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# The Bottom Sampler – a new technique for sampling bed sediments in streams and lakes

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## Abstract

New, easy to use, liquid nitrogen-cooled equipment is described for sampling the upper layer (80–160 mm) of water sediment and associated benthic organisms in streams and lakes up to 1.2 m deep. The sediment sample has an area of 0.0531 $m^2$ and retains its natural composition and spatial structure. The two sampler components weigh 15 kg in total, which enables sampler use by hand, even in rural areas that are not readily accessible. A successful 2-year testing period in several first and second order streams demonstrated the suitability of the apparatus for sampling sediment textures ranging from fine clay to cobbles and current velocities up to 1 m $s^{-1}$.

## Introduction

Detritivore primary consumers are the basis of the main ecosystem energy pathway in streams and the benthic zones of lakes. Changes in detritus quantity and quality have a great influence on community composition and energy budgets, as predicted for streams by the River Continuum Concept (Vannote et al., 1980). Thus ‘processing of materials in stream channels and retention or export of residuals has been recognised as a basic property of streams and rivers’ (Fisher et al., 1998) and this is closely related to the sediment.

This knowledge has recently led to great interest in the investigation of the benthic zone. Studies of this kind, as well as studies of environmental pollution (Hill, 1999) inevitably require quantitative sampling of the sediment and associated organisms, and demand appropriate sampling techniques that supply samples containing all particle sizes and leave the natural sediment composition unchanged. The sampling should be inexpensive to large numbers of samples to be taken and should be practicable in a broad range of sediment conditions. Moreover, an instant sample supply for analysis is often important in monitoring operations.

Traditional sampling techniques do not satisfy all these demands (Table 1). Hand picking (Bretschko, 1990), net sampling methods, and the traditional Hess Sampler (Hess, 1941) fail to collect the fine sediment fraction. Moreover, hand picking can give subjective results. The Shapiro core-freezer (Shapiro, 1958) and tube corers (Kajak, 1971) are not suitable for hard, coarse sediments since driving the tubes into the sediment is impossible. Furthermore, the spatial structure of the sediment sample is not entirely maintained, which is also a problem with hand picking and Hess sampling. Traditional freezing core techniques (Stocker & Williams, 1972; Bretschko, 1985) are too cumbersome for many sampling purposes and alter the sediment structure during tube insertion.

Waiting periods of several days are necessary to re-establish natural sediment conditions before taking samples, which means that instant sampling following pollution accidents is impossible. Newer freezing core techniques that overcome these disadvantages, as described by Hill (1999) and Niederreiter (1999), are either limited to water depths up to 0.3 m and are

*Table 1.* Features of different sediment sampling methods, − absent, (+) present to some degree, + present

| | Quantitative | Complete particle range in sample | Applicable in all substrate types | Applicable in higher water depths (>0.3 m) | Sample in natural composition and spatial structure | Sample available immediately | Mobile, flexible application | Low personnel demands |
|---|---|---|---|---|---|---|---|---|
| Hand collecting (Bretschko, 1990) | (+) | − | + | − | − | + | + | + |
| Hess-Sampler (Hess, 1941) | + | − | + | − | − | + | + | + |
| Sediment corer (Kajak, 1971) | + | + | − | + | + | + | + | + |
| Freezing core technique (Stocker & Williams, 1972) | + | + | + | + | (+) | − | − | − |
| Freezing core technique (Hill, 1999) | + | + | + | − | + | + | + | + |
| Freezing core technique (Niederreiter, 1999) | + | + | + | + | + | + | − | − |
| Bottom sampler | + | + | + | + | + | + | + | + |

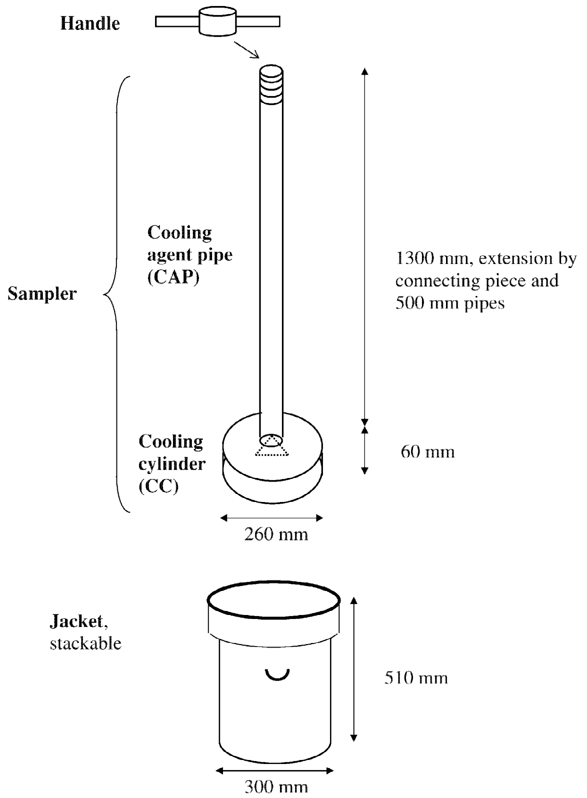


*Figure 1.* Schematic drawing of the Bottom-Sampler components.

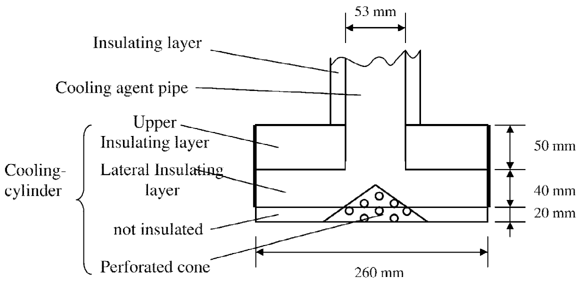


*Figure 2.* Detailed view of the Bottom-Sampler basis with the insulating layer.

time-consuming (approximately 48 min freezing time for each sample) or else need heavy equipment which prevents rapid mobile deployment.

This paper describes a new sampling technique which immediately produces sediment samples including organisms from pure water-saturated sediment to water depths up to 1.2 m and deeper and overcomes the problems of the methods mentioned above.

## Description and operation of the bottom sampler

The bottom sampler (BS) consists of two components: the stamp-shaped hollow sampler and a jacket (Fig. 1). The sampler itself is 1.3 m high. The hollow cooling cylinder (CC) is welded from 2-mm thick steel and is closed except for the connection to the cooling agent pipe (CAP). A perforated cone at the centre of the CC bottom evenly spreads the cooling agent which is led in by the CAP (Fig. 2).

The sampler is insulated to prevent heating effects: polyurethane foam for insulation and a polyester layer to prevent mechanical damage cover the CC, except for the bottom and a 20 mm fringe at the side (Fig. 2). A polyethylene foam coat insulates the CAP. A screw-thread on the top of the CAP allows the attachment of handles or extends the CC for use in deeper water (>1.2 m). The jacket that protects the sampling area from heating effects and the loss of sediment and organisms is a part of a water pipe (Omniplast) with two handles attached (Fig. 1).

Several jackets can be stacked to adjust to the water depth via the connecting piece at the top. The 15 kg total weight of the BS (sampler 10 kg, one jacket 5 kg) makes handling easy, even when access is via steep-sided banks, and allows researchers to carry the equipment for a few hundred meters in field conditions. The sampler covers an area of 0.0531 $m^2$ (diameter 0.26 m).

To operate the sampler the operator(s) wade(s) into the water and inserts the jacket a few centimetres into the bed if possible. He/she then wraps a piece of polyethylene foam around the jacket base held in place by an elastic cord to ensure the sampling area is well protected from the flow. If the water is deep and the flow weak, the foam can be attached before the insertion of the jacket, or it may be omitted in fine sediment conditions. In the next step, the sampler is inserted gently into the jacket on the bed surface. Approximately 15 l of liquid nitrogen are carefully poured into the CAP over a period of 8–10 min using a high density polyethylene beaker and funnel. The nitrogen demand depends on the water temperature (minimum 13 l at 2 °C and maximum 17 l at 20 °C) and the size of sample needed (mean sample wet mass: 8 kg). After waiting 2 min to allow the nitrogen to evaporate completely, the sampler with the jacket is lifted out of the water and transported to a tub on the bank to remove the sample ice disc from the CC bottom, either by using a hammer or letting the sample warm up and fall off automatically. Then the complete sample is transferred into a bucket for subsequent analysis in the laboratory. The BS is immediately ready for the next sampling operation. Using the sum of pore water and sediment volume ($V$) and the sampler area ($A$) it is possible to calculate the mean sampling depth ($d$) by Equation (1).

$$d = \frac{V}{A}.$$

This sampling depth ($d$) can be used to standardise the results of the sediment analysis. In shallow water (up to 0.4 m depth) a single operative is able to handle the equipment alone. In deeper water the sampler tends to float and does not stand stably and a second operative is necessary hold the jacket and sampler in position. Movements of the sampler must be kept to a minimum to prevent suspension of sediments.

During a 2-year testing period we used the BS to take more than 80 samples in six different first- to third-order streams in Thuringia (Germany) featuring sediment grain sizes up to 0.2 m and maximum depths of 1.2 m. Successful use in very coarse sediment (grain sizes $>$0.2 m) is not assured, since large cobbles make fitting the jacket to the bed surface problematic. Nevertheless all our samples were adequate for sediment analyses. Sediment disc heights of between 80 and 160 mm were achieved. At six sample sites a high flow velocity ($>$1.0 m $s^{-1}$) and coarse sediment (0.15–0.2 m) caused a remaining flow inside the jacket, leading to incomplete ice discs. This can be avoided by careful sealing of the jacket base by a piece of polyethylene foam which, was not yet in use in four of these six cases. In the incomplete ice discs we estimated the proportion of the sampler area obtained and fitted the results to a complete sample. The average time needed to obtain one sample was 15 min.

The BS is an improvement over traditional methods (Hess, 1941; Shapiro, 1958; Stocker and Williams, 1972; Bretschko, 1985; Hill, 1999) in that it is mobile, it supplies samples instantly, and the samples contain organisms and the bed sediment in its natural composition and spatial structure over a broad range of sediment conditions. Although our first tests were limited to sampling streams, the use of the BS in shallow lakes and the littoral region promises to be successful as well. The BS is appropriate equipment for use in research, applied studies and environmental monitoring.

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