variation. Primary production was measured after a drawdown, using two methodologies: light and dark incubations, with filtered and unfiltered water, by dissolved oxygen variation, and total biomass variation. Combining biomass variation values and nutrient concentration of plants, the amount of nutrients uptake during sampling interval was also estimated. The samplings were done monthly, between March/97 and July/97, in the period of water column recomposition and great growth of Charophytes, after a sandbar breaching in January/97. The incubation results show that there is no significant difference between unfiltered and filtered water situations, with low contribution of phytoplankton to final production. Through the incubations, the values of NPP fluctuated between 0.91 and 2.53 $mgC.mg^{-1}DW.h^{-1}$. The maximum values

of NPP by biomass variation were approximately 5.9 $gDW.m^{-2}.d^{-1}$, which means a daily uptake of 210 $gP.ha^{-1}$ and 1 $kgN.ha^{-1}$ in its biomass. This high uptake maintains the nutrient concentrations in the water at low levels, preventing the phytoplanktonic growth, represented by high water transparency and low chlorophyll-a concentration.
Key-words: Aquatic macrophytes, Charophytes, Primary production, Pollution.

Introduction

This research took place at Imboassica lagoon, located in the city of Macaé, RJ (Brazil) (22°24'S and 42°42' W). Its mean depth is 1.09m (Panosso *et al.*, 1998), with high transparency and alkalinity (Petrucio, 1998), and it is a predominantly oligohaline environment (Branco, 1998; Petrucio, 1998), favorable to the development of dense stands of the submersed macroalgae *Chara*. The species *Chara angolensis* A. Braun and *C. fibrosa* ex Bruz. Emend. R.D. Wood occur in mixed stands (Palma-Silva, 1999).

This lagoon has been subjected to several human impacts, which caused changes of large scope in the structure of several communities, as shown by Branco (1998) for the zooplankton, by Melo & Suzuki (1998) for the phytoplankton, by Frota & Caramaschi (1998) for fishes, by Albertoni *et al.* (1999) for shrimps, by Albertoni *et al.* (2001) for macroinvertebrates, by Palma-Silva (1998; 1999) and Palma-Silva *et al.* (2000) for aquatic macrophytes. The two kinds of human impacts under observation are the artificial drawdown, a control measure of the lagoon water level, and the input of "in natura" domestic sewage in the lagoon (Faria *et al.*, 1998; Esteves, 1998; Albertoni *et al.*, 1999; Frota & Caramaschi, 1998; Kozlowsky-Suzuki, 1998).

Aquatic macrophytes are a very important component of the metabolic processes in several shallow coastal lagoons. At Imboassica lagoon, Furtado (1994), Lopes-Ferreira (1995), Furtado & Esteves (1996;1997), Furtado (1998), have shown the importance of the community of emergent and floating aquatic macrophytes.

Schuette & Alder (1929) acknowledged the role of Charophytes as the most important primary producer in many lakes. In more recent years, the importance of these submersed macroalgae was related to their role in the maintenance of clear water in oligo and mesotrophic lakes of the northern hemisphere, as they present two alternate conditions, a turbid stage dominated by phytoplankton and a stage with clear waters dominated by submersed macrophytes (Timms & Moss, 1984; Blindow, 1992; Blindow *et al.*, 1993; Scheffer *et al.*, 1993; Scheffer, 1998; Stephen *et al.*, 1998; Van den Berg, 1999).

The nutrient assimilation in the water column and their role in cycling by aquatic macrophytes, decreasing their availability to the phytoplankton, has been investigated by several authors (Reddy *et al.*, 1989; Ozimek *et al.*, 1990; Kufel & Ozimek, 1994; Van den Berg *et al.* , 1998; Van den Berg, 1999).

At Imboassica lagoon, it was observed that in routine samplings the presence of Charophytes is associated with periods of high Secchi values and low chlorophyll-*a* values. Aiming to expand the knowledge of Charophytes community role in Imboassica lagoon after a drawdown, and the later reestablishment of the water level with a continuous input of domestic sewage, the rates of primary production obtained by *in situ* incubation and by biomass variation were estimated. The role of this community as a nutrient pool was estimated by macroalgae biomass nutrient concentration, and the amount of nutrients incorporated by this biomass during the growth.

Material and Methods

This research was performed between March/97 and July/97, after an artificial drawdown that took place in January/97. The estimates of primary production by Charophytes incubation were performed in one day in the first week of each month by the oxygen method, with incubations in light and dark flasks. The incubations took place in the morning, near a monitoring station in the central zone of the lagoon ᵎig. 1). Previous samplings showed that, considering flasks volume and oxygen ariation, the ideal time for incubation was one hour. In each sampling date, 2 stimates of production were taken with incubation periods of one hour; the first ıcubation beginning at 9:00 AM and the second at 10:00 AM, both with filtered (plankton et, 0.23 µm mesh) and unfiltered water. In each sampling period 20 flasks were sed, with a volume of 150 ml in each flask, and a portion of the plant apex with bout 7 cm of length.

Thus, 5 replicates were arranged for each incubation period for the following

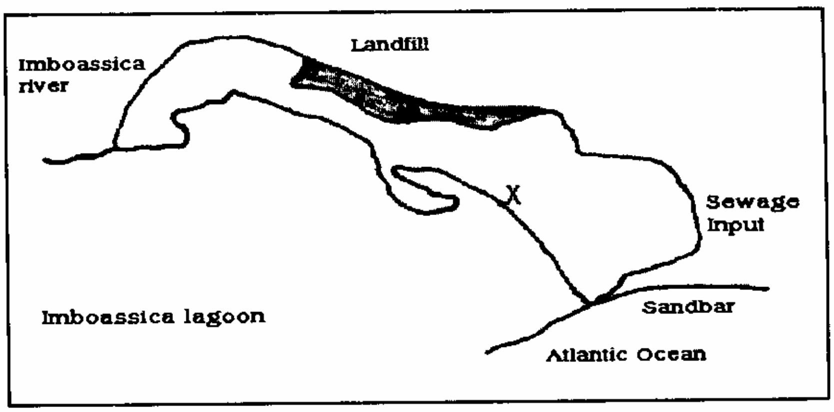

Figure 1: Imboassica lagoon and the site of incubations (X).

treatments: light flask with unfiltered water; light flask with filtered water; dark flask with unfiltered water, and dark flask with filtered water. The estimates of Net Primary Production (NPP), Respiration (R) and Gross Primary Production (GPP), were determined using the formulae presented by Menezes (1984).

Shortly before the incubation *Chara spp* were collected, and the flasks were set up and later attached to a buoy at a depth of 40 to 50 cm. The concentrations of initial dissolved oxygen were determined by fixation of the water used in the incubation, and the final concentrations were withdrawn from each incubating flask. In the laboratory, the macrophytes were withdrawn for the establishment of their dry weight.

The following environmental variables were estimated in the samples: pH with a digital pHmeter, salinity with a refractometer, temperature with a digital thermistor, alkalinity with the titulometric method proposed by Gran and described by Carmouze (1994), total nitrogen of the water column according to Mackereth *et al.* (1978), and total phosphorus of the water column according to Golterman *et al.* (1978). The estimate of the photosynthetically active radiation (PAR) intensity was monitored by a radiometer Li-Cor Li-185B with a spherical sensor, with three measurements in each incubation period. The concentrations of dissolved oxygen were obtained by the method of Winkler, modified by Golterman *et al.* (1978). The concentration of chlorophyll-*a* was estimated as proposed by Nusch & Palme (1975).

Charophytes mean biomass in the area close to the incubation site was obtained with squares of 25x25 cm (n=6), sampled randomly. All plants, including the underground material, were withdrawn manually. After collection, the samples were washed in the field and again in the laboratory under running water on a 1mm mesh sieve. Values of NPP were obtained by biomass variation in two consecutive samples. The amount of incorporated nutrients at each interval was calculated by means of biomass NPP values and macroalgae biomass nutrient concentration.

The dry weight of Charophytes was obtained in an oven at 50 °C for 48 hs, and detected in a digital scale (0.01mg). The nutrient concentration in the Charophytes biomass was determined by the following methods: carbon, by sample combustion on a muffle furnace (Westlake, 1965), nitrogen by the micro-Kjeldahl method (Allen *et* *al.*, 1974), and phosphorus with the method proposed by Fassbender (1973). The C:N:P ratio for charophytes biomass was calculated based on these values.

The results of Net Primary Production (NPP), Respiration (R) and Gross Primary Production (GPP), are presented with median, minimum and maximum values, and the comparisons were made using the Kruskal-Wallis test, between the incubations of the same sampling date. The Spearman correlation test ($p<0.05$) was used to quantify the covariance matrix of the NPP and the monitored environmental variables.

Results

The results had few instances of significant differences between the groups of values, showing a small time influence in the time of the beginning of the incubation and the filtering of the water (Tab.I).

Table I: *Chara* spp median, minimum and maximum values ($mgC.mg^{-1}DW.h^{-1}$) for each incubation period, in all sampling dates in Imboassica lagoon. "A" = flasks with filtered water incubated at 9:00 AM, "B" = the same at 10:00 AM; "C" = flasks incubated with unfiltered water at 9:00 AM, and "D" = the same at 10:00 AM. "p" indicates the treatment with significant differences (*) = ($p < 0.05$), and (**) = ($p < 0.01$) (Kruskal-Wallis and Dunn tests).

		NPP				***R***				***GPP***			
		Med	**Min**	**Max**	**p**	**Med**	**Min**	**Max**	**p**	**Med**	**Min**	**Max**	**p**
March	A	2.09	1.84	2.23	-----	0.84	0.71	0.88	-----	2.90	2.68	3.10	-----
	B	2.05	1.72	2.37	-----	0.75	0.62	1.00	-----	2.88	2.39	3.18	-----
	C	1.88	1.68	2.38	-----	0.81	0.70	0.94	-----	2.82	2.42	3.25	-----
	D	2.09	1.70	2.53	-----	0.74	0.68	0.86	-----	2.88	2.40	3.48	-----
April	A	1.32	1.18	1.67	-----	0.71	0.67	0.86	(AxD)*	2.18	1.86	2.37	(AxD)*
	B	1.42	1.19	1.46	-----	0.82	0.78	0.99	-----	2.19	2.04	2.36	(BxD)*
	C	1.29	1.03	1.55	-----	0.87	0.81	1.12	-----	2.14	1.97	2.60	-----
	D	1.54	1.39	1.85	-----	0.99	0.86	1.01	(AxD)*	2.56	2.31	2.84	(DxAxB)
May	A	0.97	0.92	1.20	-----	1.27	0.97	1.47	(AxD)*	2.21	1.89	2.67	-----
	B	1.24	0.79	1.50	-----	1.21	0.82	1.46	-----	2.32	2.14	2.48	-----
	C	1.46	0.98	1.63	-----	1.13	1.00	1.43	-----	2.63	2.17	2.66	-----
	D	1.21	0.91	1.72	-----	1.00	0.82	1.14	(DxA)*	2.29	1.83	2.72	-----
June	A	1.66	0.98	2.05	-----	0.74	0.57	1.31	(AxD)*	2.49	1.55	2.97	-----
	B	1.13	1.08	1.44	(BxD)**	0.99	0.87	1.18	-----	2.12	0.91	2.62	-----
	C	1.71	1.22	1.84	-----	0.83	0.71	0.98	-----	2.58	1.93	2.82	-----
	D	1.56	1.54	1.61	(DxB)**	0.91	0.80	1.18	(DxA)*	2.50	2.21	2.99	-----
July	A	1.08	0.95	1.16	(AxD)**	0.87	0.73	1.11	-----	1.91	1.68	2.02	(AxD)**
	B	1.25	1.05	1.37	-----	0.91	0.56	1.22	-----	2.07	1.80	2.50	-----
	C	1.24	0.92	1.41	-----	0.92	0.82	1.05	-----	2.14	1.74	2.33	-----
	D	1.19	1.12	1.92	(DxA)**	1.29	0.82	1.36	-----	2.28	2.00	2.92	(DxA)**

The NPP rates had a significant difference in June/97 ($p < 0.01$) between the treatment with *Chara* spp in filtered water from the lagoon and the treatment in unfiltered water, both beginning at 10:00 AM. The other significant result ($p < 0.05$) was observed in July/97, between the incubations with filtered water at 9:00 AM and those with unfiltered water at 10:00 AM.

For the R rate results, significant values ($p < 0.05$) were observed in April/97, May/97 and June/97, between the treatments with *Chara* spp incubated at 9:00 AM with filtered water and the incubations at 10:00 AM with unfiltered water. However, in the treatments with highest median values in each case, it can be noticed that in May/97 the highest values occurred in the incubation at 9:00 AM with filtered water, while in the other months this result was the opposite.

The GPP rates had significant differences ($p < 0.05$) in April/97 between the treatments with filtered water at 9:00 AM and 10:00 AM and the incubation of 10:00 AM in unfiltered water. Significant differences ($p < 0.01$) were found between the treatments with filtered water at 9:00 AM and 10:00 AM.

Comparing the net, total primary production and respiration rates, between the same incubation treatments, also indicate a small variation between the different months. The significant differences in NPP rates were between March/97 and May/97, and between March/97 and July/97 for the unfiltered and filtered water treatments incubated at 9:00 AM. For respiration rates, the results showed differences ($p < 0.05$) between April/97 and May/97 for the unfiltered water treatment at 9:00 AM, and between March/97 and June/97 for the unfiltered water treatment incubated at 10:00 AM, and between March/97 and July/97 for the filtered water treatment incubated at 10:00 AM. The differences in GPP were detected between March/97 and April/97 and between March/97 and June/97, both of them for the unfiltered water treatment incubated 9:00 AM.

Therefore, when considered as a group, all values of each rate in the different months, had a greater number of data significantly different (Tab.II).

Table II: Significance values for *Chara* spp comparing of NPP, R and GPP at Imboassica lagoon, considering all sampling dates. (* = p<0.05) (** = p< 0.01) (*** = p<0.001) and (Ns, non significant) (Kruskal-Wallis test).

Comparison	NPP	R	GPP
March/97 x April/97	***	Ns	***
March/97 x May/97	***	***	**
March/97 x June/97	***	Ns	**
March/97 x July/97	***	*	***
April/97 x May/97	Ns	**	Ns
April/97 x June/97	Ns	Ns	Ns
April/97 x July/97	Ns	Ns	Ns
May/97 x June/97	Ns	*	Ns
May/97 x July/97	Ns	Ns	Ns
June/97 x July/97	Ns	Ns	Ns

The results showed that some NPP values were positively related to the concentration of nitrogen (r=0.41) and chlorophyll-*a* (r=0.25), and negatively related to phosphorus (r=-0.27) and PAR (r=-0.39). The variation of NPP, GPP and R rates throughout the year is presented in Figure 2. The greatest values of NPP and GPP were observed in March/97. In April/97, there was a significant decrease in the rates of NPP and GPP, which increased slightly in the months of May/97 and June/97 and dropped again in July/97. The R rates had a very slight increasing trend from March/97 to May/97, when it reached its maximum value, dropping later to levels slightly higher than the initial ones. The values of the environmental variables in each sampling date are presented in Tab.III.

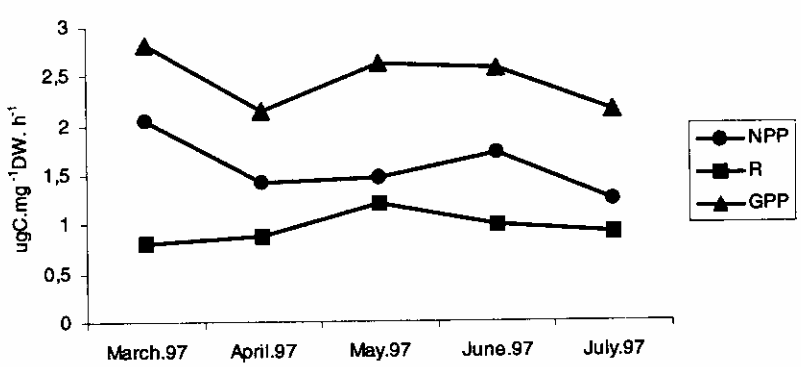

Figure 2: Net Primary Production (NPP), Gross Primary Production (GPP) and Respiration (R) of *Chara* spp, at Imboassica lagoon.

Table III: Water column environmental variables in each date of *Chara* spp incubation, at Imboassica lagoon.

	Salinity (‰)	AlKalinity (μEq/l)	N_t (mg/l)	P_t (μg/l)	Irradiance ($\mu E/m^2/s$)	Temp. (°C)	pH	Chlorophyll-a (μg/l)
March/97	10	446.6	1.10	19.24	630	29.0	8.25	3.74
April/97	9	705.1	0.77	30.06	345	25.7	8.53	2.27
May/97	5	743.4	0.45	19.24	1230	25.1	8.31	3.11
June/97	2	537.1	0.31	19.41	1200	20.0	8.02	1.94
July/97	1	764.2	0.49	20.80	1200	23.0	7.99	3.04

The NPP results estimated by the biomass variation ($gDW.m^{-2}.d^{-1}$) the biomass nutrient concentration, and C:N:P ratio of *Chara* spp show the quick growth of the macroalgae and the great variation in the nutrient concentration. The greatest values of mean accumulated biomass (March-April with 4.6 and April-May with 5.9 $gDW.m^{-2}.d^{-1}$) occurred in the period of initial growth. Biomass values seem to establish around 500 $gDW.m^{-2}$. The monthly accumulated biomass by Charophyte community in Imboassica lagoon was variable, but considering the greatest value obtained in the period (5.9 $gDW.m^{-2}.d^{-1}$) as well as the nutrient concentration in the biomass, it was estimated that about 21 $mgP.m^{-2}.d^{-1}$ and 100 $mgN.m^{-2}.d^{-1}$ are incorporated by the stands, what is equivalent to 210 $gP.ha^{-1}$ and 1$kgN.ha^{-1}$, daily (Table IV).

Table IV: *Chara* spp biomass and nutrient concentration values at Imboassica lagoon.

	Biomass $gDW.m^{-2}$	Accumulated Biomass in this period $gDW.m^{-2}.d^{-1}$	Carbon $mg.g^{-1}DW$	Nitrogen $mg.g^{-1}DW$	Phosphorus $mg.g^{-1}DW$	C:N:P
March/97	143	---------	304.6	16.6	0.19	1603:87:1
Abril/97	280	4.6	354.3	19.4	1.26	281:15:1
May/97	456	5.9	306.0	17.2	3.59	85:5:1
June/97	507	1.7	301.4	19.7	2.78	108:7:1
July/97	518	0.4	297.1	20.7	1.40	212:15:1

Discussion

In several lakes, the Charophytes occupy significant areas of the sediment, and have, therefore, an important limnological role (Hutchinson, 1975). The great values of biomass found in Imboassica lagoon (Palma-Silva, 1999) indicate the importance of this macroalgae in this system.

According to Knoppers (1994), coastal lagoons have high rates of primary production, ranging from 200 to 500 $gC.m^{-2}.y^{-1}$, but comparisons with lagoons dominated by macroalgae are difficult, since they received scarce attention and there are few estimates of their primary production.

In this research, by incubation method, the results of different replicates of the same treatment did not show strong differences, probably due to the previous drawdown which, promoting large-scale mortality in the macrophytes, causes homogeneous growth in the stands and also reduces the presence of epiphytes. This result shows that the phytoplankton community did not present a significant contribution to primary production in the lagoon, despite the positive correlation with chlorophyll-*a* values and NPP.

The expected NPP values for submersed aquatic macrophytes in fertile locations in periods of optimum growth range from 2 to 10 $mgC.mg^{-1}DW.h^{-1}$ (Westlake, 1975). The results by oxygen variation method, ranged from 0.91 to 2.53 $mgC.mg^{-1}DW.h^{-1}$, being low when compared with the expected values for submersed macrophytes. However, they are similar to the results of Kautsky (1988), who, using the method of oxygen variation, found values of primary production between 0.5 e 2.8 $mgC.mg^{-1}DW.h^{-1}$ for *Chara aspera*,

C. baltica, C. fragilis and C. tormentosa. The values presented by Herrera-Silveira (1994) for the production of C. fibrosa in a Mexican coastal lagoon reached 498 $gC.m^{-2}.y^{-1}$, also showed similar estimates.

The incubations were executed with the apex of the plant, apparently in good shape for primary production, but the total biomass was not in the same condition, and in the deeper regions the plants usually had less chlorophyll (Andrews *et al.*, 1984; Carneiro, 1992). Then, as suggested by Kairesalo *et al.* (1989), monthly biomass measurements, are probably a better estimate of the growth.

The NPP estimates, through biomass variation during growth period, showed great variations, between 0.4 and 5.9 $gDW.m^{-2}.y^{-1}$. Considering 3.1 $gDW.m^{-2}.d^{-1}$ as a median value, a NPP of 1,116 $gDW.m^{-2}.y^{-1}$ was reached.

According to Forsberg (1959), the production of *Nitella mucronata* by biomass variation reaches values between 0.7 and 2.5 $gDW.m^{-2}.d^{-1}$, and Forsberg (1960) quotes the production of 8.6 $gDW.m^{-2}.d^{-1}$ for *C. fragilis*. Howard-Williams (1978), found for *C. globularis* an annual production of 263 $gDW.m^{-2}.y^{-1}$, and the results of Kufel & Ozimek (1994) for *Chara* sp reached a production of 10.8 $mgDW.g^{-1}.d^{-1}$. For *Nitella opaca*, Kairesalo *et al.* (1989) found the production of 153 $mgC.m^{-2}.d^{-1}$.

Charophyte biomass at Imboassica lagoon becomes stabilized around 500 $gDW.m^{-2}$, result consistent with Carneiro (1992), which found a biomass variation for *Chara hornemannii* , at Piratininga lagoon (RJ) in a year cycle, between 13.3 and 564 $gDW.m^{-2}$.

The biomass variation of *Chara* spp at Imboassica lagoon in the growth period may withdraw a great amount of nutrients from the water column. The ability of stocking soluble phosphorus is one of the competitive advantages of *Chara*. In the case of reactive soluble phosphorus input to the water column, the uptake of 15 to 100% by these plants shows a great ability of this nutrient removal, acting as a phosphorus buffer and preventing phytoplankton massive growth (Kufel & Ozimek, 1994).

According Lopes-Ferreira (1998) the amounts of nutrients dumped by the main sewage channel of the lagoon are, daily, 70 Kg N and 7 Kg P, and these concentrations are reduced by more than 90% when the sewage goes through an area densely colonized by emergent and floating macrophytes. So, it was estimated that the input of nutrients in the limnetic region of the lagoon is close to 7 Kg N and 700 g P each day. Considering the great area of colonization by Charophytes in the bottom of the lagoon (Palma-Silva, 1999), it was assumed that these concentrations are quickly uptaken by this community in their growth period. These results give Charophyte community the ability to maintain a clear water environment at Imboassica lagoon, at least in the period of greater growth, showing its potential role in strategies of maintenance and recuperation of the water quality.

In the same period of this research, Kozlowsky-Suzuki (1998) found in a site close to the end of the sewage channel, maximum values 15.9 $\mu g.l^{-1}$ of chlorophyll-*a*. In this site, the biomass of *Chara* is smaller and has a greater concentration of nitrogen and phosphorus (Palma-Silva, 1999).

Estimates of the phytoplanktonic production at Imboassica lagoon reached an average of 340 $mgC.m^{-3}.d^{-1}$, with a dominance of the class › 35 µm (Roland, 1998). Our research did not find an important role for the phytoplanktonic production, since the values of the incubations with unfiltered and filtered water had few significant differences (Table I), and the concentrations of chlorophyll-*a* (Table III) were always low, in spite of a positive correlation between NPP and chlorophyll-*a* (r_s = 0.25).

The analysis of the results indicate that the significant differences between the incubations in the same sampling date are small, but the differences between each sampling date were clearer when all treatments were considered. These observations suggest that some environmental variables, or even the plant growth metabolism, may be related to this monthly variation.

The positive correlation with nitrogen and negative correlation with phosphorus are not conclucive to a simplistic explanation, and can indicate the ability of phosphorus uptake of this community, which resulted in the establishment of nitrogen as the limiting nutrient, but this subject needs more detailed investigation.

The Imboassica lagoon presents, in average, a great penetration of light in the water column, reaching close to the bottom (Petrucio, 1998). According to Esteves *et al.* (1988), the high values of dissolved oxygen found in Imboassica lagoon may be attributed to the greater penetration of light in the water column, which can result in a greater net primary productivity in this environment. The great concentration of dissolved oxygen may also result in a greater removal of phosphorus from the water into the sediment (Wetzel, 1993), and this can be related to the negative correlation between the NPP of *Chara* spp and the concentration of phosphorus in the water column.

The estimates of primary production by oxygen variation method were considered low within the range found for this genus in the literature. The variation of the monthly biomass in the months of fast growth after drawdowns, provides good results and allows the evaluation of the nutrient uptake and its role in the lagoon metabolism.

The Charophytes ability to grow, even with high C:N:P ratio, associated with its quick growth after the artificial drawdowns, absorbing a great amount of nutrients may have resulted in an environment with low nutrient availability for the phytoplankton. This fact reflects the low concentrations of chlorophyll-*a* and the small contribution of the phytoplankton for the total primary production.

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