Oligochaeta in eutrophic reservoir: the case of Salto Grande reservoir and their main affluent (Americana, São Paulo, Brazil).

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ABSTRACT: Oligochaeta in eutrophic reservoir: the case of Salto Grande reservoir and their main affluent (Americana, São Paulo, Brazil). The purpose of this work was to evaluate the composition and distribution of Oligochaeta on the sediment of Salto Grande reservoir and Atibaia River (Americana, São Paulo, Brazil), for the duration of 4 months (May, August and November/ 2000, and February/2001), at 13 sampling stations. Sediment samples were collected using an Ekman grab and washed using a 210-mm mesh net on field work. The laboratory samples were preserved in 4% formalin, afterwards, benthic invertebrates were sorted by hand and preserved in 70% ethanol. Additional samples were collected for analysis of grain size and organic matter content. The Taxa Richness, Shannon-Wiener Diversity and Oligochaeta Index of Sediment Bioindication (OISB) were determined. Three Families: Naididae (Dero sp, Pristina sp, Pristinella sp, and Slavina sp), Tubificidae (Limnodrillus hoffmeisteri and Branchiura sowerbyi) and Opistocystidae (Opistocysta funiculus) were found. High Taxa Richness (8 species) was observed on station 2L (littoral zone) in August, and the high diversity (1.46) were observed on station 3R (littoral zone) in November. In August, the OISB values presented bad or poor environment, except for station 2L, which showed favourable quality. Predominant grain sizes were fine sand, silt and clay with organic matter on sediments higher than 10%, except for the Atibaia River. Results point to an impacted environment that can cause adverse effects to aquatic biota, mainly on account of the input of inorganic (industrial) and organic pollution, which can contribute to the decrease of the abundance and number of species present in the system studied, as well as to the total absence of organisms in some station samplings.

Key-words: Sediment, eutrophication, Salto Grande reservoir, Atibaia River.

RESUMO: Oligochaeta em reservatório eutrofizado: o caso do reservatório de Salto Grande e de seu principal afluente (Americana, São Paulo, Brasil). O objetivo deste trabalho foi avaliar a composição e distribuição de Oligochaeta nos sedimentos do rio Atibaia e do reservatório de Salto Grande (Americana, São Paulo, Brasil), em 4 meses (Maio, Agosto e Novembro de 2000 e em Fevereiro de 2001) e em 13 estações de amostragem. O sedimento foi coletado usando uma draga de Ekman e lavado em campo com uma rede com malha de 210 mm. No laboratório, as amostras foram preservadas em formol 4% e depois das amostras triadas, os organismos foram preservados em álcool a 70%. Amostras adicionais foram coletadas para análise da Granulometria e do conteúdo de matéria orgânica. Os resultados foram expressos em Riqueza, Diversidade de Shannon-Wiener (H') e Índice de Oligochaeta como Bioindicador de Sedimentos (OISB). Três Famílias: Naididae (Dero sp, Pristina sp, Pristinella sp e Slavina sp), Tubificidae (Limnodrillus hoffmeisteri e Branchiura sowerbyi) e Opistocystidae (Opistocysta funiculus) foram encontradas. A maior Riqueza (8 espécies) foi observada na estação 2L (região de margem) em Agosto e a maior diversidade (1,46) foi observada na estação 3R (região de margem) em Novembro. Os valores do OISB indicam um ambiente de qualidade ruim ou pobre, exceto para a estação 2L em Agosto que foi considerada de boa qualidade. A porcentagem de matéria orgânica foi superior a 10%, exceto no rio Atibaia. As frações granulométricas predominantes foram areia fina, silte e argila. Os resultados indicam um ambiente impactado que pode causar efeitos adversos à

biota aquática. A poluição inorgânica (industrial) e orgânica podem contribuir para a diminuição na abundância e no número de espécies presentes, bem como na ausência total de organismos em algumas estações de amostragem.
Palavras-chave: Oligochaeta, eutrofização, reservatório de Salto Grande, rio Atibaia.

Introduction

Health evaluation or monitoring of an ecosystem through chemical analyses enables to have an idea about the quantity of substances and the system's quality in relation to contaminants. However, it does not show the adverse effects on the population or communities that are exposed to stressful conditions (Dornfeld et al., 2001). For this reason, the study of benthic macroinvertebrates has enormous importance on monitoring of freshwater quality. These organisms may live from several weeks to many years and directly depend on adequate habitat and water quality for survival. Macroinvertebrates can indicate pollution impacts from various sources (Mandaville, 2000).

Among benthic macroinvertebrates, oligochaetes have been studied as indicators of biologic quality of sediments and toxic effects caused by metals or other micropollutants on different watersheds (Prygiel et al., 2000).

Oligochaeta are quite common inhabitants in freshwater ecosystems and a number of these organisms are able to survive on low dissolved oxygen concentrations. They are routinely observed in organically polluted habitats (Mandavile, 2000) and the abundance of different species could be a fine indicator of the water quality (Alves & Lucca, 2000; Beier & Traunspurger, 2003). Some species of Tubifex and Limnodrillus, for example, are abundant in organically polluted waters, where the food resource is abundant and predators or competitors are non-existent. A pollutant may eliminated many macroinvertebrates, thus, those that remain would become abundant as a result of decrease competition (Myslinski & Ginsburg, 1977).

The purpose of this study was to evaluate the composition and distribution of the faunal Oligochaeta in the sediment of Salto Grande reservoir and Atibaia River, and to show the relationship with some of the abiotic characteristics.

Study Area

Both the reservoir and Atibaia River are located in Americana, SP (Piracicaba River Watershed), at an altitude of 530m. The reservoir has average depth of 8.00m and a maximum depth of 19.80m. Its length is 17 km and the maximum volume is 106 x 10^6m^3, with a mean retention time of 30 days (Espíndola et al., 2004). These systems contribute for the regional development by the water supply, mainly for industry and agriculture, and also serving as a receptor of residues produced by Paulínia and Campinas cities.

Material and methods

Sediment samples were collected in May, August, November 2000 and February 2001, at 12 sampling stations (Center-C, Right-R and Left-L) of the reservoir and one in the Atibaia River (Fig. 1). Sediments were collected with an Ekman grab (225.0 cm^2), subsequently. Three replicates were taken from each sampling station. Replicates were homogenized and samples were washed using a 210-mm mesh net in the field, being preserved in 4% formalin until sorted. After, the organisms were separated and preserved in 70% ethanol. Oligochaeta species identification was carried out using the Identification Key of Brinkhurst & Marchese (1991).

Additional samples were collected to analyze the sediment grain size (ABNT, 1968) and organic matter content (on furnace muffle at 550°C for 2 hours). In the field, dissolved oxygen close to the sediment (10.0 cm) was measured by a Horiba U-10 water-checker.

Taxa Richness, Shannon-Wiener Diversity Index (Savage, 2000) and Oligochaeta Index of Sediment Bioindication – OISB (Rosso et al., 1995, apud Prygiel et al., 2000) were computed. Pearson's correlation (STATISTICA for Windows, 4.3 StatSoft Inc., 1993) was used in order to show the relationships between grain size, organic matter, dissolved oxygen and depth against the genera densities observed.

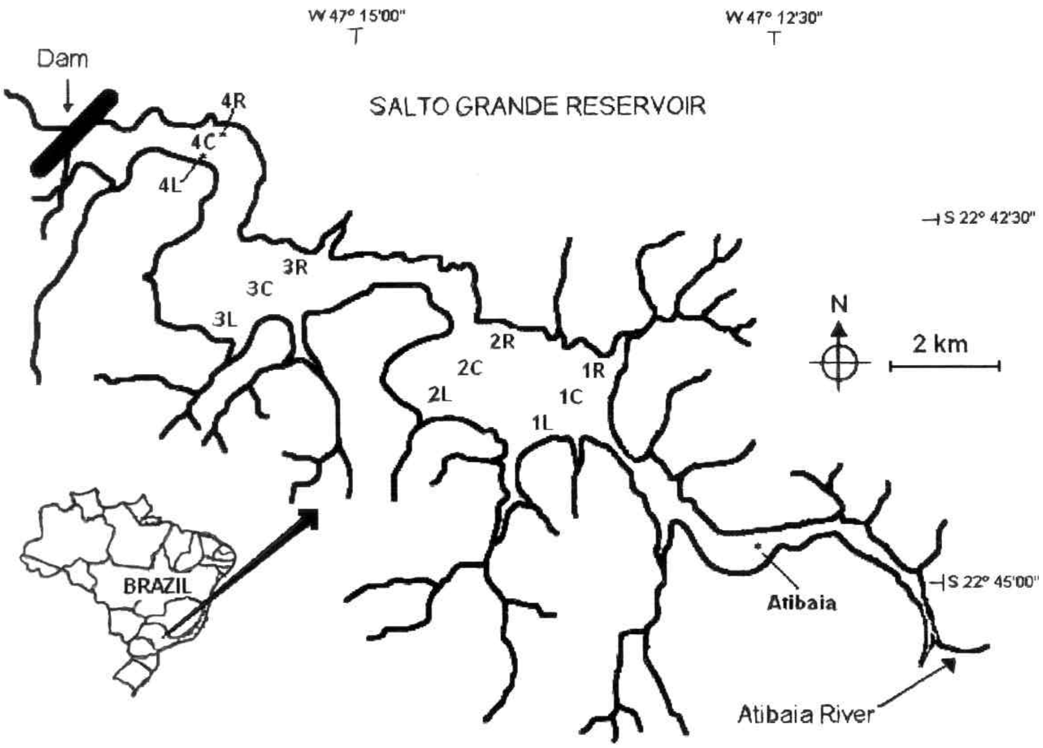

Figure 1: Location of sampling stations of the Atibaia River and Salto Grande reservoir (Americana, São Paulo, Brazil).

Results

Table I presents data on the depth and dissolved oxygen. The sampling station 4C presents the prominent depth (11.50 m in May) and total depletion of dissolved oxygen content in almost all months sampled. Dissolved oxygen concentrations had great seasonal variation, with higher concentrations on littoral zone (for ex. in station 3L, 7.12 and 8.10 $mg.L^{-1}$ in August and November, respectively). In February/2001, the Atibaia River showed the maximum dissolved oxygen concentration (5.80 $mg.L^{-1}$), probably resulting from the rainy season, that elevates the outflow values (58.27 $m^3.s^{-1}$, Dornfeld, 2002) causing a mixture on the water column, but in the other months, the dissolved oxygen concentration was below 3.0 $mg.L^{-1}$.

High percentage of silt + clay was found in the central stations (1C, 2C, 3C and 4C) and in the littoral zone, 1R and 1L (Tab. I). In the other sampling stations (Atibaia and littoral zone), high sand values and high organic matter contents were recorded in all months, with maximum values of 19% (2R) in August.

Table II shows the density of Oligochaeta during the study period. Limnodrilus hoffmeisteri was the more abundant species in the Atibaia River and 1C station during the sampling months. The higher density was observed in the Atibaia River in August with 40,711 ind/m^2, which represents 91.87% of the total Oligochaeta collected at this sampling station. Branchiura sowerbyi was distributed in almost all stations, except for the Atibaia River, found mainly in the littoral zone of the reservoir. Elevated density of B. sowerby was verified at 1C station (in November) with 8,711 ind/m^2, which represents 58.15% of the total Oligochaeta collected at 1C. Opistocysta funiculus was observed at stations 1C, 2R, 2L and 3R (May), 2L and 3C (August) and 3R (November), with a maximum density of 978 ind/m^2 at 2L station in August.

Naididae was represented for 4 genera (Dero sp., Pristina sp., Pristinella sp. and Slavina sp.). Pristina sp. presented the higher density, with 3,333 ind/m^2 in August in the Atibaia River, which represents 7.51 % of this sampling station. A pattern of distribution was not observed for this Family during the period studied, but in February a decrease of organisms in all sampling stations was observed, probably due to the inflow increase of the Atibaia River (rainy season).

Table I: Depth (m), dissolved oxygen content ($mg.L^{-1}$), percentage of sand (S), silt+clay (S+C) and organic matter (OM) in the Salto Grande reservoir and Atibaia River.

Sampling Stations	May					August					November					February				
	Depth	DO	S	S+C	OM	Depth	DO	S	S+C	OM	Depth	DO	S	S+C	OM	Depth	DO	S	S+C	OM
Atibaia	1.6	3.7	88	14	3	3.0	0	82	18	7	2.0	2.8	91	7	1	2.0	6.8	48	60	11
1C	6.0	2.0	46	60	13	7.0	0.4	3	68	14	6.9	0	64	43	13	4.0	2.6	47	48	16
1R	4.0	1.2	46	63	14	2.6	2.6	62	44	16	2.0	6.0	62	43	16	2.6	1.1	60	46	16
1L	6.4	1.3	16	80	14	3.6	0	38	67	14	2.6	0	43	61	13	2.0	2.6	26	69	16
2C	10.0	1.6	33	60	14	11.6	0	36	68	13	11.0	0	38	66	13	10.0	3.0	36	69	14
2R	3.0	3.1	66	39	14	3.0	4.6	67	40	19	1.6	6.8	74	26	16	2.0	1.3	73	24	18
2L	1.6	6.1	86	14	4	1.6	6.7	74	24	11	1.6	4.0	67	33	11	3.0	1.3	80	19	3
3C	10.0	0.4	61	46	16	9.0	2.0	42	64	16	7.0	4.7	69	38	16	8.6	1.0	66	43	16
3R	4.6	2.6	88	12	2	3.6	4.7	94	6	1	2.0	6.6	92	6	3	1.6	2.3	94	4	2
3L	1.0	3.6	70	12	6	1.0	7.1	94	6	1	1.0	8.1	94	6	1	4.6	2.2	77	21	18
4C	11.0	0.3	66	40	17	9.0	3.0	46	49	16	11.6	0	64	41	16	12.0	0	46	61	17
4R	1.6	2.0	74	12	2	2.0	6.6	94	7	2	2.0	6.4	93	6	6	2.0	1.6	94	6	2
4L	1.6	2.1	86	14	7	2.0	4.6	92	10	4	1.6	4.8	86	14	2	2.6	2.2	87	14	3

Table II: Oligochaeta density (ind/m²) during the study period.

Taxa		Sampling Stations												
		Atibaia	**1C**	**1R**	**1L**	**2C**	**2R**	**2L**	**3C**	**3R**	**3L**	**4C**	**4R**	**4L**
Dero (Aulophorus) sp.	May	89	311	444	133	-	844	89	-	-	44	-	44	-
	Aug	-	-	-	-	-	133	89	-	-	-	-	-	-
	Nov	-	-	-	-	-	89	-	-	-	44	-	-	-
	Feb	-	-	133	133	-	133	-	-	44	-	-	-	-
Dero (Dero) sp.	May	311	489	89	44	-	89	44	-	-	-	-	89	-
	Aug	-	-	44	-	-	133	89	89	-	-	44	-	-
	Nov	-	-	-	-	-	267	-	-	89	-	-	44	44
	Feb	-	-	44	178	-	-	-	-	-	-	-	-	-
Dero (?) sp.	May	-	-	-	-	-	-	-	-	-	-	-	-	-
	Aug	-	-	-	-	-	89	267	-	-	-	-	-	-
	Nov	-	-	-	-	-	711	-	-	-	-	-	-	-
	Feb	-	-	-	1,022	-	89	-	-	-	-	-	-	-
Pristina sp.	May	178	-	-	-	-	-	-	-	-	44	-	711	44
	Aug	3,333	-	-	-	-	-	2,622	-	-	-	-	133	44
	Nov	-	-	-	-	-	-	-	-	622	2,800	-	-	711
	Feb	-	-	-	-	-	-	-	-	-	-	-	-	-
Pristinella sp.	May	-	-	-	-	-	-	-	-	-	-	-	-	-
	Aug	267	-	-	-	-	44	3,022	-	-	-	-	44	-
	Nov	-	-	-	-	-	-	-	-	-	-	-	-	-
	Feb	-	-	-	-	-	-	-	-	-	-	-	-	-
Slavina sp.	May	-	-	-	-	-	44	-	-	-	-	-	-	-
	Aug	-	-	-	-	-	-	178	44	-	-	-	-	44
	Nov	-	-	-	-	-	-	-	-	-	44	-	-	-
	Feb	-	-	44	-	-	-	-	-	-	-	-	-	-
Opistocysta funiculus	May	-	267	-	-	-	133	44	-	44	-	-	-	-
	Aug	-	-	-	-	-	-	978	44	-	-	-	44	-
	Nov	-	-	-	-	-	-	-	-	311	-	-	-	-
	Feb	-	-	-	-	-	-	-	-	-	-	-	-	-
Branchiura sowerbyi	May	-	1,511	3,600	89	-	1,067	889	-	622	533	-	133	-
	Aug	-	-	-	-	-	-	267	533	44	-	-	133	-
	Nov	-	8,711	-	-	-	356	-	222	578	133	-	667	-
	Feb	-	3,556	133	-	-	44	44	44	-	44	-	44	89
Limnodrillus hoffmeisteri	May	667	1,467	2,178	222	-	1,778	3,911	-	978	222	-	-	89
	Aug	40,711	-	-	-	-	-	-	178	222	-	-	-	-
	Nov	21,822	6,267	-	-	-	-	-	-	356	-	-	-	44
	Feb	-	2,133	222	-	-	89	756	-	-	-	-	-	-

The higher diversity values were observed at stations 2D (in all months), 1C (May), 2E (August), 3D (November) and 1D (February). The higher Richness was obtained at the same sampling stations (Tab. III).

Oligochaeta Index of Sediment Bioindication (OISB), demonstrated that the system presents bad and poor quality in Atibaia River and Salto Grande reservoir, except for station 2E, in August (Fig. 2)

Pearsons' correlation did not show any relation ($p<0.05$) of Oligochaeta with the sediment grain size or organic matter content analyzed in any month. However, Persons' correlation showed a slight relation of L. hoffmeisteri with dissolved oxygen concentration (0.6), suggesting that dissolved oxygen content can increase the density of L. hoffmeisteri.

Table III: Shannon-Wiener Diversity Index (H') and Richness (R) of Oligochaeta fauna in the Atibaia River and Salto Grande reservoir.

Sampling Stations	May		August		November		February	
	H'	R	H'	R	H'	R	H'	R
Atibaia	1.14	4	0.30	3	0.00	1	0.00	0
1C	1.36	5	0.00	0	0.67	2	0.66	2
1D	0.93	4	0.00	1	0.00	0	1.43	5
1E	1.24	4	0.00	0	0.00	0	0.7	3
2C	0.00	0	0.00	0	0.00	0	0.00	0
2D	1.29	6	1.31	4	1.18	4	1.32	4
2E	0.65	5	1.42	8	0.00	0	0.21	2
3C	0.00	0	0.00	5	0.00	1	0.00	1
3D	0.77	3	0.45	2	1.46	5	0.00	1
3E	0.95	4	0.00	0	0.33	4	0.00	1
4C	0.00	0	0.00	1	0.00	0	0.00	0
4D	0.86	4	1.25	4	0.23	2	0.00	1
4E	0.63	2	0.69	2	0.42	3	0.00	1

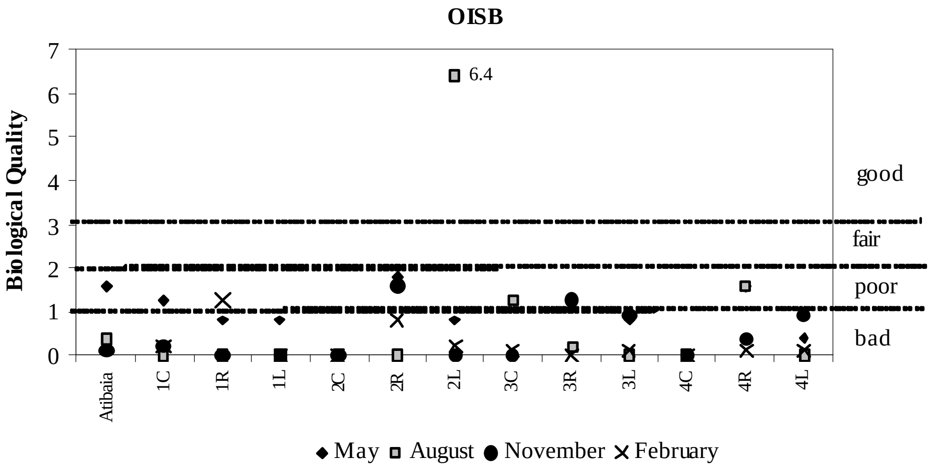

Figure 2: OIBS (Oligochaete Index of Sediment Bioindication) for Atibaia River and Salto Grande reservoir.

Discussion

Oligochaeta species of freshwater reside in all types of freshwater habitats, but they are most abundant in littoral zone, although various species live on profundal zone of the lakes. The abundance of different species could be used as a bioindication of water quality (Barnes, 1995).

Timm (1980) recorded the existence of 15 cosmopolites species, including Limnodrillus hoffemeisteri and Branchiura sowerbyi, which were also observed in this study.

Among the taxa observed, L. hoffmeisteri was the most cited one in studies around the world (Poddubnaya, 1980; Milbrink, 1980; Marchese, 1987; Alves & Strixino, 2000). This species occurs in different types of water bodies and trophic states on account of its ability to adjust to environmental changes, as dissolved oxygen and organic matter contents. The abundance of L. hoffmeisteri could be altered by environmental changes, such as temperature and organic matter that generate effects on the time, duration and intensity of the reproduction. This situation could cause change in the structure and productivity of the population (Poddubnaya, 1980).

On the profundal zone of eutrophic lakes, as Salto Grande reservoir, dissolved oxygen is a limiting factor to the majority of species, with pollution also reducing the number of species (Sauter & Güde, 1996). According to Wiederholm (1980), some tolerant species of Oligochaeta, like L. hoffmeisteri, can increase in abundance with relation to the Chironomidae under conditions of nutrient enrichment or specific pollution. Thus, when an increase of organic pollution occurs, increase in the abundance of Tubificidae (Milbrink, 1980; Brinkhurst &

Cook, 1974 apud Wetzel, 1993) is also observed. Dornfeld et al. (2005), observed a decrease in the number of Chironomidae in the Salto Grande reservoir and related this fact to the increase of eutrophication in this reservoir.

In the Salto Grande reservoir, a predominance of Tubificidae was also observed. Tubificidae also causes alteration in environmental conditions, thus actively contributing in some biochemical processes and modifying master parameters such as, Eh, pH, in addition to acting on the material flow through water-sediment interface throughout the borrowing behaviour, providing a linking to the oxidized and reductive regions in the system (McCall & Fisher, 1980). Predominance of Tubificidae occurs in sediments that have a wide variety of silt and clay contents, suggesting that the grain size holds little importance in its distribution (Sauter & Güde, 1996).

B. sowerbyi (Tubificidae) was also well represented in Salto Grande reservoir, and is a good bioindicator of warm and organically polluted water bodies (Sang, 1987). In August, lower water temperature was observed during the studied period, as well as a lower density of these organisms.

There was a more noticeable difference in the densities of Naididae, when compared with the study of Pamplin (1999), which found one taxa, Dero (Aulophorus) sp. This difference is probably related to the heterogeneous distribution and aggregation pattern of such organisms. Moreover, it is known that migration of these organisms in sediment is very slow and only certain species with swimming capabilities, as some Naididae, would be able to distribute more rapidly in the system (Timm, 1980).

On the profundal zone in the reservoir (stations 2C, 3C and 4C) we did not observe a high abundance of oligochaete, and there was no organism on station 2C during all study period. According to Newrkla & Wijegoonawardana (1987), decomposition occurs in the profundal zone, which can cause total depletion of dissolved oxygen in the sediments and is a limiting factor for organisms development.

Oligochaeta Index of Sediment Bioindication suggested that the Atibaia river and Salto Grande reservoir showed a bad to poor quality. Leite et al. (2004), showed that the reservoir was contaminated by metals (iron, chromium, copper and cadmium) from Atibaia River. Concentration of these metals was, in some cases, above the values established by CONAMA 357/05, for Class 2 rivers (Brazilian Legislation for Water Bodies). According to Mackie (1998 apud Mandaville, 2000) the values found for the diversity index could represent a polluted ($H' < 1$) or sub-polluted ($1 < H' < 3$) environment.

In conclusion, we found that inorganic (industrial) and organic pollution could be contributed for the lower number of individuals and genera/species, or for the total absence of organisms at some stations. The community had lower diversity and richness, with dominance of Tubificidae, which is a fine indicator of organic pollution.

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