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Seasonal dynamics of a large, shallow lake, laguna Chascomús: The role of light limitation and other physical variables

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Abstract

The most conspicuous waterbodies in the Pampa region of Argentina are the so-called "lagunas". A typical Pampean laguna may be described as a relatively large (100 + ha), permanent, shallow lake. Here, we report the dynamics of laguna Chascomús, sampled weekly, from April 2001 to June 2003. During the period, the lakes experienced three consecutive floods waves that affected the concentration of major ions and the optical signature of the dissolved organic matter. Despite these hydrological alterations, laguna Chascomús was permanently limited by light. Transparency was to a great extent controlled by the incident photosynthetic available radiation irradiance. We hypothesize that wind contributes to the permanent mixing of the lake, as well as to lessen the sedimentation losses of photoautotrophs.

Keywords: Light limitation; Shallow lake; Nutrients; Transparency; Floods

Introduction

The most conspicuous waterbodies in the Pampa region of Argentina are the so-called "lagunas". A typical Pampean laguna may be described as a relatively large (100 + ha), permanent, shallow lake. Shallow lakes often alternate between two possible states: a turbid state, in which production is dominated by phytoplankton, and a vegetated, relatively clearer state, in which production is dominated by rooted vegetation (Scheffer, 1998; Scheffer, Hosper, Meijer, Moss, & Jeppesen, 1993). A third type of laguna has been described in the Pampa region by Quirós et al. (2002). This third type corresponds to turbid lakes, in which turbidity is mostly due to inorganic suspended material. Based on the chronicles of XIX travelers, it has been suggested that, before the settlement of Europeans and their descendants, most Pampa lagunas occurred in a vegetated state (Quirós, 1995, 1998; Quirós, Rennella, Boveri, Rosso, & Sosnovsky, 2002). However, because of their occurrence in fertile lands, these already eutrophic lakes (Quirós & Drago, 1999) have experienced increased levels of eutrophication in recent times, and many of them have switched to a turbid state. Once in a turbid state, the lake morphometry, the general flatness of the terrain, and the persistence and strength of winds combine to favor water mixing and to prevent stable stratification (Quirós & Drago, 1999), which purportedly act as stabilizing factors of the turbid state.

Shallow lakes in the Pampa region have long been impacted by human activities, including agriculture, urban and industrial discharges, and the emplacement of

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flood control structures. In addition, there is already evidence that the area is experiencing large-scale change in climate, such as elevated temperatures, higher precipitation and increased frequency of floods and droughts events. This study describes some aspects of the dynamics of three lakes occurring in the north-eastern part of Buenos Aires Province (Argentina), a region usually termed "Pampa deprimida" (low grassland). The three lakes belong to an extended watershed, customarily referred to as "lagunas encadenadas del Salado". Presently, all lakes within the watershed are in a turbid state. Here, we present the results of a 2-year study, during which we had the opportunity of documenting three salient aspects: (i) the consequences of flood events, (ii) the spatial heterogeneity within and between lakes and (iii) the seasonal variability of laguna Chascomús.

Materials and methods

Study area

The Pampa region of Argentina harbors a large number of shallow lakes of varied size. This study deals with lakes occurring in the "Pampa deprimida" in northeastern Buenos Aires (Argentina). The climate in this region is temperate, with warm summers and mild winters. Mean annual temperature is 15.3 °C. The average precipitation for the whole area is about 800 mm $year^{-1}$ (Quirós, & Drago, 1999), but in the vicinity of laguna Chascomús, it reaches about 1055 mm $year^{-1}$ (unpublished data). Winds blow with a mean annual speed of 10.1 km h^{-1} ($\pm$7.2), and during the study period, ranged from absolute calm to 122 km h^{-1}. The landscape lacks major geographic features and is characterized by a gentle slope (0.05% in average) (Dangavs, Blasi, & Merlo, 1996). As regard to the ionic concentration, Pamapean lakes are typically dominated by sodium-bicarbonate (Fernández Cirelli, & Miretzky, 2002).

Laguna Chascomús belongs to a watershed customarily termed "lagunas encadenadas del río Salado" (i.e., the river Salado chained lakes). The watershed covers an area of about 801 km^2 (Dangavs et al., 1996). The system "lagunas encadenandas" includes seven lakes: Vitel (1305 ha), Chascomús (3014 ha), Adela/Manantiales (2098 ha), del Burro (1070 ha), Tablilla (1674 ha), Chis-Chis (1481 ha) and Las Barrancas (885 ha). These lakes are interconnected by short streams, and ultimately drain into the Salado river (Fig. 1) (Fernández Cirelli & Miretzky, 2002). Under most circumstances, the water flows from its headwaters, upstream of laguna Vitel, thought the system of chained lakes, into the Salado river. However, because of the flatness of the landscape, floods originated in the upper the Salado river watershed may overflow and raise the water level at the point of discharge of Laguna Barrancas, causing a reversion of the normal flow, which may result in an ingression of river water into the "Encadenadas" (Chornomaz, Etchepare, Escaray, Bustingorry, & Conzonno, 2002; Maizels et al., 2003).

Our study was performed in three of the previously mentioned lakes, namely Vitel (35°31′S, 58°07′W), Chascomús (35°36′S, 58°02′W) and Adela (35°40′S, 58°00′W). These three lakes are shallow (Vitel Z_{mean}: 1.17 m. Chascomús Z_{mean}: 1.53 m, and Adela Z_{mean}: 1.24 m) (Dangavs, 1976) and, at least during the study period, they were predominantly devoid of macrophytes. All the previous characteristics: large surfaces, shallow depths, strong and persistent winds, flat landscape, and absence of rooted plants favor a state of continual mixing and lack of stratification.

Measurements and sampling collection

Laguna Chascomús was sampled weekly from April 2001 to June 2003, at three sampling sites (see Fig. 1). Sites 1 and 3 were visited during the whole study, but sampling of site 2 was discontinued after October 2002. The other two lakes, Vitel and Adela were sampled starting on November 2002. Conductance (Hach conductimeter), pH (Orion pH meter), temperature and Secchi disk transparency were measured "in situ" at each sampling site. In addition, water samples were collected directly from about 30 cm below the surface for chemical determination of major ions and nutrients.

Major ions were measured on filtered (Whatman 0.45 μm) water samples as follows: bicarbonate (HCO_3^-) and carbonate (CO_3^{-2}) by acid titration, using successively heliantine and phenolphthalein as endpoints; calcium (Ca^{+2}) and magnesium (Mg^{+2}) by EDTA titration; sodium (Na^+) and potassium (K^+) were measured by flame photometry (Ciemar JMG-1); chloride (Cl^-) was measured by silver nitrate ($AgNO_3$) titration, using potassium chromate solution (K_2CrO_4) as indicator; sulfate (SO_4^{-2}) by precipitation titration with $BaCl_2$ (turbidimetry). All these determinations were performed according to APHA (1992).

Total phosphorous (TP) was measured by acid digestion with persulfate; Soluble reactive phosphorus (SRP) by molybdate-ascorbic method; total nitrogen (TN) was considered as the sum of nitrates, nitrites, ammonia and organic nitrogen. Nitrates were reduced to nitrites using a cadmium column. Nitrites were analyzed by diazotization. Organic nitrogen was determined by Kjeldahl method (APHA, 1992). Ammonia was determined by formation of indophenol blue and read at 630 nm (Hitachi U-2000 Spectrophotometer) (Mackereth, Heron, & Talling, 1978).