Temporal variability of suspended sediment transport and rating curves in a Mediterranean river basin: The Celone (SE Italy)

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ABSTRACT

In the Mediterranean region suspended sediment transport is the predominant process in sediment export in most river basins. The aim of this paper is to analyze suspended sediment variability over a period of 12 months in the Celone river, a temporary river located in the Puglia region (SE-Italy), and to evaluate sediment rating curves for estimating suspended sediment concentrations for subsequent load calculations. Similarly to most temporary rivers, the Celone river shows relevant differences among mean daily flows and the extreme instantaneous flows during floods. To take into account these peculiarities, the rating curves were developed as a function of hydrological conditions: high, normal and low flows. Continuous measures of streamflow and frequent samplings of suspended solid concentrations (SSCs) during flood events, normal flow and low flow were used. The plot of the SSC against discharge takes the form of a hysteresis loop. Clockwise, anticlockwise and mixed-shaped loops were observed. Suspended sediment yield was found to be in the range of 250–384 t km⁻² y⁻¹. The results show that about 94% of the total suspended materials were transported during the high flow regime, while less than 0.1% were under low flow conditions. Moreover, it was observed that 90% of the total annual suspended loads were moved between November to May. Flash floods that occur in summer exhibit the highest values of SSC. The proposed method, which was based on sediment rating curves, has proved to be valuable to generate SSC data for high and normal flows although it tends to underestimate the highest values. It can represent a useful tool for water resource managers who need a quick and inexpensive method, specific for temporary rivers, to evaluate suspended sediment yield.

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1. Introduction

In the Mediterranean region, most river basins are affected by erosion and soil degradation (Jones et al., 2012). The geomorphologic and climatic factors that characterize these basins and the agricultural practices such as frequent tillage, which are quite common in these areas, exacerbate soil losses (Gomez et al., 2009). In recent decades, erosion and its impacts on soil and surface waters have received an increasing interest from local, national, European, or international policy makers. Many studies have focused on soil erosion processes, sediment dynamics, sediment yield evaluation, reservoir sedimentation, and ecological aspects related to the suspended sediment transport and on specific measures to reduce soil erosion (e.g., Kirkby et al., 2000; Lenza and Marchi, 2000; Morgan, 2005; Rodriguez-Blanco et al., 2010; Soler et al., 2008; van Rompaey et al., 2005; Verstraeten et al., 2003). Most of the studies on the dynamics of suspended sediment carried out in the Mediterranean region have analyzed small semi-arid catchments. Few studies of suspended sediment transport have been carried out in medium Apennine basins with high seasonal differences in streamflow (Pavanelli and Cavazza, 2010). In these basins, soils are characterized by a high percentage of silt and clay particles, which have a great erodibility. Soil erosion and river suspended solids (SSCs) are strongly related and suspended sediment transport can constitute a large part of the total sediment load (Pavanelli and Cavazza, 2010). Hence, the quantification of suspended sediment yield at the basin outlet provides an order of magnitude estimate of the erosion and depositional processes occurring within the catchment.

The hydrologic regime of the Mediterranean rivers is an important factor in influencing erosion and sediment delivery processes. Due to the high variability in time and space of rainfall events, these rivers are often characterized by extreme variations in flow (Nikolaidis et al., 2013) and flash floods with high suspended sediment transport (Alexandrov and Laromne, 2003). This aspect makes it more difficult to make accurate and continuous measurements of SSC (Navratil et al., 2011) and at the same time it implies that suspended sediment load computation is quite difficult (Phillips et al., 1999).

Several methods have been developed to predict suspended sediment yield in medium and large catchments (Moat and Meybeck, 2005; Letcher et al., 1999). These include the use of empirical relationships (rating curves) between SSC and streamflow, and more process-based generation and transport models (Arnold et al., 1998). Data