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New plate sediment traps for lentic systems

Damien BANAS and Gerard MASSON

Abstract:

A new type of sediment trap, which overcomes a methodological gap in the study of sedimentation fluxes in shallow lentic systems, is described. The sedimentation rates measured in the field with these new traps were compared with those from other plate and cylindrical traps. As do other plate traps, the new traps allow the resuspension of deposited particles observed on bottom sediments. Furthermore, the new traps do not disturb particle sedimentation on the collecting area and allow to collect the net sedimentation rates in lentic systems.

Key words: sediment trap, sedimentation, resuspension, shallow aquatic system.

Introduction

The gross sedimentation is the sum of the primary flux of new particles (autochthonously and allochthonously produced) and particles resuspended from the lake bottom which form the secondary flux (Evans & Håkanson 1992). According to Bloesch (1994), the most interesting methodological approach to quantify resuspension has been proposed by Flower (1991). He compared traps having aspect ratios (height/diameter) greater than five, which are the most accurate tools to estimate the total flux of sedimentation (Evans & Håkanson 1992, Rosa et al. 1994, Bloesch 1996), with traps having lower aspect ratios. Whereas the former traps measured gross sedimentation, the latter traps, allowing resuspension of deposited particles, yielded settling flux similar to that found in the bottom deposits, i.e., net sediment accumulation rates. Nevertheless, these two types of sediment traps cannot be used in shallow systems because of two major constraints. Cylindrical traps having high aspect ratios neglect a large part of the water column if they rest on the bottom in shallow water. This problem can be overcome using traps with receptacles buried in the sediments (Banas et al. 2002). On the other hand, the use of traps having lower aspect ratios can be criticised because of the loss of material during recovery. Kozerski & Leuschner (1999) proposed a solution with plate traps and the hydraulic lowering of the collecting area into a recess. When this plate trap is in collecting position, a cover kept (with three pins) in a parallel plane to the collecting area is located a few centimetres above it. During trap recovery, the collecting area and the cover are slowly lowered. Then, the collecting area is enclosed in the recess which is closed by the cover. However, in collecting position, the cover forms a roof above the collecting area and does not allow the collection of vertically-settling particles. Consequently, these traps may not be used in lentic systems. The aim of this paper is to present a new plate trap suitable to study ponds or lakes. This apparatus must:

- not disturb particle sedimentation on the collecting area;
- allow resuspension of deposited particles as observed on the bottom sediments;
- avoid loss of particles during recovery.

Material and methods

Design of the new plate traps

Traps are composed of a collecting area (PVC disc: $\text{Ø} = 153.5$ mm) surrounded by a margin (10 cm wide, 5 mm thick) which limits disturbance on the collecting area (Fig. 1). Collecting area and surrounding margin are fixed with three screws to a support disc. The design of these components is in agreement with optimal dimensions for the estimation of settling fluxes as determined by Kozerski & Leuschner (1999). The surrounding margin is separated from the collecting area by a small 3.3-mm gap in which a short PVC cylindrical ring (internal diameter 153.6 mm, thickness 3.2 mm, height 20mm) is placed. A 400-mm high and 165-mm diameter

polyethylene bag was made from an autoclave bag which was given the appropriate dimensions using a heatsealing apparatus. The top of this bag is glued to the bottom of the ring, and the bottom of the bag is glued to the support disc. In collecting configuration, the bag is folded under the collecting area. The tops of the surrounding margin, collecting area and ring are placed at the same level by adjusting that of the ring with four screws placed on the support disc. Total height of the new traps is 4.5 cm. In order to avoid the resuspension of bottom sediments during trap deployment and retrieval, the trap bottom is fixed to a horizontal support arm which can slide along a vertical guide firmly fixed in the sediments (Fig. 1). In order to recover the trap and settled sediment, the bag is unfolded by pulling three nylon threads fixed to the short cylinder top and attached to a float.

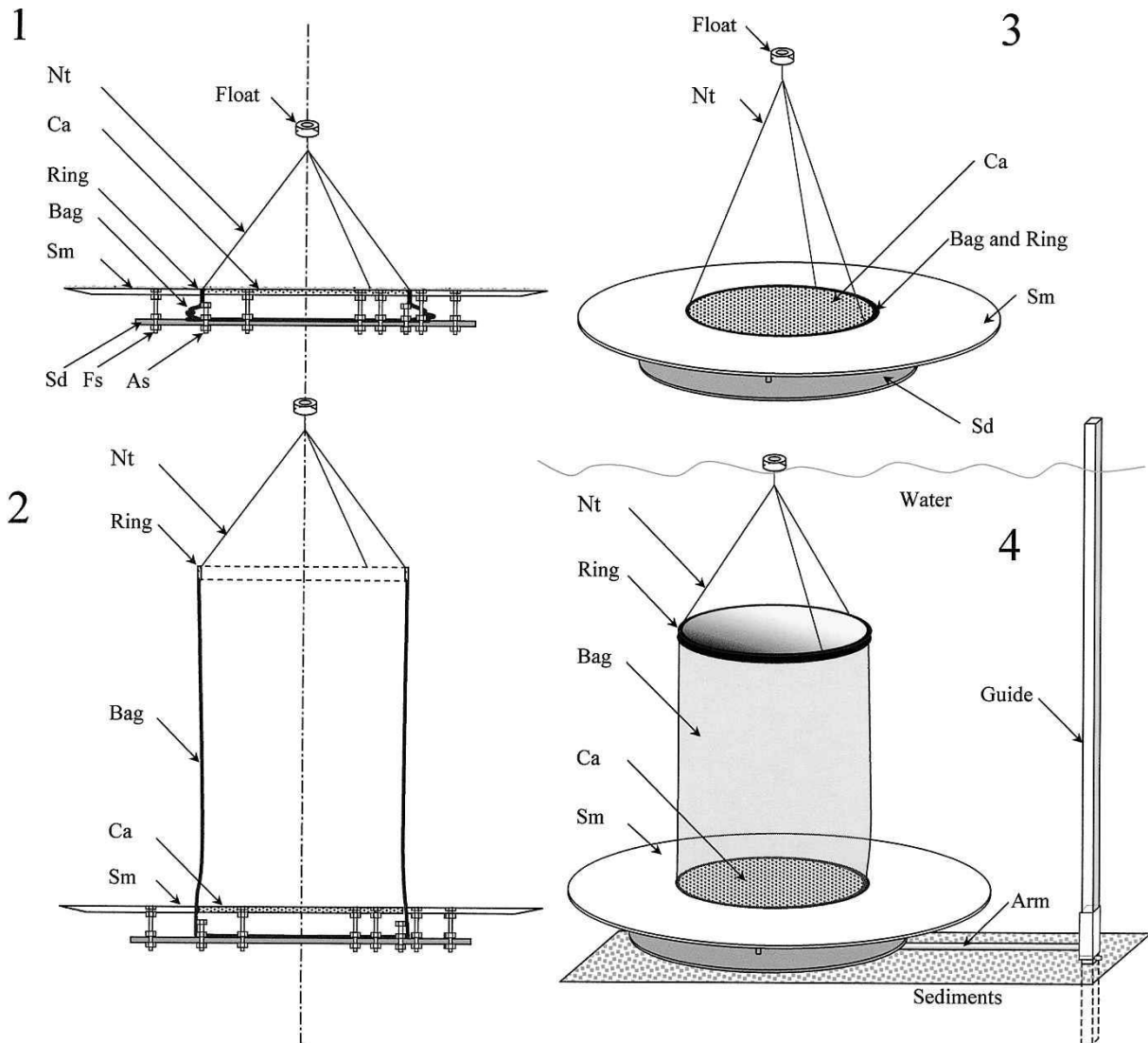


Fig. 1. New sediment traps (Type-3): 1; Side view when exposed. 2; Side view during recovery. 3; Aspect when exposed. 4; Aspect with guide and support arm during recovery. (Arm) Support arm, (As) Screws for adjusting Ring, (Bag) Polyethylene bag, (Ca) Collecting area, (Fs) Fixation screws, (Nt) Nylon® threads, (Sd) Support disc, (Ring) Cylindrical ring, and (Sm) Surrounding margin.

Tests in a pond

Sediment traps were tested in a pond with a surface area of 0.034 km² and a mean depth of 1.2m in North-Eastern France (Banas et al. 2002). In three experiments (February, April and May

2000), three cylindrical traps (“type-1 traps” buried in the sediments as those presented by Banas et al. 2002), three “type-2” plate traps (with a cover placed 3.3 cm above the collecting area as the traps presented by Kozerski & Leuschner 1999), and three new “type-3” plate traps, were exposed during one week in the pond. For better comparison, collecting areas of each type of traps were located about eight centimetres above the pond bottom, which was the lowest height for type-2 plate traps. Daily sedimentation rates were calculated as dry mass (DM) of sediment deposited on the collecting areas divided by the product of the collecting area and by days of exposure ($\text{gDMm}^{-2} \text{d}^{-1}$). Dry weight was measured by drying the sediments at 105°C for a minimum of 24 h. Organic Matter (OM) content was estimated by ignition at 525°C during 12 h. To highlight the difference in sedimentation rates obtained with each type of trap, mean trapping ratios were calculated as ratios of daily sedimentation rates between two types of traps. Wind speed was measured permanently by the “Météo-France” weather station located on the Metz-Nancy-Lorraine airport, 40 km from the study site.

Table 1. Mean sedimentation rates (\pm SD), organic matter content (OM \pm SD) of sediment collected by the three types of traps, and mean trapping ratios between types of traps. * Rates significantly different (t-test, $p < 0.05$) from those measured with the two other types of traps.

Experiment (2000)	Mean wind speed (km.h^{-1})	Sedimentation rates \pm SD in $\text{g/m}^2/\text{d}$ and (OM content in %)			Mean trapping ratios among types of traps		
		Type 1 Cylindrical traps	Type 2 Plate traps with cover	Type 3 New plate traps	Type 1 Type 2	Type 1 Type 3	Type 3 Type 2
Feb.	23	26.7 \pm 3.6* (15.2 \pm 0.8)	2.8 \pm 0.2 (14.8 \pm 0.7)	3.1 \pm 0.2 (15.1 \pm 0.8)	9.4	8.7	1.1
April	11	5.9 \pm 0.4* (17.3 \pm 3.6)	1.7 \pm 0.2* (16.2 \pm 2.0)	2.3 \pm 0.3* (16.9 \pm 2.9)	3.4	2.6	1.3
May	17	6.7 \pm 0.5* (22.1 \pm 3.1)	0.5 \pm 0.1* (16.3 \pm 1.1)*	1.5 \pm 0.2* (23.1 \pm 3.4)	15.0	4.5	3.2

Results

In February and May the winds were stronger than in April (Table 1). Sedimentation rates estimated with cylindrical traps were much higher (t test, $p < 0.05$) than those measured with the plate traps (Table 1). During the April and May experiments, sedimentation rates estimated with type-3 plate traps were significantly higher (t test, $p < 0.05$) than those measured with type-2 (covered) plate traps. OM contents of the sediments were not significantly different among the three types of traps except in May when particles collected by the type-2 plate traps were significantly less rich in OM (Table 1).

Discussion

The higher the resuspension, the greater were the trapping rates measured with cylindrical traps when compared to those measured with plate traps, as the former collect primary and secondary flux while the latter measure net sedimentation rate (Flower 1991, Bloesch 1995). High resuspension rates are generally observed in shallow aquatic systems (Golterman et al. 1976, Bloesch 1994). Differences in trapping rates observed during our study were presumably due to resuspension and were of the same order of magnitude as ratios observed by Gust & Kozerski (2000) on the River Spree (ratios of 1 to 30). The ratio between cylindrical traps and type-3 plate traps was greatest (8.7) in February and smallest (2.6) in April. Similar ratios were observed between cylindrical traps and type-2 plate traps (9.4 in February and 3.4 in April). These results confirm the high resuspension of bottom sediments induced by wind. However,

the ratio of trapping rates between cylindrical traps and type-3 plate traps was only 4.5 in May despite a high wind speed. This smaller difference than in February was probably due to growth of *Ranunculus circinatus* and *Potamogeton pectinatus* in May (Banas et al. 2002), which presumably inhibited sediment wind-induced resuspension (Barko & James 1998). The greatest ratio (15) between cylindrical traps and type-2 plate traps observed in May was due to low collection of particles by type-2 plate traps. Moreover, during this experiment, trapping rate was 3.2 times lower for type-2 than for type-3 plate traps. This difference can be explained by an underestimation of sedimentation by type-2 plate traps because of the cover which retains a part of the primary flux of sedimentation when horizontal translation of water is limited by submerged macrophytes. This hypothesis was confirmed by a significantly lower OM content of particles collected in May by type-2 plate traps which overlooked a part of the autochthonous sedimentation that is rich in OM (Table 1). The significant difference (Table 1) of sedimentation rates measured by the two types of plate traps in April confirms the underestimation of primary sedimentation flux by type-2 plate traps when wind speed and horizontal water flow are low.

Conclusions

Plate traps designed by Kozerski & Leuschner (1999) had opened new opportunities for measuring sedimentation in slowly flowing rivers and shallow aquatic systems where resuspension is high. However in lentic systems, low horizontal water translation velocity does not allow to use plate traps with an obstacle (i.e. cover) above the collecting area. The new plate traps with a polyethylene bag folded under the collecting area avoid interrupting the vertical sedimentation of particles and allow to collect complete primary sedimentation flux in these aquatic systems.

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