Tripton sedimentation rates in the Salto Grande Reservoir (Americana, SP, Brazil): a methodological evaluation

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Resumo: Taxa de sedimentação do tripton no reservatório de Salto Grande (Americana-SP): uma avaliação metodológica. Para avaliar as variações nas taxas de sedimentação do tripton em câmaras com maior e menor suscetibilidade à ressuspensão, estudos foram desenvolvidos no reservatório de Salto Grande (Americana-SP), considerando-se o período seco (agosto e setembro/97) e chuvoso (dezembro/97). As amostragens foram realizadas em 4 estações de coleta distribuídas longitudinalmente no sentido rio-barragem, utilizando-se câmaras de sedimentação com razões altura/diâmetro de 3:1 e 10:1, as quais foram incubadas a 70% da profundidade de cada estação, durante 24 horas. Os resultados obtidos não demonstraram diferenças significativas em setembro/97 (C.V. <10%) em todas as estações e, embora nos outros meses as diferenças entre as câmaras também não tenham sido significativas (C.V. <10%), os resultados obtidos na estação de coleta 2 apresentaram um alto coeficiente de variação em agosto/97 (45,8%) e coeficiente de variação mais baixo em dezembro/97 (20,8%). No entanto, as análises estatísticas mostraram que não houve diferenças significativas (P < 0,05) entre as câmaras com razões altura/diâmetro 3:1 e 10:1 , mesmo com as variações ocorridas na estação de coleta 2, sendo que ambos os tipos podem ser utilizados nos estudos de sedimentação no reservatório de Salto Grande.

Palavras-chave: Câmaras de sedimentação, reservatório de Salto Grande, taxa de sedimentação, tripton.

Abstract: Tripton sedimentation rate in the Salto Grande reservoir (Americana, SP, Brazil): a methodological evaluation. Variations on the sedimentation rate of tripton in traps with greater and lesser susceptibility to resuspension were evaluated at the Salto Grande reservoir in Americana, SP, Brazil, during the dry season (August-September 1997) and the rainy season (December 1997). Samples were taken from four sampling stations distributed longitudinally in the river – dam direction, using sedimentation traps with height/diameter ratios of 3:1 and 10:1, which were incubated for 24 hours at 70% of the depth of each station. No significant differences among the four sampling stations were found in September 97 (C.V. <10%) and, although the differences found among the traps during the other months were insignificant (C.V. <10%), the data from sampling station 2 presented a high coefficient of variation in August 97 (45.8%) and a lowest variation coefficient in December 97 (20.8%). But, no significant differences (P < 0.05) between traps with height/diameter ratios 3:1 and 10:1 were obtained , even considering the variations at sampling station 2. Both traps could be used in the sedimentation studies at the Salto Grande reservoir.

Key words: Sedimentation traps, Salto Grande reservoir, sedimentation rate, tripton.

Introduction

Sedimentation is one of the most important physical processes in waters worldwide, as billions of tons of suspended matter are deposited in water bodies (Kozerski, 1994). This process derives from sediment, erosion and transportation by lotic ecosystems and a deposition of particles, although it is usually only called sedimentation when it involves silting up of reservoirs (Carvalho, 1994).

Due to the need for cost studies for rational water management, and in face of the impact caused by activities developed in hydrographic basins, research focusing on sedimentation has become common place in recent years (Zytkowicz, 1989). Among the various methods of analysis, sedimentation traps are important tools to evaluate the downward flow of particles through the water column (Rosa *et al.* 1991).

Sedimentation traps are simple tools that can be used for several purposes and are most commonly employed in the form of traps fixed to buoys and suspended in the water column (Hakanson *et al.*, 1989). According to Rosa *et al.* (1991), the most efficient traps for collecting particulate material include cylindrical models, whose efficiency ranges from 95 to 100%.

A variety of factors may influence the data. For instance, the diameter of a trap's opening may directly influence the quantity of material collected inside the cylinder and, according to Hakanson *et al.* (1989), the diameter should be over 4 cm. White & Wetzel (1973), evaluating the variations in trap with 4.82, 10.31 and 13.30 cm diameters, had shown that the variance of the collected material increased directly with increasing collecting area.

Blomqvist & Hakanson (1981), upon evaluating sedimentation using traps with diameters varying from 2.1 to 5.7 cm, verified that the adequate results (trapping efficiency) were obtained for heigth (H) / diameter (D) ratio ≥ 3. Hakanson *et al.* (1989) stated that cylinders should present a heigth/diameter ratio of over 3, and that this value should be increased to 6 in turbulent waters. According to Rosa *et al.* (1991), a trap to accurately determine the downward flow of particles in calm or turbulent waters should be at least 5:1 the H/D ratio.

A comparative study on spatial and seasonal variation of sedimentation rates using traps with two opening sizes (5 and 10 cm), with 10:1 and 3:1 heigth/diameter ratios was made.

Material and Methods

The experiment was carried out in August and September (dry season) and in December (rainy season), 1997, at four sampling stations in the Salto Grande reservoir (Fig. 1) in Americana, SP, Brazil (22°44'S and 44°15'W). The reservoir is classified as eutrophic, with a volume of 106×10^6 m^3, average retention time of 30 days, and its main tributary is the Atibaia river (annual average flow of 38.10 $m^3.s^{-1}$).

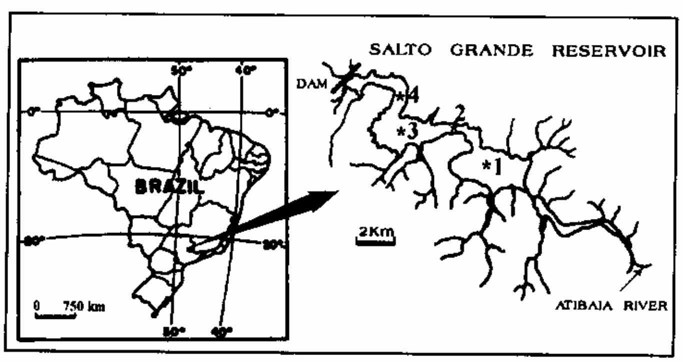

Figure 1: Salto Grande reservoir and sampling stations (*). (Modified from Lopes-Ferreira et al. 1998).

A set of four cylindrical sedimentation traps with 3:1 (Edmondson & Winberg , 1972) and 10:1 (Bloesch & Burns, 1980) height/diameter ratios with 30 cm length / 10 cm diameter and 50 cm length / 5 cm diameter respectively was used. The traps in PVC were placed in the water column at 70% of the total depth of each sampling station and were filled with distilled water before incubation to prevent the admission of material inside the traps (Henry & Maricato, 1996).

The sets with two types of traps were attached to buoys, fixed by anchors and incubated for 24 hours. After the sedimentation traps were removed, the content of each trap was mixed and filtered through Whatmann GF/C filters (0.45 µm). The amount of suspended material was determined according to Teixeira *et al.* (1965), modified by Wetzel & Likens (1991) and computed through:

$$SR = \frac{VxC}{AxT}$$

where: *SR* = Sedimentation rate; *V* = volume of the sedimentation traps (L); *C* = concentration of the material in suspension inside the traps ($mg.L^{-1}$); *A* = surface area of the sedimentation traps (cm^2); *T* = time (days).

A nonparametric statistical test (Kolmogorov-Smirnov) at $P < 0.05$ was used to compare sedimentation rates taking into account the type of trap and the dry or rainy season. For a qualitative comparison of data, the variation coefficients of the different types of traps were presented.

Results

In August 97, the sedimentation rates in both traps at sites 1, 3 and 4 were similar (close to 0.5 $mg.cm^{-2}.\ day^{-1}$), with a variation coefficient of less than 10% (Fig. 2). On station 2 an increase of the sedimentation rate in trap 3:1 ratio was detected, but in September 97, all the values found in both types of traps were homogeneous (C.V.< 10%).

Similarly to data of August, an increase in the sedimentation rate at station 2 was found in December 97, but it was observed in trap with 10:1 ratio, which reached 3.0 $mg.cm^{-2}.day^{-1}$, while in trap with 3:1 ratio the rate was 2.0 $mg.cm^{-2}.day^{-1}$. A less significant increase was also observed in the sedimentation rate in trap with 10:1 ratio at station 3 but with a low coefficient of variation (10.58%).

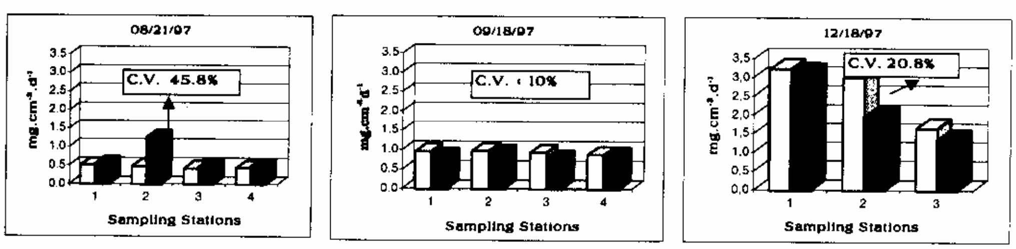

Figure 2: Sedimentation rates and variation coefficients in the 3:1 (■) and 10:1 (□) ratios traps from the sampling stations at the Salto Grande reservoir in August, September and December 1997.

No significant differences ($P < 0.05$) in the sedimentation rates between the 3:1 and 10:1 traps were found, even with the variation coefficient data obtained in August and December 97.

Discussion

The amount of collected material in August was higher in the traps with 3:1 ratio while the traps with 10:1 ratio retained more material in September and December. A very slight variation was detected among the traps, and thus the reduction on diameter of the trap openings leads to an increase in the amount of collected material. Similar observations were obtained by White & Wetzel (1973).

The low sedimentation rates (C.V. <10%) at 1, 3 and 4 sampling stations were due to the low amount of allochtonous material introduced in the reservoir during the dry season. In contrast, the sedimentation rates were higher during the period of greatest rainfall (December 97) than in August and September. The gradient on sedimentation rates from the Atibaia river toward the dam, indicates that the river is the main source of allochtonous material in the system (Fig. 3).

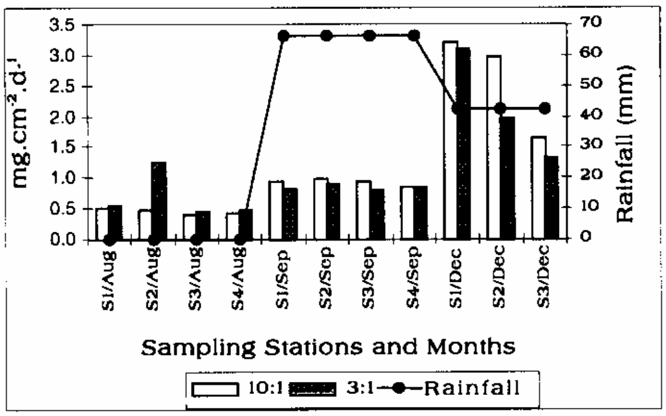

Figure 3: Relationships between monthly rainfall and sedimentation rates.

However, station 2 showed the greatest differences between sedimentation traps, with a high coefficient of variation in August (in the traps 3:1 ratio) and a low C.V. in December (in the traps 10:1 ratio). The differences may be attributed to several causes, among them, the detritus from the floating macrophytes, the wind action and the water flow. According to Rosa *et al.* (1991), the wind action and water flow are controlling factors that govern processes such as sediment transportation, deposition, erosion and resuspension.

An analysis of the thermal behavior and dissolved oxygen distribution over the 24-hour period revealed that a mixture in the water column led to a rupture of the thermocline at sampling station 2 (Fig. 4). The wind action at the shallow station (5 m), produced an increase on sedimentation rates.

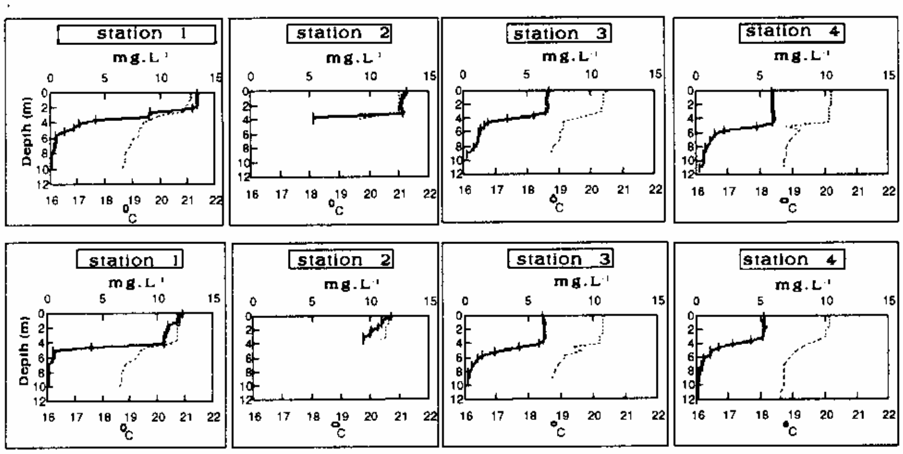

Figure 4: Profiles of dissolved oxygen (+) and temperature (...) at four stations, in August 1997.

However, Froelich *et al.* (1978) reported that strong winds are infrequent in the region of Salto Grande reservoir. Their influence appears to be insufficient to promote circulation in the water column.

Despite the wind velocity was higher in September than in August and December, no significant variations were found between the two types of traps, and the variation coefficients at all sampling stations were lower than 10%.

Another factor influencing the sedimentation rates in the 3:1 and 10:1 ratio traps at sampling station 2 is the daily inflow. However, the water inflow in August 97 was the same than in September 97, when no differences were found in the sedimentation rates. Only in December 97 an increase in the daily inflow (maximum of 22 $m^3.s^{-1}$) was detected. The wind and the water inflow, *per se* don't modify the sedimentation rates of the two types of traps (Fig. 5).

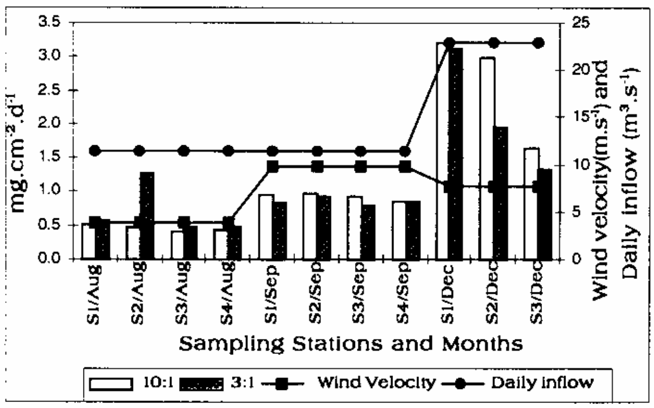

Figure 5: Relationship between sedimentation rates, water inflow and wind velocity in the dry and rainy seasons.

According to Evans (1994), wind exceeding 15 - 20 $km.h^{-1}$ is necessary to a significant resuspension in most aquatic systems. Winds with 13, 35 and 27 $km.h^{-1}$ velocities were recorded at the Salto Grande reservoir in August, September and December 97, respectively. The strongest velocities occurred in September, when no alterations in the sedimentation rates in the traps were found. For a resuspension of the bottom material did occur (as in December), it may have been caused by the combination wind and water inflow forces.

Gloor *et al.* (1994), on the other hand, pointed out that some modifications on sedimentation rates may also be associated with nepheloid layers (with high particulate matter concentrations at the bottom).

No significant differences ($P<0.05$) between the 3:1 and 10:1 ratio traps were found and therefore, both these trap sizes can be employed for the sedimentation studies at the Salto Grande reservoir.

Differences on the sedimentation rates of the two types of traps at station 2 (August and December 1997) were attributed to isolated factors such as wind or water inflow, which could lead to a resuspension of the bottom matter inside the traps. These differences may be related to the deposition of matter from floating aquatic macrophytes or to combined effect of wind, inflow and rainfall.

References

Bloesch, J. & Burns, N. M. 1980. A critical review of sedimentation trap technique. Schweiz. Z. Hydrol., 42: 15-55.

Blomqvist, S. & Hakanson, L. 1981. A review on sediment traps in aquatic environments. Arch. Hydrobiol., 91 : 101-132.

Carvalho, N. O. 1994. Hidrossedimentologia prática. Rio de Janeiro, CPRM. 372p.

Evans, R. D. 1994. Empirical evidence of the importance of sediment resuspension in lakes. Hydrobiologia, 284: 5-12.

Edmondson, W. T. & Winberg, G. G. 1972. A manual of methods for assessment of secondary produtivity in fresh waters. Oxford, Blackwell Scientific Publications. (IBP, 17).

Froehlich, C. G., Arcifa-Zago, M. S. & Carvalho, M. A. J. 1978. Temperature and oxygen stratification in Americana Reservoir, State of São Paulo, Brazil. Verh. Int. Verein. Limnol., 20: 1710-1719.

Gloor, M., Wüest, A. & Münnich, M. 1994. Benthic boundary mixing and resuspension induced by internal seiches. Hydrobiologia, 284: 59-68.

Henry, R. & Maricato, F. E. 1996. Sedimentation rates of tripton in Jurumirim Reservoir (São Paulo, Brazil). Limnologica, 26: 15-25.

Hakanson, L., Floderus, S. & Wallin, M. 1989. Sediment trap assemblages - a methodological description. Hydrobiologia, 176/177: 481-490.

Kozerski, H. P. 1994. Possibilities and limitations of sediment traps to measure sedimentation and resuspension. Hydrobiologia, 284: 93-100.

Lopes-Ferreira, C. M., Calijuri, M. C. & Espíndola, E. L. G. 1998. The role of a natural system in improving the quality of the Atibaia River's water (State of São Paulo). Proceedings - 6th International Conference on Wetland Systems for Water Pollution Control. Unesp, Rio Claro. p. 176-185.

Rosa, F. , Bloesch, J. & Rathke, D. E. 1991. Sampling the settling and suspended particulate matter (SPM). In: Mudroch, A., Macknight, S.D. (eds) Handbook of techniques for aquatic sediments samplin'g. Lewis Publications/ CRC-Press, Florida. p. 97-130.

Teixeira, C. , Tundisi, J.G. & Kutner, M.B. 1965. Plankton studies in a mangrove, II: The standing-stock and some ecological factors. Bol. Inst. Oceanogr., 24: 23-41.

White, W. S. & Wetzel, R.G. 1973. A modified sedimentation trap. Limnol. Oceanogr., 18: 986-988.

Wetzel, R.G. & Likens, G.E. 1991. Limnological analysis. 2 ed. Springer Verlag, New York. 391p.

Zytkowicz, R. 1989. Characteristics of tripton sedimentation in ten small lakes. In: Salánki, J. & Herodek, S. (eds.) Conservation and management of lakes, Akademiai Kiado, Budapest p. 547-552. (Symposia Biologica Hungarica, 38).