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HUMIC SUBSTANCES AND PHYTOPLANKTON PRIMARY PRODUCTION IN CHASCOMUS POND (ARGENTINA). FACTS AND SPECULATIONS

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RESUMEN. Sustancias húmicas y producción primaria del fitoplancton en la laguna de Chascomús (Argentina). Hechos y especulaciones.
Durante un año, se estudiaron las fluctuaciones de las sustancias húmicas y la producción primaria del fitoplancton en la Laguna de Chascomús, en el cual, a causa de lluvias intensas, se produjeron cambios importantes en las características físicas, químicas y biológicas. Como consecuencia, se observó un aumento de la concentración de sustancias húmicas de alto peso molecular provenientes de la cuenca de drenaje, al igual que un incremento significativo de la actividad y eficiencia de la producción primaria del fitoplancton. Se discute la relación entre estos dos hechos en términos de la influencia de las sustancias húmicas en el proceso fotosintético.

ABSTRACT. Fluctuations of humic substances and phytoplankton primary production in Chascomús Pond were studied in a one year period, in which a heavy rainfall promoted important changes in physical, chemical and biological characteristics of the pond. As a consequence, an increase of humic substances of high molecular weight coming from the drainage basin was observed, as well as a significative increment of activity and efficiency of the phytoplankton primary production. A relation between these two facts is discussed in terms of the influence of humic substances on the photosynthetic process.

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INTRODUCTION

Relation between humic substances and phytoplankton primary production has been evidenced in several studies (Prakash and Rashid, 1968; Prakash *et al.* 1973; Prakash *et al.*, 1975; Stewart and Wetzel, 1982), which may be summarized by the following facts:

- Humic substances influence the magnitude of the phytoplankton primary production. They stimulate it within a certain concentration and beyond it they promote inhibition.

- This influence depends on the molecular weight of the humic substances.

- The extent of this influence depends on the species of the algal community present in the water body.

Hypotheses arising around these results are the following:

- Chelation of metal ions produces diminution of the toxicity and increase the availability of trace metals. This is in accord with the fact that a high concentration of humic substances inhibits algal growth, since an excess of chelator should make essential ions unavailable for algae.

- Humic substances may act as specific sensitizing agents enhancing the permeability of the plant cell membrane and thus increasing the uptake of nutrients from the surrounding medium.

- Flexibility of humic substances molecules under electrical fields has been proved on the basis of electrophoretic studies (Münster, 1985). This property may enable humic substances to act as intermediate carriers for nutrients, metal ion species and organic substrates in the electric double layer of the cell surfaces of aquatic microorganisms.

- In many lakes, planktonic primary productivity is limited by and linked to the availability and cycling of phosphorus. Humic substances may sequester organic phosphorus and render phosphate available only through enzymatic hydrolysis. Because of this, a biotic equilibrium can be established only after the increase of alkaline phosphatase activity that allows more phosphorus to become available by the microflora.

In the present paper, we try to relate the fluctuations of humic substances concentration with phytoplankton primary production in Chascomús Pond (35° 36' S, 58° W). In previous reports (Conzonno and Claverie, 1987/8, Conzonno and Fernández Cirelli, 1988), we have studied the significative changes in chemical and biological features during a period of one year. In this period (January, 1984-January, 1985), a heavy rainfall, towards the end of October, promoted the diminution of salinity, the increase in depth and the entrance of humic substances from the catchment area. On the basis of these data we try to find a relation between the fluctuations in humic substances concentration and phytoplankton primary production.

Morphometric parameters as well as physical and chemical characteristics of the pond have been presented before (Conzonno and Claverie, 1987/8, 1990). Briefly, it is a shallow (maximun depth = 1.90 m, mean depth = 1.53 m, surface area = 30.1 km^2) eutrophic ecosystem (Tot-P = 0.25 mg/l; Tot-N = 1.56 mg/l), alkaline (pH = 8.6) and with high values of suspended particulate matter (112.8 mg/l).

MATERIAL AND METHODS

The study was performed over samples taken monthly in the centre of the pond.

Water temperature was measured in situ with a mercury thermometer. As the euphotic zone was nearly 0.5 meter depth because of the suspended particulate matter (Conzonno and Claverie, 1987/8), samples for chemical analysis were taken by means of 2 liter 0.5 meter length nonmetallic Van Dorn sampler placed at the subsurface in a vertical position in order to have representative samples of the photic layer. They were immediately filtered (0.2 μm pore size, Millipore) previous to analysis of chemical oxygen demand (Golterman, 1971), absorbance at 250 nm (1 cm path length Carl Zeiss PMQII) and absorbance at 365 nm (1 cm path length Metrolab RC 325). Chlorophyll a was determined spectrophotometrically according to Golterman (1971).

Primary production (PP) was determined by the oxygen method and the conversion to carbon was made considering a photosynthetic quotient of 1.2 (Strickland and Parsons, 1960).

The in situ PP was measured at 0.1; 0.2; 0.3; 0.4; 0.5; 0.7 and 1.0 meter depth. The incubation period varied 4-5 hours and daily PP (Pd, mg $C/m^2.d$) was calculated by integration of the vertical production, using a suitable factor for light. Optimun rate of PP per hour (Popt) was evaluated by dividing the maximun value in the water column by the length of daylight.

Light photosynthesis curve was obtained in the laboratory, with bottles containing the sample taken by the Van Dorn sampler incubated in a light gradient from 0 up to 2500 $\mu E\ m^{-2}\ s^{-1}$. The curve was used to evaluate the maximun PP (Pmax), that it is to say the primary production under no limiting light conditions, and the photosynthetic efficiency (α), which is the initial slope of the curve normalized to chlorophyll a according to Platt and Jassby (1976).

RESULTS AND DISCUSSION

Water temperature, which is one of the main factors that influence primary production, was between 7.0°C in winter and 28°C in summer (figure 1 A). As it could be appreciated in figure 1 B, Pd as well as Popt followed a seasonal pattern until the occurrence of the heavy rainfall during October already mentioned. The excess of water, because of this major rain event, produced the export of algal biomass which is reflected in the decrease of the chlorophyll a concentration from values above 8 μg/l to about 2 μg/l (figure 1 A). As a consequence of the loss of algal biomass, Pd becoming lower, since the value obtained in November (76.7 mg $C/m^2.d$) is similar to the values belonging to the winter time (figure 1 B). The same occurred with Popt with a value of 49.9 mg $C/m^3.h$, which is of the same order expected for winter time (figure 1 B). Nevertheless, if we consider the relation between Popt and chlorophyll a concentration, it presented a significative increment from less than 7 mg C/mg chlorophyll a.h to 27.7 mg C/mg chlorophyll a.h, as it could be seen in figure 2 A. This fact indicated a considerable increase of the photosynthetic activity under the conditions established in the pond after the rainstorm.

From the light photosynthesis curve obtained by means of artificial incubations, we could get the maximun primary production. This parameter, which is analogous to Popt, changed from values above 200 mg $C/m^3.h$ to values of the order of 100 mg C/m^3.h from November on (figure 1B). In contrast, taking into account the assimilation number, which is the relation between maximun primary production and chlorophyll a, it showed a significant increment with values less than 20 mg C/mg chlorophyll a.h to 57.9 mg C/mg chlorophyll a.h in November (figure 2 A).

Another parameter that comes from the light photosyntesis curve is the photosynthetic efficiency (α). On figure 2 B, it could be appreciated that before the rainstorm the values were less than 0.5 mg C/mg chlorophyll a.h.μE m^{-2} s^{-1} and after that it reached 1.16 mg C/mg chlorophyll a.h.μE m^{-2} s^{-1}.

Therefore, after the changes introduced by the rainstorm and through Popt/chlorophyll a, assimilation number and α, a significant increment in photosynthetic activity and efficiency were observed. Since, there was an important input of nitrate and ortophosphate to the pond as a consequence of the rainfall (Conzonno and Claverie,

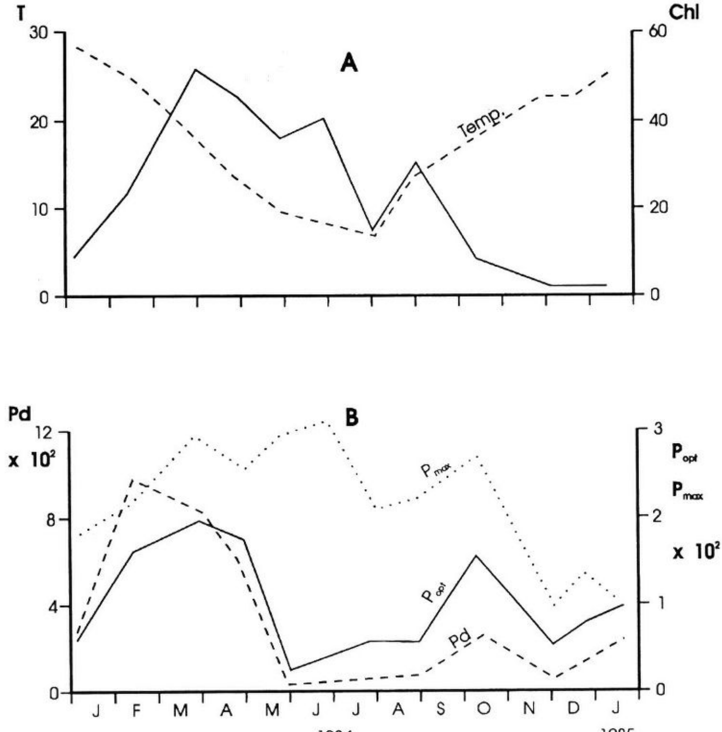

Fig. 1: Seasonal variations of: A: temperature, T (°C); Chlorophyll a, Chl (μg/l) —; B: daily primary production, Pd (mg C/m^2.d); optimun primary production, Popt (mg C/m^3.h); maximun primary production, Pmax (mg C/m^3.h).

1987/8), at first sight it is possible to think that this was the reason of the changes related to photosynthetic parameters already mentioned. But, as nutrients in this pond are normally high on account of its eutrophic state, we believe that it is neccesary to take into consideration the quantitative and qualitative changes in humic substances.

In figure 3 A, it is shown that the concentration of soluble organic matter, measured in terms of chemical oxygen demand, increased in November, since in this month the value obtained was 18.7 mg O_2/l and the mean between January and October was 12.6 mg O_2/l. This result may be associated to the import of humic substances from the drainage basin after the rainstorm. Similar observations may be made for the absorbance at 365 nm (A_{365}), where in November the absorbance was 0.146 and the mean before this month was 0.047 (figure 3 B). The contrary was observed for the absorbance at 250 nm (A_{250}), that tended to diminish in November in

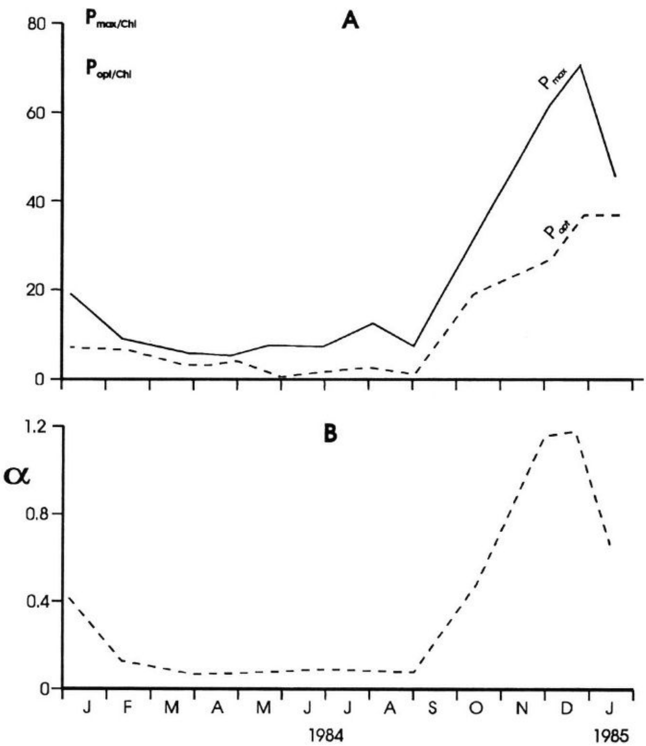

Figure 2: Seasonal variations of: A: optimun primary production/chlorophyll a, Popt/Chl (mg C/mg chlorophyll a.h); Maximun primary production/chlorophyll a, Pmax/Chl (mg C/mg chlorophyll a.h); B: photosynthetic efficiency, α (mg C/mg chlorophyll a.h.μE m^{-2} s^{-1}).

comparison to October, as it could be seen in figure 3 B. Nevertheless, taking into consideration the value 0.414 measured in November, it was slightly higher than the mean of the rest of the months which was 0.353. These two wavelengths are commonly used for humic substances determination (De Haan *et al.* 1982) and the relation between them, A_{250}/A_{365}, has been associated to the molecular weight (De Haan, 1972; De Haan and De Boer, 1987). This relation decreases as the molecular weight of humic substances becomes higher be-

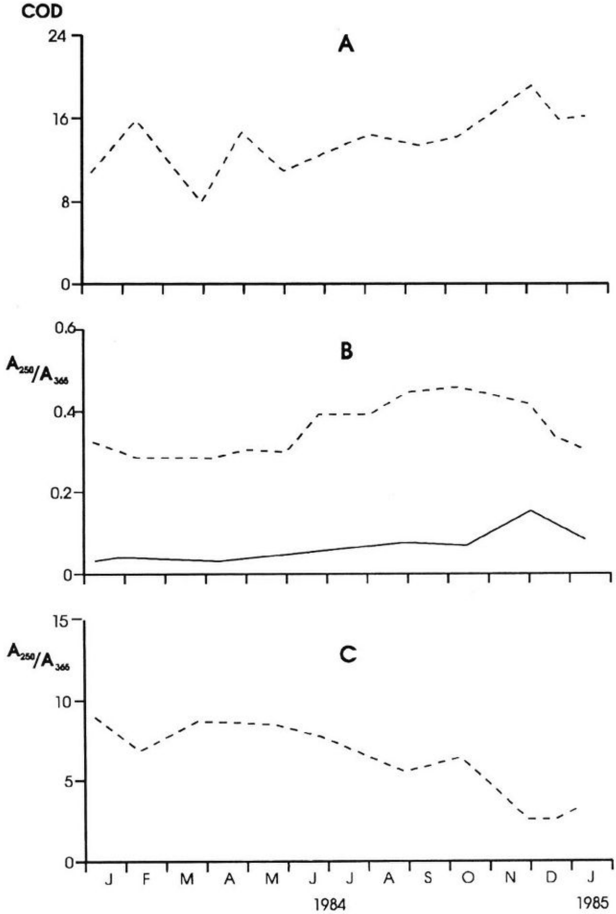

Figure 3: Seasonal variations of: A: chemical oxygen demand, COD (mg O_2/l); B: absorbance at 250 nm, A_{250}; absorbance at 365 nm, A_{365}; C: relation A_{250}/A_{365}.

cause the absorbance per unit carbon decreases at 250 nm (Stewart and Wetzel, 1981). In a previous report, we have discussed the utility of this relation in connection with the humic substances characteristics of this pond (Conzonno and Fernández Cirelli, 1988). Comparatively, the relation was high before November, which means that the molecular weight of the humic substances present in that period was low (figure 3 C). This fact may be explained taking into account the formation of calcium carbonate that produces coprecipitation of humic substances in particular with the larger ones (Stewart and Wetzel, 1981). Our studies in this pond (Conzonno and Fernández Cirelli, 1995), showed a selective loss or removal of humic substances of high molecular weight because of the presence of calcium carbonate. After the rainstorm the pH decreased and consequently the calcium carbonate disappeared, with the result that the input of humic substances of higher molecular weight coming from the drainage basin could persist as soluble organic matter. This fact was evident through the values of the relation A_{250}/A_{365} up to the end of the studied period, as it could be appreciated in figure 3 C. Then, this reflects mainly qualitative changes of humic substances present in the pond.

According to the hypothesis mentioned in the introduction, it is possible that under the new conditions established in the pond after the rainstorm, humic substances may have something to do in the improvement of the photosynthetic activity and efficiency observed, through a direct and/or indirect stimulatory effect on the algal commnunity. Further studies are needed which may involve incubations under control conditions to establish the influence of humic substances in the primary production of this pond and on other ponds of the Pampas that contain humic substances in their chemical composition.

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