Sampling of Suspended Solids Flowing in a River: Design and Test of Methodologies Aimed at Chemical Analysis

AUTHORS

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INTRODUCTION

The evaluation of suspended solids (SS) and related chemical content flowing in river waters plays an important role during the characterisation and monitoring of a complex river-lake system where historical contamination has occurred. However, SS investigations can be challenging due to the complex sampling process, seasonal and hydrological variability, analytical limitations and the lack of consolidated standards.

A number of SS sampling methodologies were tested at different locations during an environmental characterisation conducted by ARPA and Ramboll Environ (on behalf of Syndial SpA) on the Toce river in Piedmont, Italy. The results presented here relate to sampling sites located near the small town of Candoglia Toce.

MATERIALS AND METHODS

ARPA device (Figures 1 and 2)

ARPA developed a device composed of the following elements:

- Two shopping bags made from mater-bi® biodegradable and compostable bioplastics were placed one inside the other. Three horizontal cuts were made to the external one and three vertical cuts to the internal one to let the water current flow inside.
- A concrete parallelepiped (0.24 x 0.20 x 0.10m) was placed at the bottom of the bags to anchor the device to the bottom of the river.
- Folded high-density polyethylene (HDPE) strips (1.0 x 0.10 x 0.0005m) occupied the void in the parallelepiped in order to trap the sediment suspended in the current.
- The whole device was inserted into a PVC net with 2cm mesh used to hold the entire thing.
- A floatation device (0.5 litre PET bottle) was fixed to the net to make it easier to recover the device in case of a flood.

Figure 1: ARPA device placed into the river.

Figure 2: ARPA device - internal view.

Mouth of the Toce river.

Ramboll Environ device (Figures 3 and 4)

Ramboll Environ modified a device designed by Galas *et al*, which was similar to that developed by ARPA, except for the way it was anchored. ARPA's device was posed and anchored to the river bed, while Ramboll Environ's device floated and was anchored to a bridge using ropes.

In order to collect a representative sample from different water depths, three devices were connected to floats on one side and weights on the opposite side, as shown in Figure 3.

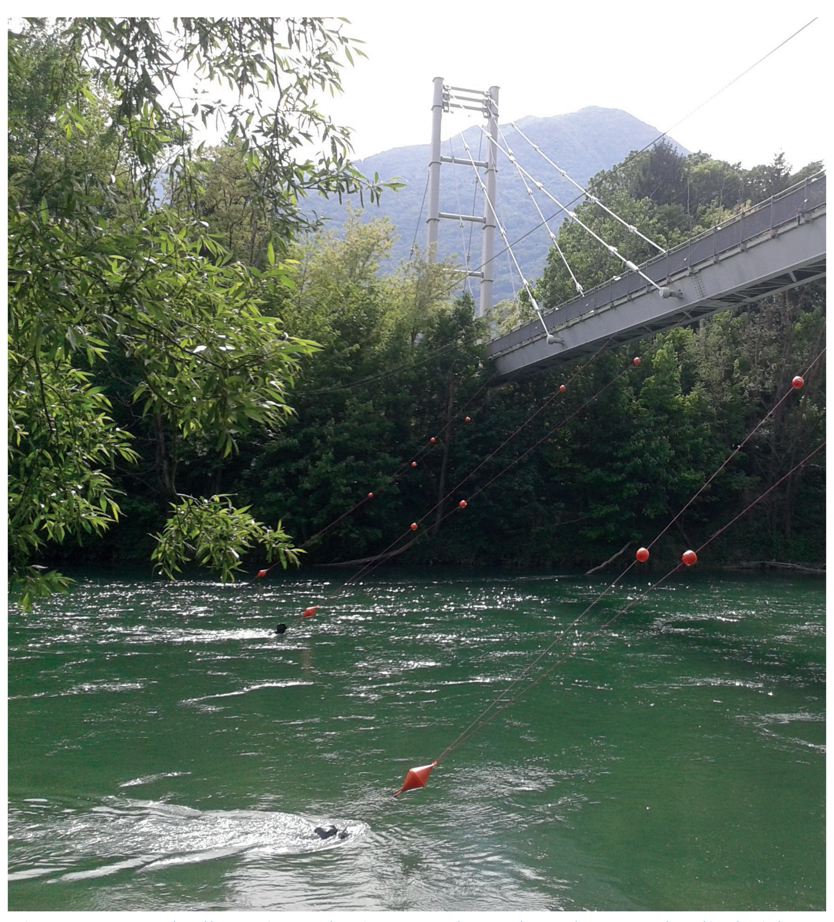

Figure 3: Ramboll Environ devices anchored to the Candoglia bridge.

Figure 4: Ramboll Environ device: detailed view.

SAMPLING MECHANISM

Both ARPA and Ramboll Environ's sampling devices allowed passive sampling of suspended soils. Water flowed into the device and slowed down due to the presence of HDPE strips, which allowed suspended solids to be deposited.

MONITORING ACTIVITIES AND RESULTS

The devices were in place during different time periods and therefore experienced different hydrological regimes (Figure 5).

Ramboll Environ (2015)

The device developed by Ramboll Environ was put in place from the bridge and left for two weeks ('exposure period'). During recurrent floods some devices were lost, which resulted in only a little solid mass being collected. After this, Ramboll Environ made some adjustments, such as incorporating an external protective net to improve the device's mechanical strength.

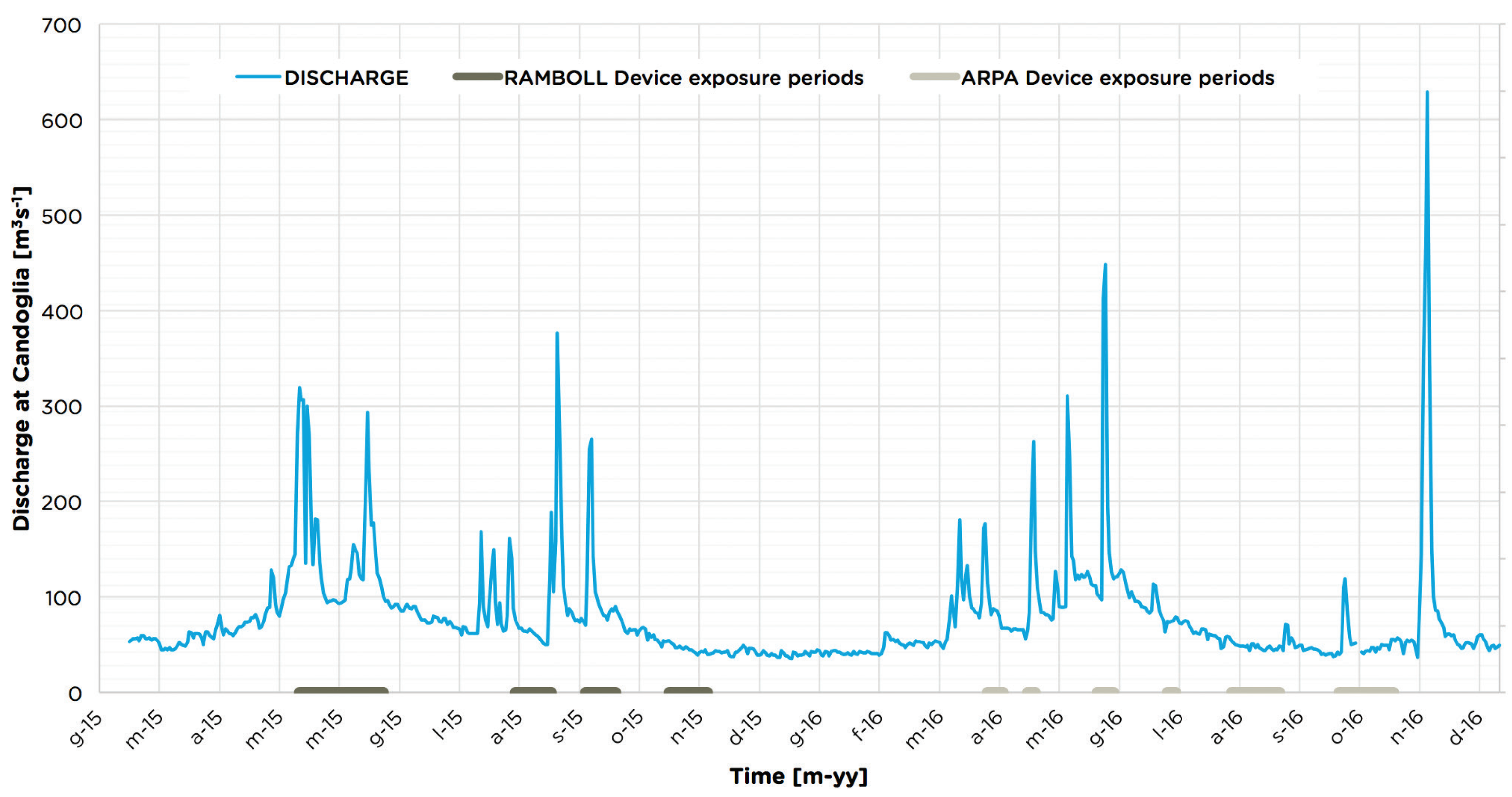

Figure 5: Discharge series in Toce river (Candoglia station) and device exposure periods.

The distribution of the grain sizes of suspended solids trapped in Ramboll Environ's device in 2015 is detailed in Table 1 below.

Date	Silt (<0.062mm)	Sand (2 to 0.062mm)
26/05/2015	32.89%	67.11%
04/06/2015	27.83%	72.17%
22/06/2015	24.95%	75.04%
14/09/2015	**60.34%**	**39.67%**
16/10/2015	**51.31%**	**48.7%**
01/12/2015	**89.89%**	**10.11%**

Table 1: Grain size distribution of suspended sediment sampled by Ramboll Environ Italy's devices in 2015.

ARPA (2016)

The device developed by ARPA was put in place manually by walking into the river channel as short a distance as possible. The exposure times varied in relation to the river's hydrologic regime (Figure 5) with a maximum of four weeks during low discharge periods. The device was in place during recurrent floods when the water was more than 2m deep, and it showed to be reliable as it was never submerged by bedload. In several cases it was completely filled by sediment.

The distribution of the grain sizes of suspended solids trapped in ARPA's device in 2016 is detailed in Table 2 below.

Date	Silt (<0.062mm)	Sand (2 to 0.062mm)
27/04/2016	11.9%	88.1%
13/05/2016	12.1%	87.9%
21/06/2016	8.5%	91.5%
22/07/2016	**73%**	**27%**
12/09/2016	13.1%	86.9%
08/11/2016	**74.3%**	**25.4%**

Table 2: Grain size distribution of suspended sediment sampled by ARPA's devices in 2016.

DISCUSSION AND PERSPECTIVES

The SS sampling techniques described are practical and cheap, and allow the collection of enough solid mass to perform chemical analysis and preliminary characterisation of grain size distribution over a range of time periods. Both techniques also allow the collection of silt fraction, which is the prevalent fraction in certain conditions (evidenced in Tables 1 and 2).

The main limitations and uncertainties are:

- Lack of quantification of water volume that flowed into the devices.
- Grain size representativeness and possible problem of selection/exclusion.

New tests are planned for 2017 that apply different sampling techniques including:

- Active isokinetic sampling based on pumping and filtration system.
- Floating passive sampler that allows water flow-rate measurements.

The overall aim will be to identify a sampling technique suitable for long term SS monitoring.

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