Flood flow water quality analysis using low-cost samplers in small rivers

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Abstract Water quality studies require field data for assessment and mathematical simulation. Manual collection of water samples during floods in small rivers is very difficult due to the short event duration and quick response to rainfall. Some low cost siphon samplers presented in the literature have been developed and adapted to collect event-based samples, but they only collect samples when the stream stage is rising. This work presents a new design of a low cost siphon sampler developed to allow collection when the stream stage is decreasing. It was tested in the laboratory and also installed in a river with flood flows strongly dominated by urban runoff. The major problem faced in the field work was to keep the samplers in place due to the amount of debris carried by the floods. Laboratory tests showed water intrusion into the sampler during the rising stage and further improvement is proposed to solve the problem.

Key words low cost sampler; water quality sampling; sampler

INTRODUCTION

Water quality monitoring is necessary to obtain information about anthropogenic impacts on the environment. Due to the variation of river water quality as a consequence of the hydrological events as well as land use, water sampling during flood flows is very important to evaluate transported contaminant loads. In small rivers, flood events can occur within a few hours and it can be very difficult to manually take samples during storms and at night. Also, more efficient automatic systems are very expensive, especially so for potential users in developing countries. In this context, mechanical systems, also known as siphon-samplers, can provide an alternative or complimentary solution.

The syphon-sampler was originally developed by the ICWR (1961), and it was further optimized as reported by Edwards & Glysson (1988), Graczyk *et al.* (2000) and Newham *et al.* (2003). This study presents some advantages of this system and stresses its major limitation related to sampling being confined to the rising limb of the flood.

This paper presents two configurations of the mechanical sampler: (i) an adaptation of the standard siphon-sampler; (ii) a modification to allow sampling during the recession limb. The samplers were tested in the laboratory and in the field, the latter involving three gauging stations in a small river.

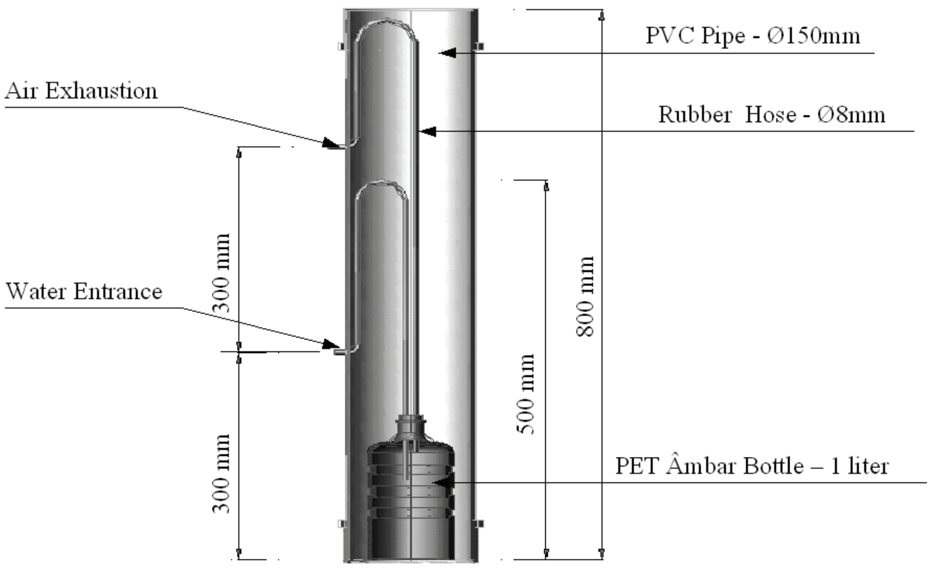

Fig. 1 Siphon-sampler (SS1) for water sampling during the rising limb of the flood.

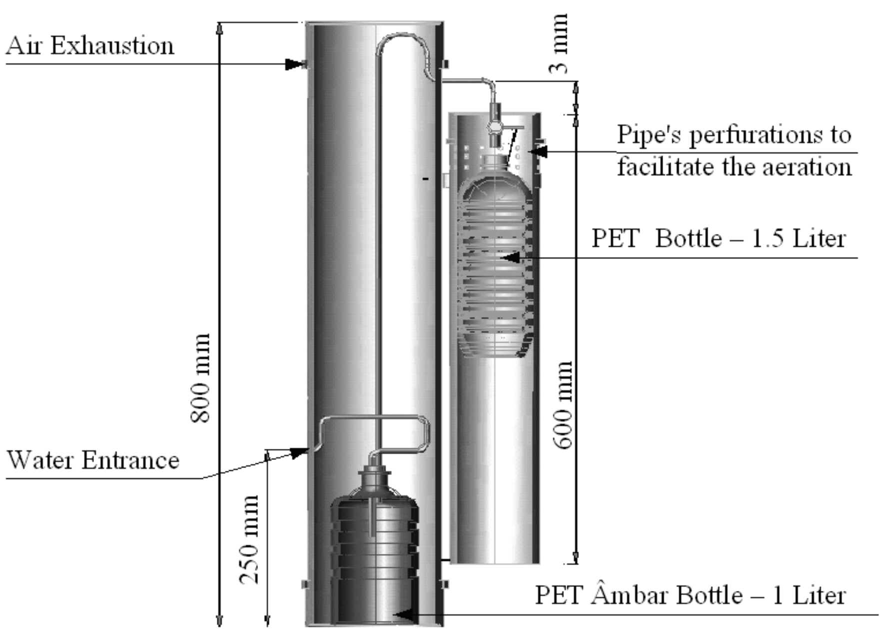

Fig. 2 Siphon-sampler (SS2) for water sampling during the recession limb of the flood.

SAMPLER DESCRIPTION

The first system designed (SS1) was an adaptation of the standard siphon-sampler (Fig. 1). The sampler body was made of a 150 mm PVC pipe, 800 mm in length. The diameter was chosen for easy access to the sample bottle placed inside it, while the length was defined so that the user can easily reach the bottle. PET amber bottles with

1 L volume were used to collect the sample. The sampler has two hoses connected to the sample bottle; one to act as a water inlet and the other as an air exit. When the river stage is rising, water enters into the bottle through one hose as air exits through the other hose.

In order to allow sampling during the recession limb of floods, a modified sampler (SS2) was designed (Fig. 2). A gas check valve was installed at the end of the air exit hose. A PET bottle is attached to the valve arm. In the field, when the river stage rises, the bottle is filled up with water and when the river stage decreases the weight of the bottle, now full of water, opens the gas valve, allowing the air to escape and thus allowing the water to enter the sample bottle. While the sampler is submerged, the bottle is also under the water and so its weight is counterbalanced.

Easy access to the air control system is important because after each sample collection, the gas valve must be lubricated and the bottle has to be emptied. The position of the samplers in the river bank is important to allow collection at the desired stages.

SAMPLER TESTS AND RESULTS

Before the installation of the samplers in the field, laboratory tests were carried out to assess the sampler performance. For the hose diameter chosen, the required time to fill up the sample bottle was 1.25 minutes (±20 s). When the water head over the SS2 sampler was high, water dripped into the sample bottle due to the compression of the air in the bottle but, for the expected river stages, the amount of water entering was considered negligible.

Eleven samplers were installed at three gauging stations in the Descoberto River basin. The first station has an upstream rural basin of about 500 km^2 and is located downstream of a dam. The second station is located on the Melchior River which drains a very densely populated area. The river receives stormwater from the city and at the time of sampling was receiving raw sewage from about 500 000 inhabitants. The third station is located on the Descoberto River downstream of the Melchior River, and has an upstream catchment area of about 800 km^2. For a few events, all the samplers worked properly, but during a large flood some samplers installed at the latter two stations were washed away due to the amount of debris generated by river bank erosion and litter from the city carried to the river by the stormwater.

CONCLUSIONS AND RECOMMENDATIONS

The SS2 sampler that has been developed is a reliable and low-cost solution to collecting water samples during the recession limb of floods. The samplers can be built with material readily available anywhere, even in small cities in Brazil.

The major problem found during the use of the samplers was fixing them at the river bank due to their size and the amount of litter and debris carried by the river. It was also observed that the gas valve can easily get rusty and dirty and, in a few cases, the bottle weight was not enough to open the gas valve. So, it is important to lubricate the valve after each sample collection.

In the case of sampler installation in rivers with very large stage variations, the compression of the air inside the sample bottle may allow a significant amount of water to enter before the desired stage. In such cases it is recommended to install a check valve with a weight bottle in the water inlet, similar to the arrangement in the gas exit of the SS2 sampler, in order to have both valves opening when the water level decreases to the desired stage.

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