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Bacterioplankton and phytoplankton production in seven lakes in the Middle Rio Doce basin, south-east Brazil

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Abstract

The purpose of this study was to measure the phytoplankton production (PP) and bacterial production (BP) simultaneously in seven lakes in the middle Rio Doce basin (southeast Brazil) during the dry and the rainy seasons. Limnological monitoring was conducted from 1999 to 2001 as well as both PP (radioactive carbon fixation) and BP (^{3}H-Leucine incorporation) in four specific depths (100%, 10%, 1% of incident radiation, and aphotic zone). Furthermore, trophic state of the lakes was analyzed, considering the index proposed by Salas and Martino (1991) and Carlson (1977). In general, some parameters increased during the rainy season such as pH, conductivity, chlorophyll and total nitrogen. In the period of 1999/2000, the rain caused PP reduction in the lakes, excepting Carioca and Águas Claras Lake, but in the years 2000/2001, the lakes did not show a similar pattern. In contrast, the rainy season of both years caused an expressive bacterioplankton production enhancing. Using Salas and Martino index, we observed that some lakes were affected by the seasonal runoff, therefore the typologie of these lakes changed from oligotrophic to mesotrophic conditions, otherwise considering the Carlson index all lakes were classified as eutrophic in both dry and rainy seasons. Indeed, Salas and Martino index demonstrated to be more appropriate to determine the trophic status of the lakes. Finally, our data indicate that until now, in spite of the lakes location, protected and unprotected area, the lakes still maintain their natural characteristics.

Keywords: Lakes; Trophic state; Phytoplankton; Bacterioplankton; Primary production; Bacterial secondary production

Introduction

The study of trophic interactions between bacterioplankton and phytoplankton as well as the relations between these communities and the abiotic matrix has experienced considerable progress with the studies conducted by Pomeroy (1974) and Azam et al. (1983). Afterwards, some studies have indicated an existence of a coupling between bacteria and phytoplankton (Cole et al., 1988; Lind et al., 1997; Ochs et al., 1995), since algal carbon exudate might be the principal source for bacterial production. Nevertheless, bacterioplankton

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community also utilizes a considerable part of the dissolved organic carbon (DOC) available within aquatic ecosystems, besides absorbing inorganic nutrients thus competing with phytoplankton community (Hobbie, 1988). In addition, the importance of terrigenous carbon (Cole & Pace, 1994; Wetzel, 1995; Jonsson et al., 2001; Biddanda & Cotner, 2002; Pålsson et al., 2005) and aquatic macrophyte carbon have been reported (Rooney & Kalff, 2003; Huss & Wehr, 2004) to lake metabolism, which support secondary production. Indeed, the relative importance of each mechanism responsible for the regulation of bacterioplankton production (BP) within a lake (Kisand et al., 1998; Tammert et al., 2005).

Even now, studies focusing simultaneously on phytoplankton and bacteria remain scarce in tropical aquatic ecosystems (Carvalho et al., 2003) and there are questions in relation to the several and complex mechanisms which regulate functioning and diversity of planktonic and interactions between algae-bacteria communities (Le et al., 1994; di Sierve et al., 1995; Mariazzi et al., 1998; Reche et al., 1998). However, it is plausible to assume that nutrients concentration, mainly C, N and P, constitutes an important factor determining primary and secondary production in tropical lakes.

We have investigated the bacterioplankton production (BP) and phytoplankton production (PP) in protected and unprotected lakes, situated in the middle Rio Doce basin (southeast Brazil). We have considered that PP varies seasonally (dry and rainy seasons), as well as BP, resulting in changes of BP/PP ratio. Lower temperatures and the higher input of allochthonous material during the rainy season might influence the autotrophic and the heterotrophic activities. The relationship between bacterioplankton and PP has not been investigated in the lakes of this area yet.

The initial knowledge of these lakes began in the decade of 70 and an important detailed description of the lake systems in the area could be found by Tundisi and Saijo (1997). Some of these lakes, about 40, are located inside the Rio Doce State Park (Minas Gerais State) and are included in one of the largest Brazilian freshwater systems which are composed by about 140 lakes. This area is biologically significant as a water source for human population and for biological diversity that represents a refuge for fauna and flora.

Limnological data were determined for the understanding of factors that controls the bacterioplankton/phytoplankton relationship. The trophic state of the lakes was analyzed considering the index proposed by Salas and Martino (1991) and Carlson (1977), in as much as typology is an important tool for lake management and the development of strategies for conservation and its implementation.

Studied area

This investigation was carried out in lakes of Rio Doce State Park (Parque Estadual do Rio Doce, PERD) and its surroundings, including areas exposed to different anthropogenic impacts (domestic and industrial effluents; cattle raising). The State Park is surrounding by large plantations of *Eucalyptus* spp. and degraded pastureland. The PERD was founded in 1944 and it is located in the middle stretch of the Rio Doce basin (southeast Brazil) with an area c. 36,000 ha (19°29′24″–19°48′18″S; 42°28′18″–42°38′30″W), and protects the largest remnant of the original Atlantic forest in the State of Minas Gerais (Fig. 1).

According to Köppen system (1936), the climate can be classified as tropical wet and dry (A_w), with a rain season in the summer and a dry season during the months of May, June, July and August. The annual mean precipitation and the annual mean temperature are about 1300 mm and 23 °C, respectively (CETEC, 1978).

About 40 lakes were found inside the PERD area which does not show any communication with the Doce River, covering about 9% of the State Park area (Petrucio and Barbosa, 2004), situated about 300 m above the sea level. The park limits are defined by Doce River and Piracicaba River on the east and north, respectively. The Timóteo and Mariliéria districts delineate the park extension on the west and by south through Dionísio district.

Ultisol, eutrustox and alfisols are the most representative kinds of soils found in the park area (Silva Jr. et al., 1995). The relief is dominated by soft contours, as hills and sedimentary flat valleys, with altitude varying from 230 to 515 m. About 21% of the area of the Park corresponds to flat relief, whereas, lightly and strongly undulated montains represent 39% and 34%, respectively (CETEC, 1982).

Two lakes were selected within the PERD (Dom Helvécio and Carioca) and five lakes in its surroundings (Amarela, Águas Claras, Barra, Jacaré, and Palmeirinha). Dom Helvécio Lake is the largest and deepest lake of the system (6.87 km^2; 32.5 m) open to tourism and offering fishing, swimming, and rowing. Carioca Lake (0.13 km^2; 11.8 m) is not open to the public, exhibiting more preserved conditions. Among the lakes of the surroundings, Amarela Lake is the smallest and shallowest (0.11 km^2; 2.0 m) and colonized by a dense community of floating and submerged macrophytes. Águas Claras Lake is situated in an area of eucalyptus plantation, demonstrating low human impact and oligotrophic features. Palmeirinha Lake suffers direct influence of a charcoal plant and Barra Lake and Jacaré Lake, besides surrounded by eucalyptus plantations also holds fishing clubs, receive intermittent loads of untreated domestic sewage (Petrucio and Barbosa, 2004).