SHORT-TERM CHRONOSEQUENCE INDICATING LIGHT AND NUTRIENTS REGULATION OF PLANKTONIC PRODUCTION IN A TROPICAL SMALL DOWNSTREAM

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INTRODUCTION

It is well recognized that nutrients and light are limit aquatic primary production (Schindler 1978), while nutrients and organic matter limit aquatic respiration (Azam 1998). The difference between gross primary planktonic production (GPPP) and planktonic respiration (PR) is called net planktonic production (NPP). NPP may be positive, indicating net autotrophy, or negative indicating net heterotrophy.

Along the spatial and temporal scales, different ecological conditions contribute to change NPP in aquatic environments. Ecological studies often show logistic difficulties to assess not seasonal temporal changes (ecological succession). An alternative for these temporal studies is the chronosequence scale. A chronosequence represents a serie of sites varying in age since surface formation or catastrophic disturbance, but with all other extrinsic driving factors being relatively constant (Wardle et al. 2004). According to Emgtrom et al. (2000) ecological succession is a fundamental concept in Ecology that is still poorly understood in aquatic ecosystems.

Net PP may be modified by natural processes on a long-term scale. Human dynamics, usually change NPP regulating factors, usually caused by nutrient inputs and dredging. Dredging is a catastrophic disturbance in aquatic ecosystems, whereas changes important ecological conditions (Lohrer & Wetz 2003).

HYPOTHESIS

A catastrophic disturbance (dredging) is followed by short-term changes in NPP of a tropical oligotrophic downstream. The NPP might be strongly heterotrophic right after the sediment re-suspension by dredging, more autotrophic after sedimentation (increase in light availability) of suspended solids, and more heterotrophic after reduction in nutrients availability due to biological consumption.

MATERIAL AND METHODS

The study area was the downstream of Imboassica River (22o 25' S e 42o 55' W), situated at the North coast of Rio de Janeiro State (Southeast of Brazil). We studied a longitudinal section of the Imboassica River downstream close to its mouth into Imboassica Lagoon. The natural status trophic of these ecosystems is oligotrophic. In May 2002, this fluvial section had not showed a superficial water column and had been densely colonized by emerged aquatic macrophytes (Typha domingensis Pers; Typhaceae). From June to September 2002, a dredging removed these aquatic macrophytes and peat sediments (5 m of height and 10 m of width). This dredging made this fluvial section to show a perennial water column, with depth of 0.9 m and absence of measurable water flow. This condition contributed to form a short-term aquatic chronosequence.

We studied a linear extension of 1200 m of the Imboassica River downstream. The dredge ran this section in 120 days with an average rate of 10 m d-1. Six sampling stations were simultaneity collected at September 1st 2002: St 02, St 15, St 30, St 60, St 90 and St 120. These stations represented different distances from dredge and 2, 15, 30, 60, 90 and 120 days after dredging as a chronosequence.

We estimated GPPP, PR and NPP from changes in oxygen concentrations by light-dark bottle method as Wetzel & Likens (2000). Water samples were collected for total nitrogen (N) and phosphorus (P) analysis (APHA, 1992). We assessed > 0.7 ƒÝm total suspended solids concentrations (TSS). Chlorophyll a concentrations was determined by ethanol extraction and aquatic macrophytes biomass by harvest method (APHA, 1992).

Data were log-transformed to obtain premises of parametric tests and submitted to one-way ANOVA test ($p<0.05$) and Tukey-Kramer post-test ($p<0.05$) using STATISTICA 6.0.

RESULTS AND DISCUSSION

The proximity to dredging in St 02 resulted in the highest nutrient (170.0 ƒÝmol L de N e 6.6 ƒÝmol L de P) and TSS (1000 mg L-1) concentrations (Tukey-Kramer, $p<0.05$). Nutrient and TSS concentrations were around 10 and 4 times higher in St 02 than other stations. The strong decrease in nutrient concentrations in more distant stations to the dredge may be often related to biological incorporation, sedimentation or chemical reduction (Saunders & Kalff 2001). The reduction on TSS concentrations in these stations may be mainly attributed to sedimentation, whereas this process is favored by a low flow (Biddanda & Cotner 2002).

The more eutrophic condition in St 02 also showed the most heterotrophic NPP (-8.1 mg O2 L-1d-1) in our study, conflicting the positive relationship between nutrient concentrations and autotrophic NPP (Biddanda et al. 2001). This result was attributed to the highest TSS concentrations in St 02. High TSS concentrations increases light attenuation in the water column, and contributes to reduce the aquatic autotrophic production (Schindler 1978). In contrast to St 02, the station situated in intermediate position to dredge (St 30) showed the most autotrophic NPP (3.1 mg O2 L-1d-1; Tukey-Kramer, $p<0.05$) and the highest chlorophyll-a concentrations (9.8 ƒÝg L-1; Tukey-Kramer, $p<0.05$). The lower light attenuation by intermediate TSS concentrations, absence of aquatic macrophytes shading, and intermediate nutrient availability favored autotrophic NPP in St 30. This result confirmed the classical positive relationship from nutrient and light availability to phytoplankton production. Despite the similar TSS and nutrient concentrations, St 60 showed a GPPP 50% lower than St 30. This result was related to colonization by floating aquatic macrophytes (Salvinea auriculata) in St 60 (around 300 g DW m-2), whereas this vegetation blocks light for aquatic primary production.

CONCLUSION

Our hypothesis was partially confirmed, whereas NPP did not turn more heterotrophic only due to nutrient lacking, but mainly due to light shortage after colonization by floating macrophytes. Changes in NPP at short-term period after a dredging in small tropical rivers may be significant. Tropical aquatic ecosystems with low flow may show three stages for planktonic production after a catastrophic disturbance (dredging): (i) NPP strongly heterotrophic, with high PR due to sediments and nutrients resuspension; (ii) NPP strongly autotrophic, with increase in GPPP due to high solar radiation, nutrients and organic matter availability; and (iii) NPP close to equilibrium due to reduction in GPPP and PR after decline in solar radiation and organic matter by aquatic macrophytes invasion.

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