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A simple device for automatic sampling of runoff for quality monitoring during rainfall events

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The construction and operation of a new device for automatic sampling of runoff during rainfall events is described. It is easily made, simple to use, not vulnerable to operational disturbances, and inexpensive, thus allowing use at many sites with reasonable costs. The basic principle is to use the weight of the rain to trigger the sample collection. To test the utility of the device, runoff during rainfall events was collected at three catchments over the summer of 1994.

Introduction

Sampling of runoff not only during dry periods but also during rainfall events is important for many reasons. Except for the snow-melt period, the highest flood peaks occur during events of heavy rainfall and often result in high peaks in the outflows of nutrients. In order to obtain accurate load estimates, sampling of runoff should include these peak flows (Rekolainen *et al.* 1991). Sampling of runoff during rainfall events is of particular interest in areas subjected to high levels of anthropogenic dry deposition. In such areas, the potentially leachable portions of dry deposition may be flushed out with the onset of the first rains subsequent to prolonged droughts. Intensive rainfall events may also cause significant erosion. This is particularly true in newly ditched areas (Heikurainen *et al.* 1978) and clear-cut areas (Rapp and Strömquist 1976, Larsson and Gretener 1982), where heavy rainfalls may erode soil material from the sides of ditches and from skid trails and truck roads used for wood transporting.

Due to uncertainties in weather forecasting, however, it is difficult to get runoff samples during critical rainfall episodes in a solely manually organized sampling system. There are two kinds of automatic sampling systems available for runoff quality monitoring: "in situ measuring systems", which are equipped with sensors installed in the stream or river (Kohonen 1985 and the references therein), and the use of an automatic sampler to collect the water sample which is later analysed in the laboratory (Newburn 1988). However, the devices used in both these systems are usually expensive, and laborious to construct and maintain (Kohonen 1985, Newburn 1988). Observations on runoff quality with such systems are

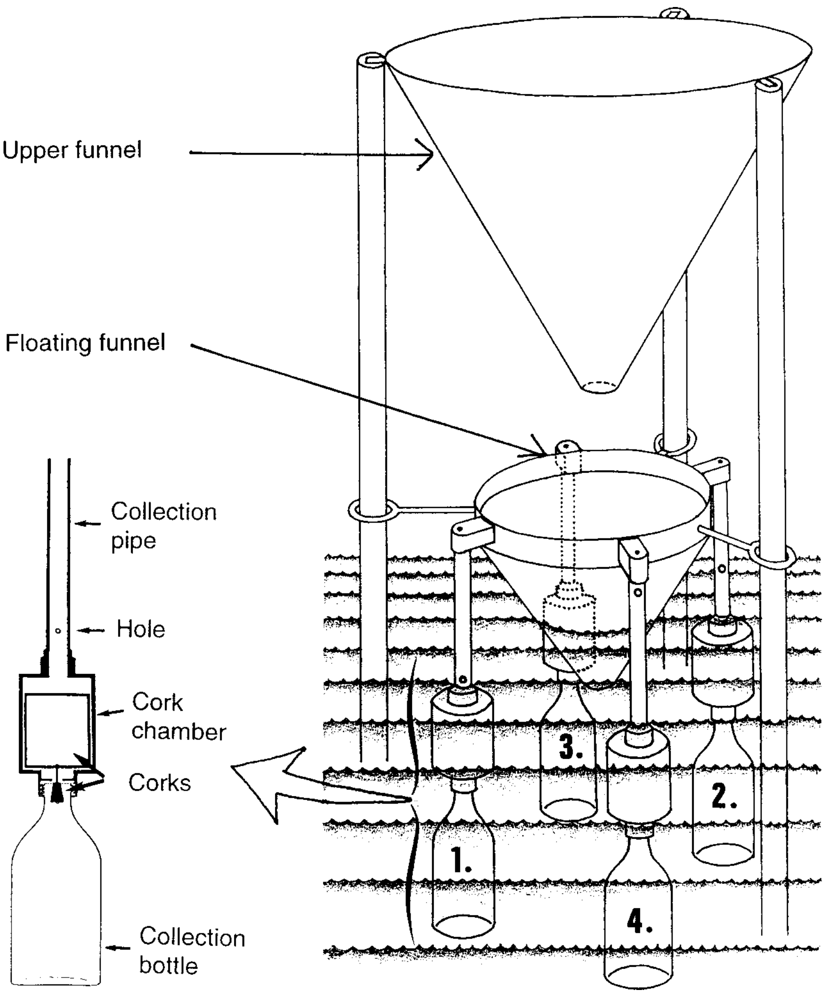

Fig. 1. Schematic diagram showing the construction of the automatic sampler.

therefore restricted to only a few sites (Lepistö 1991). The automatic measuring systems also have electronic parts, which makes them vulnerable to operational disturbances due to for example, moisture and thunder. The design and construction of a very simple and inexpensive device for automatic sampling of runoff during rains is described in this paper.

Material and methods

Construction and operation of the device

The construction of the automatic sampling device is illustrated in Fig. 1. The device consists of an upper funnel, a lower floating funnel and four collection bottles, equipped with collection pipes, cork chambers, vacuum corks inside the chambers, and rubber corks connected to vacuum corks. The collecting surface of the upper funnel is 0.50 m^2. The surface area of the lower floating funnel is 0.09 m^2, and the height 225 mm. The upper end of the collection pipes (height 240 mm; inner diameter 20 mm) are tightly attached to the floating funnel. The cork chamber has outer batten threads in the upper end and inner threads in the lower end to enable tight fitting with the collection pipe and a 1 liter collection bottle. The diameter of the cork chamber is 87 mm and the height 160 mm. The body of the sampler is made of PVC and the collection bottles are from borosilicate glass. The sampling device can be installed in the stream channel or outlet ditch, wherever the depth of water column is at least 50 cm.

The basic principle in the operation of the device is to use the weight of the rain water to trigger the sample collection. With the help of the upper funnel, rain water is conducted to the lower floating funnel, which starts to sink due to the weight of the water. When the funnel has sunk to such a depth that the hole of the collection pipe in the first collection bottle is at the same level as the surface of the runoff water, the collection bottle starts filling with runoff water. As soon as the sampling bottle and the cork chamber are full of water, both corks float up sealing the collection bottle. As the floating funnel continues sinking, the next bottle fills according to the same principle as the first bottle. The first, second, third and fourth sample correspond to 1–2, 4–5, 7–8 and 10–11 mm precipitation, respectively.

Testing of the sampling device

To test the device, samples of runoff were collected automatically during rains at three peatland dominated catchment areas in southern Finland (61°23´N, 25°03´E, 125 a.s.l.) over the summer 1994. The sampling devices were located in the outlet ditch of each catchment area. The functioning of the devices was checked the day after each rainfall event, and the possible failures were written down prior to resetting the samplers.

Results and discussion

The performance of the automatic sampling device was satisfactory. The collection bottles always filled with runoff in the correct order, i.e. only the first collection bottle after a precipitation of < 3 mm; the first and the second after that of < 6 mm, and so forth. The swaying of the floating funnel due to the increase in the weight of the collection bottle that had filled with runoff water had been taken into consideration in determining the positions of the holes in the collection pipes and did not affect the beginning or the sequence of the filling of the bottles.

Dyed waters was used in the laboratory to test if there was any leakage from the collection bottles after being sealed. Both laboratory and field tests assured that the bottles were sealed tightly enough with the vacuum cork/rubber cork system used. When emptying the collection bottles after rainfall episodes, the vacuum cork/rubber cork system always needed to be hardly pushed downwards, i.e. due to friction between the rubber cork and the hole in the cork chamber the corks did not fall down to their initial position merely by gravity.

From the 45 times (3 catchments and 15 rainfall events) the functioning of the device was tested under field conditions, it never failed to work properly. Nevertheless, the automatic sampling device can be modified so that a longer sampling period during a rainfall episode is possible. Instead of 9–10 mm precipitation, the last sampling bottle could be made to correspond to e.g. > 50 mm precipitation. Smaller collection bottles and cork chambers in relation to size of the floating funnel would decrease swaying during the filling of the bottles. The device is considered suitable for the sampling of runoff automatically during rainfall episodes.

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