Verh. Internat. Verein. Limnol.	26	2053–2055	Stuttgart, Mai 1998

Benthic macroinvertebrate community structure in an Amazonian lake impacted by bauxite tailings (Pará, Brazil)

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Introduction

Batata Lake had been subjected to tailings deposition from bauxite mining by the Mineração Rio do Norte S. A. Company over a ten year period (1979–1989). These tailings impacted about 30 % of the lake area with a clay rich in aluminum oxide, silicates and iron oxide (Esteves et al. 1994).

Benthic macroinvertebrate community structure has been largely used in biomonitoring studies on pollution in lake ecosystems, with the aim of identifying and quantifying ecological alterations (Schindler 1987, Rosenberg & Resh 1993). It was considered as one of the most important biological variables in Batata Lake (Callisto 1994).

The present study aims to investigate the importance of benthic macroinvertebrate community structure in Batata Lake, in order to assess its characteristics along a gradient of habitat degradation.

Study area

Batata lake is located between 1°25′–1°35′ S and 56°15′–56°25′ W, near Porto Trombetas in the Municipality of Oriximiná, State of Pará, Brazil. The lake is situated on the right bank of the Trombetas River, covering an area of 2,100 ha. Batata Lake is a clear water lake according to the classification of Sioli (1990). Three sampling stations were defined:

Station 1: natural area (distant from the area of bauxite effluent). Depth 8.25 m, sediment with total phosphate 70.0 ppm; total nitrogen 4,700 ppm; organic matter dry weight 23.8 % (Panosso1993). Silt (54 %) and sand (36 %) were the main sediment granulometric fractions (Callisto 1994).

Station 2: transition zone, showing some indications of the presence of tailings. Depth 9.5 m; sediment with total phosphate 5.0 ppm; total nitrogen 4,100 ppm; organic matter dry weight 19.0 % (Panosso 1993). Sand (57.0 %) and silt (33.0 %) were the main sediment granulometric fractions (Callisto 1993).

Station 3: area impacted by bauxite tailings. Depth 6.0 m, sediment with total phosphate 1.0 ppm; total nitrogen 400 ppm; organic matter dry weight 15.0 % (Panosso 1993). Clay (50.0 %) and silt (42.0 %) were the main sediment granulometric fractions (Callisto 1993).

Material and methods

Sampling was carried out during the high water periods of 1993 and 1994. The top 10 cm sediment was collected by using an 8 cm diameter corer. 30 samples were collected in stations 1 and 3, 20 samples in station 2. In the laboratory, sediment samples were washed through 1.0 and 0.5 mm-mesh sieves. Specimens were sorted and preserved in 70 % ethanol. The benthic macroinvertebrate community biomass was estimated by ash-free dry weight (AFDW) at 500 °C for two hours.

Results and discussion

The results for density and biomass of the main benthic macroinvertebrate groups are shown in Table 1. Higher densities were observed in 1994 (341 ind. to 575 m^2) than in 1993 (198 ind. to 214 m^2). Spatial variation of total organism occurred between the years. In 1993, similar densities were observed in stations 1 and 3, while in 1994 higher densities occurred in station 1 than in station 3 ($X^2 = 15.52$; $p < 0.001$). Using the same methodology, Callisto (1994) has investigated organism densities between 1990 and 1992. His data showed a pattern similar to the 1994 results, suggesting that 1993 might have been an atypical year for the system considered.

The highest density values observed at all sampling stations in 1993 were due mainly to Chaoboridae larvae (78, 124 and 107 ind/m^2, respectively). Conversely, in 1994 Ostracoda, Nematoda, Hydracarina, Calanoida, Decapoda, Cyclopoida and Cladocera were dominant (Table 1). It is clear from the AFDW data that higher density values correspond with high biomass values (Table 1). Station 1 showed a total biomass of 10.9 mg/m^2 and 96.4 mg/m^2 in 1993 and 1994, respectively. At station 2, the values obtained were 13.2 mg/m^2 (1993) and 124 mg/m^2 (1994). At station 3, we observed 38.7 mg/m^2 and 14.8 mg/m^2 during 1993 and 1994, respectively.

0368-0770/98/0026-2053 $ 0.75
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Table 1. Density (ind/m²), biomass (mg/m²) and biomass percentage results for the main groups of benthic macroinvertebrate community collected from station 1 (natural), 2 (transition) and 3 (impacted) in flood season in 1993 and 1994 (data in parenthesis) at Batata Lake. N. B. Ostracoda, Nematoda, Hydracarina, Calanoida, Decapoda and Cyclopoda were also found in the studied areas.

		Chironomidae	Chaoboridae	Olygochaeta	*Campsurus*	Other Taxa	Total
	Density	19	78	45	0	66	208
		(61)	(5)	(128)	(0)	(381)	(575)
Station 1	Biomass	2.6	4.6	3.6	0	0.1	10.9
		(26.8)	(2.1)	(15.44)	(0)	(22.6)	(96.4)
	Biomass %	23.9	42.2	33.0	0	0.9	100
		(27.8)	(2.2)	(46.5)	(0)	(23.5)	(100)
	Density	44	124	4	0	42	214
		(72)	(20)	(18)	(20)	(358)	(488)
Station 2	Biomass	1.8	6.1	0.5	0	2.3	10.7
		(57.3)	(11)	(15.4)	(23.0)	(17.3)	(124)
	Biomass %	27.8	51.0	3.6	0	17.6	100
		(46.1)	(8.9)	(12.5)	(18.5)	(14.0)	(100)
	Density	32	107	16	27	16	198
		(34)	(23)	(9)	(39)	(236)	(341)
Station 3	Biomass	1.75	2.7	0.13	33.6	0.51	38.7
		(1.7)	(2.7)	(0.2)	(9.7)	(0.5)	(14.8)
	Biomass %	4.5	6.9	0.4	86.8	1.4	100
		(11)	(18.3)	(1.2)	(66)	(3.5)	(100)

The groups that showed higher biomass at stations 1 and 2 were Chironomidae, Chaoboridae and Oligochaeta, while at station 3 *Campsurus* (Ephemeroptera) represented 66 % and 86.8 % of total biomass, respectively. *Campsurus* nymphs have been found only at stations 2 and 3 (sites with bauxite present), with about 50 % of their biomass constituted by inorganic material. Bauxite tailings represented almost all the material in the digestive tube of these animals.

Data showed differences in macroinvertebrate density and biomass among the three sampling stations. It is clear that *Campsurus* is the most significant component of the macroinvertebrate biomass in areas strongly influenced by bauxite tailings. These data demonstrate that impacted and natural areas are different with regard to organism density and biomass. The bauxite tailings impacted the benthic macroinvertebrate community in station 3, resulting in density reduction and biomass differences.

From 1990 to 1992, only Oligochaeta, larvae of Chironomidae and Chaoboridae and nymphs of Ephemeroptera were found in areas with high tailings deposition (Callisto 1994). Our results showed that besides those groups cited above, Nematoda, Ostracoda, Calanoida, Hydracarina and Decapoda were observed at the same station in 1993 and 1994.

Our research stresses the need for long term biomonitoring studies of the benthic macroinvertebrate community of Batata Lake. Besides, we stress the relevance of biomass determination of macroinvertebrates less than 0.5 mm in size to further our knowledge of the dynamics of the benthic community of Batata Lake areas impacted by bauxite tailings.

Acknowledgements

This work was funded by Mineração Rio do Norte S. A. We thank MSc. A. Furtado, MSc. R. Barbieri, MSc. P. Peres and Dr. D. H. Landers for reviewing the manuscript and for their useful comments.

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