PHYTOPLANKTON PRIMARY PRODUCTION IN CHASCOMUS POND (PROVINCIA DE BUENOS AIRES, ARGENTINA)

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SUMMARY:

In situ phytoplankton primary production in Chascomús pond (eutrophic Pampasic "laguna") was studied by the oxygen method (light and dark bottle) between January 1984–January 1985. Values obtained ranged from 37,9 to 981,6 mg C • m^{-2} • d^{-1}. Factors influencing it, as suspended particulate matter and hydrological changes, are discussed. Parallel determinations of the artificial light photosynthesis response proved to be useful, almost qualitatively under the experimental conditions applied, to follow the behaviour obtained by incubations in natural environment.

INTRODUCTION

Chascomús pond (35° 36' S, 58° W) is located in the Province of Buenos Aires, belongs to the Río Salado drainage basin and lies in a geomorphological unit called "Pampa deprimida" (Frenguelli, 1950), where there is a great variety of Pampasic "lagunas" differing in origin and in chemical and biological characteristics according to Ringuelet (1962, 1968, 1972) and Ringuelet et al. (1967). This pond is a shallow eutrophic ecosystem, rich in nutrients, alkaline and with a high content of suspended particulate matter and soluble humic substances (Conzonno and Fernandez Cirelli, 1987). During the period of study and in sampling station, phytoplankton (Claudia Intartaglia**, personal communication) was always dominated by species of Cyanophyta, with a mean value of 526000 cells per ml, that represented 86% , followed by Chlorophyta (10%) and Crysophyta (3%). Macrophytes, both submerged (*Potamogeton, Ceratophyllum Myriuphyllum*) and emergent (*Scirpus californicus*) are very important in the overall primary production, as stated by Ringuelet (1968). The littoral zone covered with aquatic plants reached 3,93 km^2 in 1966 (Dangavs, 1976); at present, the value may be higher. Details on morphometry, obtained from Dangavs (1976), are given in Table 1.

In the latest twenty years, Lauce Freyre* (personal communication) has indicated, on the basis of fish community data, an increase in the

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ECOSUR	Argentina	ISSN 0325-108X	v. 14/15	n. 25/26	págs. 7-16	1987/8

TABLE 1
Morphometric parameters of Chascomús pond (from Dangavs. 1976)

Maximum length	9,57 km
Maximum bredth	6,26 km
Maximum depth	1,90 m
Mean depth	1,53 m
Surface area	30,129 km^2
Volume	47.015.317 m^3
Shoreline length	28.120 m
Shoreline development	1,44

trophic level of the pond. This fact may be related with human activities coming from the city of Chascomús (30.000 inhabitants) located over its shore, land uses (rural, agricultural) and the industries found in the catchment area.

The present paper gives results of phytoplankton primary production in this pond, obtained from January 1984 to January 1985, as well as a discussion about the influence of environmental factors over the magnitude of it.

MATERIALS AND METHODS

Primary production (PP) was determined by the oxygen method (light and dark bottles); therefore, the values here presented correspond to the definition of gross primary production. The analyses were performed according to the method of Winkler (Alsterberg modification) and the conversion to carbon was made considering a photosynthetic quotient of 1,2 (Strickland and Parsons, 1960).

For the in situ PP measurements, samples were collected from the centre of the pond by means of a battery pump at 0,1; 0,2; 0,3; 0,4; 0,5; 0,7 and 1,0 meter depth. Each of them was transferred to one liter plastic bottle and was left open to air in darkness to reach a state of equilibrium for a few minutes. After that, samples were siphoned carefully to 110 ml glass bottles and the corresponding light ones were fixed, horizontally at the intervals mentioned, to a system in such a way so as to prevent shading effects between them. This system was left suspending on the surface of the pond by means of buoys placed in such way so that they had no influence over the bottles. Separately, bottles covered with aluminun foils were suspended for the evaluation of respiration rate. The incubation period varied 4-5 hours and daily PP (Pd, mg $C \cdot m^{-2} \cdot d^{-1}$) was calculated by integration vertical production and multiplying it by a suitable factor for light. Optimun rate of PP per hour (Popt) was evaluated by dividing the maximun value in the water column (mg $C \cdot m^{-3} \cdot d^{-1}$) by the length of daylight.

Artificial incubations were made over an integrated sample obtained from the centre of the pond using a two liter, 0,5 meter length, Van Dorn sampler. It was placed at the subsurface in a vertical position in order to take a representative sample of the euphotic zone. Then, this sample was put in a plastic container, kept in darkness and immediately carried to the laboratory of the Estación Hidrobiológica de Chascomús. There, after carefully mixing it, it was fractioned into 110 ml glass bottles and placed standing in the diagonal of a glass box (dimensions in meters: 0,45 wide; 0,20 high; 0,89 length) provided with flowing water at the same temperature of the pond water. In order to get a light gradient, a photo lamp (Iwasachi Electric Co, 500 W, type PRF, flood) was placed in one of their extremes in such a way that the first bottle received the maximun radiation perpendicularly. Incubations lasted 4 hours and the incubator calibration was made with a Li-Cor photometer (Lambda Instruments, USA). This equipment was also used to measure solar radiation and light extinction in the water column.

Suspended particulate matter, seston, was determined by weighing the residue resulting from the filtration of adequate volumes (100-150 ml) of the integrated sample through filters (Whatman GF/C), previously baked at 500°C. These filters were then used to evaluate particulate organic carbon (POC) by oxidation with potassium dichromate using glucose as standard, according to Strickland and Parsons (1960). Chlorophyll *a* (Chl) and pheopigments (Phe) were determined in the integrated sample spectrophotometrically, by using 90% acetone as a solvent following the technique described in Golterman (1971).

RESULTS

Surface temperature varied from 7,0 to 28,0°C with nearly no stratification in the water column because the pond was almost in a permanent vertical mixing. Nutrients were found in high concentrations and showed great fluctuations, since nitrate ranged from less than 10 to 380 $\mu g\ NO_3^- - N \cdot l^{-1}$; ammonia, 10-100 $\mu g\ NH_4^+ - N \cdot l^{-1}$; total phosphorus, 100-400 $\mu g\ P \cdot l^{-1}$ and orthophosphate from below detectable limit to 33 $\mu g\ PO_4^{3-} - P \cdot l^{-1}$, Fig. 1.

As a consequence of the vertical mixing mentioned, resuspension of bottom sediments promoted high values of seston, 35-204 $mg \cdot l^{-1}$. Particulate organic carbon contain (POC), ranged from 3,7 to 10,5 $mg\ C \cdot l^{-1}$. Chlorophyll *a* presented values with great fluctuations, 1,8-51,6 $\mu g \cdot l^{-1}$, similar to what happened with pheopigments, 14,5-56,1 $\mu g \cdot l^{-1}$. The ratio between the two pigments ($Chl \cdot Phe^{-1}$) which, in few months was below the unit, showed the high proportion of the degraded form of chlorophyll *a* in this pond, Table 2.

Seston caused a high attenuation of light in the water coumn, reflected in the value of the extinction coefficient (mean value 9,6 m^{-1}) and by

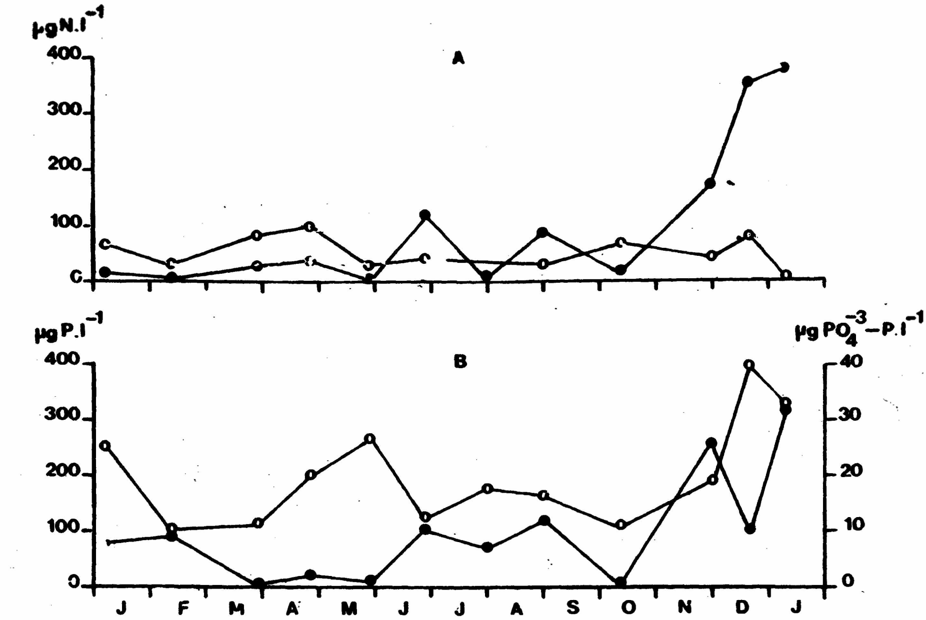

Fig. 1.– Seasonal variation of nutrients. A: nitrate (–•–) and ammonia (–○–) in μg N • l^{-1}; B: orthophosphate (–•–) and total phosphorus (–○–) in μg P • l^{-1}.

the Secchi disc reading (mean value 0,19 m), which means a photic layer of ca. 0,5 meter depth. This fact made PP to have a pattern shown in Fig. 2. Such behaviour was characterized by exhibition of no photoinhibition in samples coming from the lower depth, which appeared reasonable considering that light reached about 40% of surface intensity at this depth. So Popt was always found near the surface and ranged from 24,3 to 194,8 mg C • m^{-3} • h^{-1}. Below this, profile showed a quick declination, with a compensation depth located in general between 0,4 and 0,7 meter depth. The exception to this behaviour was found in February, during a period of unusual calm in the pond when the sampling took place, where sedimentation led to a decrease of seston that reached the minimum concentration, Table 2. Consequently, Secchi disc reading, 0,4 m, was the maximun (Fig. 2) and the euphotic zone approximately 1 meter depth. On this occasion, PP was still higher up to 0,4 meter and became nule at 1 meter depth, Fig. 2. Sedimented material seemed to be mostly of inorganic nature according to the highest percentage of POC obtained, Table 2.

Towards the end of October, intense rainstorms produced a raise in the water level, a decrease in salinity and the increasing in the content of dissolved humic substances that entered the pond via runoff from the surrounding wetlands and drainage basin (Conzonno and Fernandez Cirelli, 1988) and nutrients showed an increase in nitrate, ortophosphate and to-

TABLE 2

Seasonal changes in water temperature, suspended particulate matter, in situ and artificial incubations data of primary production in Chascomús pond.

		8.1.84	13.2	29.3	27.4	28.5	25.6	31.7	31.8	11.10	30.11	20.12	9.1.85
	Water temperature, °C	28,0	25,0	19,0	13,5	10,0	8,5	7,0	13,5	18,0	22,0	23,0	25,0
	Seston, $mg \cdot l^{-1}$	68,8	35,0	92,0	61,0	139,0	109,0	116,0	133,0	204,0	42,0	113,0	160,0
	POC, $mg\ C \cdot l^{-1}$	6,0	4,1	6,3	4,5	10,5	8,5	9,4	7,2	11,1	3,7	5,0	5,9
	$POC \cdot seston^{-1}$, %	8,7	11,7	6,8	7,4	7,5	7,8	8,1	5,4	5,4	8,8	4,4	3,7
	Chlorophyll a, $\mu g \cdot l^{-1}$	10,0	24,4	51,6	45,1	36,4	40,8	16,7	29,7	8,6	1,8	2,0	2,4
	Pheopigments, $\mu g \cdot l^{-1}$	17,0	18,3	23,6	14,5	27,8	29,9	54,9	16,6	56,1	16,4	30,8	2,0
	$Chl \cdot Phe^{-1}$	0,59	1,33	2,19	3,11	1,31	1,36	0,31	1,79	0,15	0,11	0,06	1,2
In situ PP	Pd, $mg\ C \cdot m^{-2} \cdot d^{-1}$	286,7	981,6	833,7	600,5	37,9	53,9	57,7	81,0	266,7	76,7	166,0	227,6
	Popt, $mg\ C \cdot m^{-3} \cdot h^{-1}$	67,7	164,7	194,8	177,8	24,3	41,9	60,0	60,8	159,9	49,9	75,5	90,3
	$Popt \cdot Chl^{-1}$, $mg\ C \cdot mg\ Chl^{-1} \cdot h^{-1}$	6,8	6,7	3,8	3,9	0,7	1,0	3,6	2,0	18,6	27,7	37,8	37,6
Art. photo. light-curve	α, $mg\ C \cdot mg\ Chl^{-1} \cdot h^{-1} \cdot (\mu E \cdot m^{-2} \cdot s^{-1})^{-1}$	0,41	0,13	0,09	0,07	0,09	0,09	0,10	0,08	0,45	1,16	1,18	0,72
	Pmax, $mg\ C \cdot m^{-3} \cdot h^{-1}$	182,3	222,1	296,4	258,0	295,9	307,8	212,2	221,0	272,3	104,2	141,6	113,0
	$Pmax \cdot Chl^{-1}$, $mg\ C \cdot mg\ Chl^{-1} \cdot h^{-1}$	18,3	9,1	5,7	5,7	8,1	7,5	12,7	7,4	31,7	57,9	70,8	47,1

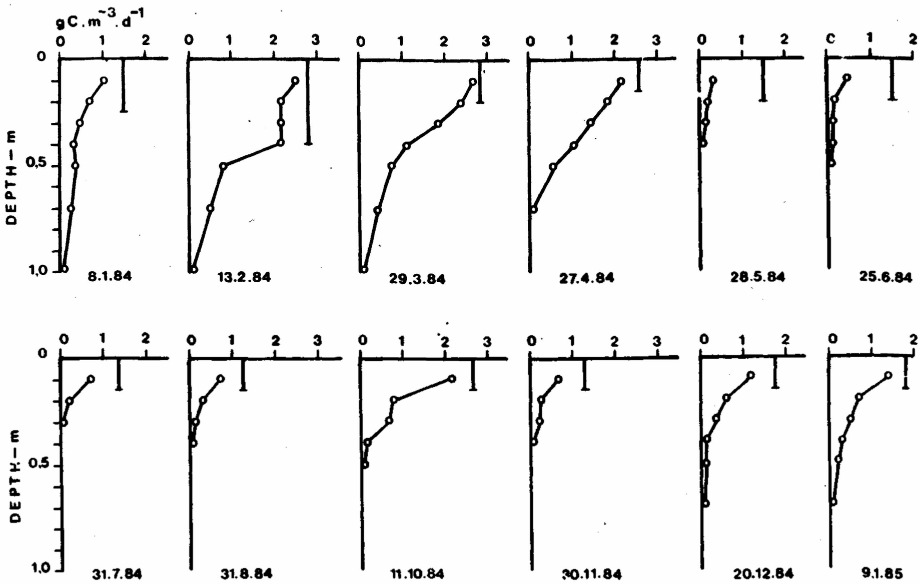

Fig. 2.– Vertical distribution of primary production (mg C • m^{-3} • d^{-1}) and ⊥ Secchi disc depth (m).

tal phosphorus, Fig. 1. This event did not produce a high reading of the Secchi disc because of the concentration of humic matter incorporated, but caused the diminishing of seston and POC. After that and up to the end of this study, these parameters reached their normal values, Table 2. Chlorophyll *a* was also affected and registered the lowest value of the period; this lack of pigment persisted afterwards. Low Chl • Phe^{-1} ratios in these circumstances may be associated with allochthonous organic detritus entering the pond, Table 2. According to the values of Pd, Popt and also Popt normalized to Chlorophyll *a*, it is possible to state that, between January and October, PP followed a seasonal pattern with a tendency to be minimun in autumn and winter, in correspondance with the variation of water temperature, Table 2. After the storm event and bearing in mind the time of the year, it is important to note that we found a great decrease in both Pd and Popt. The opposite was observed for Popt • Chl^{-1} ratio, that reached the value of 27,7 mg C • mg Chl^{-1} • h^{-1} and was even higher during the rest of this study, while between January and August was less than 7 mg C • mg Chl^{-1} • h^{-1} with a maximun of 18,6 mg C • mg Chl^{-1} • h^{-1} in October, Table 2. These results lead us to think of a great improvement of the photosynthetic activity under the conditions established in the pond after the rainstorm.

For the year in study in the sampling station, phytoplankton PP was 121,0 g C • m^{-2} • y^{-1}, with a mean daily value of 330,6 mg C • m^{-2} •

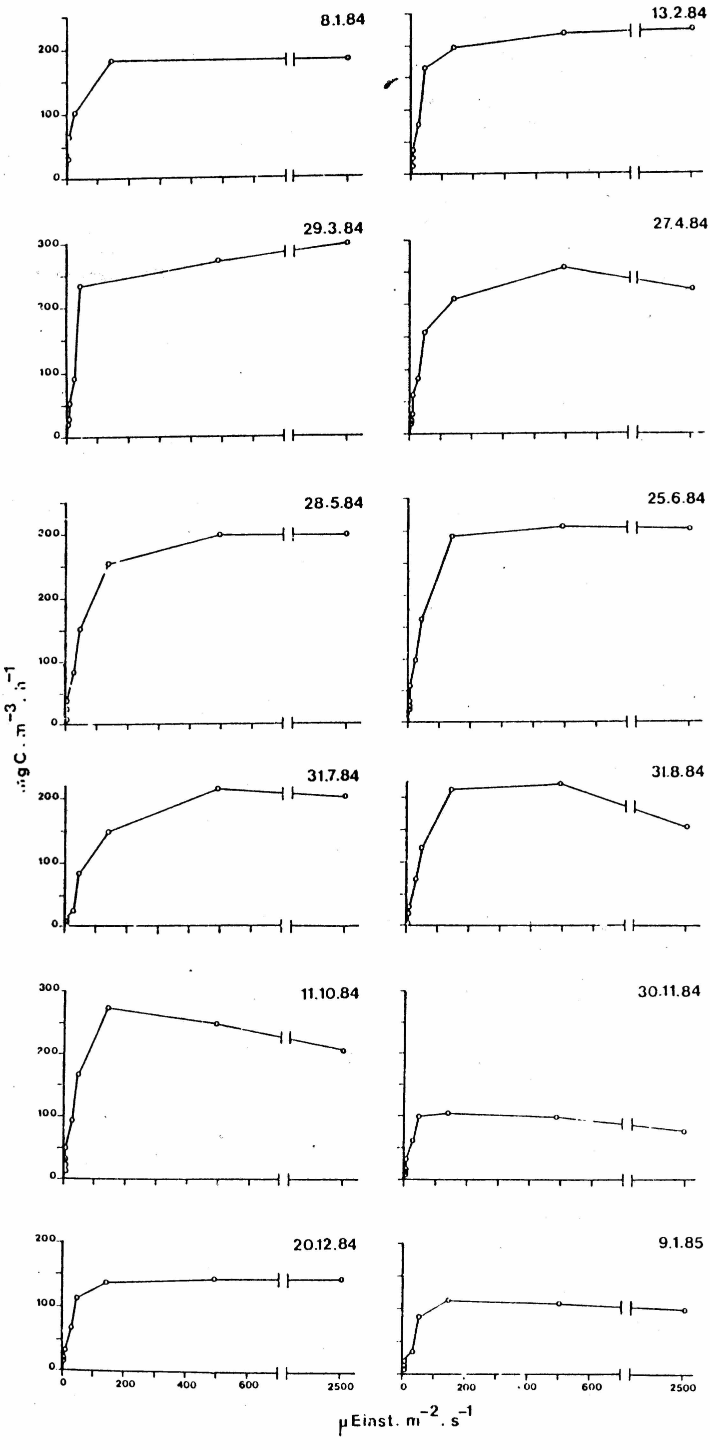

Fig. 3.– Primary production (mg C • m^{-3} • h^{-1}) as a function of light intensity (μE • m^{-2} • s^{-1}) obtained by artificial incubation technique for the different months of sampling.

d^{-1}, ranging from 37,9 (May 28, 1984) to 981,6 mg C • m^{-2} • d^{-1} (February 13, 1984).

From the light photosynthesis curve, Fig. 3, it is possible to get valuable physiological information about algal community. To begin with, the initial slope normalized to chlorophyll a, α , which is the photosynthetic efficiency according to Platt and Jassby (1976). Between January and October, it did not show a definite behaviour, with a slight tendency to have higher results in summer and spring. From November on, the high values observed may be linked to the changes introduced by the rainstorm, since it increased from less than 0,5 to 1,16 mg C • mg Chl^{-1} • h^{-1} • (μE • m^{-2} • s^{-1})$^{-1}$, Table 2.

As it could be appreciated in Fig. 3, maximum PP (Pmax) was reached at low intensities. It did not respond to a seasonal pattern; also in autumn and winter, the values were very high, 221,0-307,8 mg C • m^{-3} • h^{-1}, Table 2. These results put in evidence, in comparison with those obtained by in situ incubations, the potential photosynthetic capacity under no limiting light conditions in this water body. Referring to assimilation numbers (Pmax • Chl^{-1}), they did not seem to follow seasonal fluctuations at all, Table 2. These numbers that ranged from 5,7 to 70,8 mg C • mg Chl^{-1} • h^{-1} were considerable higher respect to other examples cited by Margalef (1983).

Similar to the other variables, the storm event affected the values of Pmax after October, since data were lower than it was expected. Assimilation number, on the contrary, was higher suggesting an increase in algal activity in the same way as Popt • Chl^{-1} ratio did, Table 2.

The shape of the curves, illustrated in Fig 3, showed no photoinhibition even at high light intensities, 500 μE • m^{-2} • s^{-1}, in agreement with what was found by in situ incubations. The highest intensity employed, 2500 μE • m^{-2} • s^{-1}, only induced inhibition in August and October (in this month we also got slight inhibition at 500 μE • m^{-2} • s^{-1}). These results may suggest that suspended matter inside the bottle prevented algae from direct exposition to radiation and/or possible adaptation of the cells to high intensities.

DISCUSSION

In situ incubation data gave an annual primary production of 121,0 g C • m^{-2} • y^{-1}, which agrees, with the production expected in shallow and turbid waters like this pond. Suspended particulate matter is the main factor responsible of the vertical distribution of PP observed, because of the effect upon light penetration. Also upwelling of these sediments through turbulence, has to do with the nutrient supplying role in the water column (Golterman, 1975) and this fact contributes to the concentrations found which may not be considered as an important factor of control in photosynthesis. In connection with this phenomenon, despite the absence of zooplankton grazing data, resuspension of bottom sediments rich in Phe were probably responsible for the high contents of this and the low Chl • Phe^{-1} ratios, in accordance to what Moss (1970) found in shallow waters.

Other factors that may be involved in the PP magnitude are those related to hydrological phenomena, e.g. the rainstorm that induced several changes in the pond at the end of October. After this event Popt • Chl^{-1}, assimilation number and α , put in evidence a higher photosynthetic activity and efficiency. This fact may be related with the increasing of nitrate, orthophosphate, total phosphorus and humic substances entering the pond from the catchment area. As nutrients in this pond were generally high, we considered important to pay attention to humic substances. Since the increment of the latter was apparently recorded for the high molecular ones (Conzonno and Fernandez Cirelli, 1988) and as iron preferentially associates with this fraction of dissolved organic matter (Koenings, 1976; Koenings and Hooper, 1976), then, the increase of metal availability could have a probable stimulatory effect over PP, specially in case of eutrophic water body, like this, according to Francko (1986). Further studies are needed in order to evaluate how much these facts take part in the PP process in this pond.

Results obtained from artificial incubations, almost qualitatively, indicated their possible usefulness to follow the situations around PP under natural conditions. Also, these incubations, if always carried out in the same way in the course of time, may be used as a biological test to detect changes in the production of the pond, which is important taking into account present man's influence over it.

ACKNOWLEDGEMENTS

We are grateful to Lic. Rubén Iriart from the Estación Hidrobiológica de Chascomús and to Mr. José Ledesma and the rest of the members of the Club de Pesca y Remo de Chascomús for their invaluable assistance in field work. To Lic. María de las Nieves Rodríguez and Téc. Susana M. Ilhero for their help in chemical analyses. This study was supported by the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) and by the Comisión de Investigaciones Científicas de la Provincia de Buenos Aires (CIC).

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