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Differences between the source contribution of bed material and suspended sediments in a mountainous agricultural catchment of western Iran

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ABSTRACT

Soil erosion is intense in semi-arid regions of Iran and causes a decline in dam reservoir capacities and losing fertile soils from agricultural areas. Effective control of sediment delivery to the water storage requires an understanding of the sediment sources. To investigate the spatial provenance of suspended and bed material sediments in the Taleghani catchment, western Iran, eleven geochemical tracers were used to distinguish sediment sources. In total, 44 source samples were collected from the surface soil of three land use sources and the sub-soil of channel banks together with eight suspended samples in different flood events, and eleven bed material samples from different river stream sites were collected. Two mixing models (i.e., the Collins and Hughes mixing models) were applied to compute the contribution of different sources to both river bed and suspended sediments. The results of more accurate mixing model, the Hughes model based on goodness of fit test, indicated that channel-derived sediments dominate (average ~71.5%) the sediment sources contributing to bed materials. In addition, temporal variability of sources when suspended load was applied as the sediment input in mixing models showed that crop fields were the dominant source of sediment in flood events with high sediment concentrations. However, in flood events with less sediment concentrations, channel banks reach to higher apportionment.

1. Introduction

In semi-arid regions of Iran, soil erosion has been dramatically increased due to extension of poor agricultural practices to steep lands. Within 50–60 years, the soil erosion dramatically intensified and its rate increased from 3.0 to 24.3 tons ha^{-1} $year^{-1}$ (Nosrati et al., 2011a). With sediment delivery ratio of 45% (WRM, 2012), the sediment deposition rate in dam reservoirs ranged around 8 to 11 tons ha^{-1} $year^{-1}$. This sediment accumulation decreases approximately 235 million cubic meters of dam reservoir capacity in each year. Although these estimations are extremely uncertain, they confirm that soil erosion is now clearly an important environmental problem in Iran.

Knowledge of sediment contribution derived from different sources (land use, or geology or erosion type sources) is critical for determining the catchment management practices and soil erosion control methods; this minimizes the off-site effects of erosion and sedimentation. Therefore, there is a strong need for techniques that establish an accurate sediment budget and predict catchment sediment yield in an efficient and cost-effective manner (Walling et al., 2003). Sediment fingerprinting methods as a field based technique that use tracer measurements to estimate the contribution of soil erosion are established (Collins et al., 1998), and the application of geochemical elements as fingerprint properties is well documented (Collins et al., 1997; Devereux et al., 2010; Karwan et al., 2011; Navratil et al., 2012; Wilkinson et al., 2013).

Our study area is a mountainous sub-catchment of Kashkan River catchment (Taleghani, 33° 42′ to 33° 44′N and 47° 39′ to 47° 44′E; elevation ranging between 1240 and 2320 m asl) in western of Iran. At the outlet of the Kashkan River catchment, Karkheh dam is located with 5347 million cubic meters water storage capacity that irrigates 320,000 ha agricultural lands. Sediment accumulation decreases approximately 235 million cubic meters of dam reservoir capacity in each year (that is 34.6 million tons of sediment in each year; www.karkheh.com). Our preliminary field examinations in the study area (Taleghani catchment) showed that the Taleghani sub-catchment is one of the major sediment suppliers in this region.

Previous sediment fingerprinting studies in Iran (Hakimkhani et al., 2009; Nosrati et al., 2011b) have just applied the bed sediment samples from stream or dam reservoirs. In our study, the contribution of sources to two fluvial types including suspended and bed material sediments were estimated. The former was used to find erosion processes within specific flood events, whereas the latter recognise the provenance of

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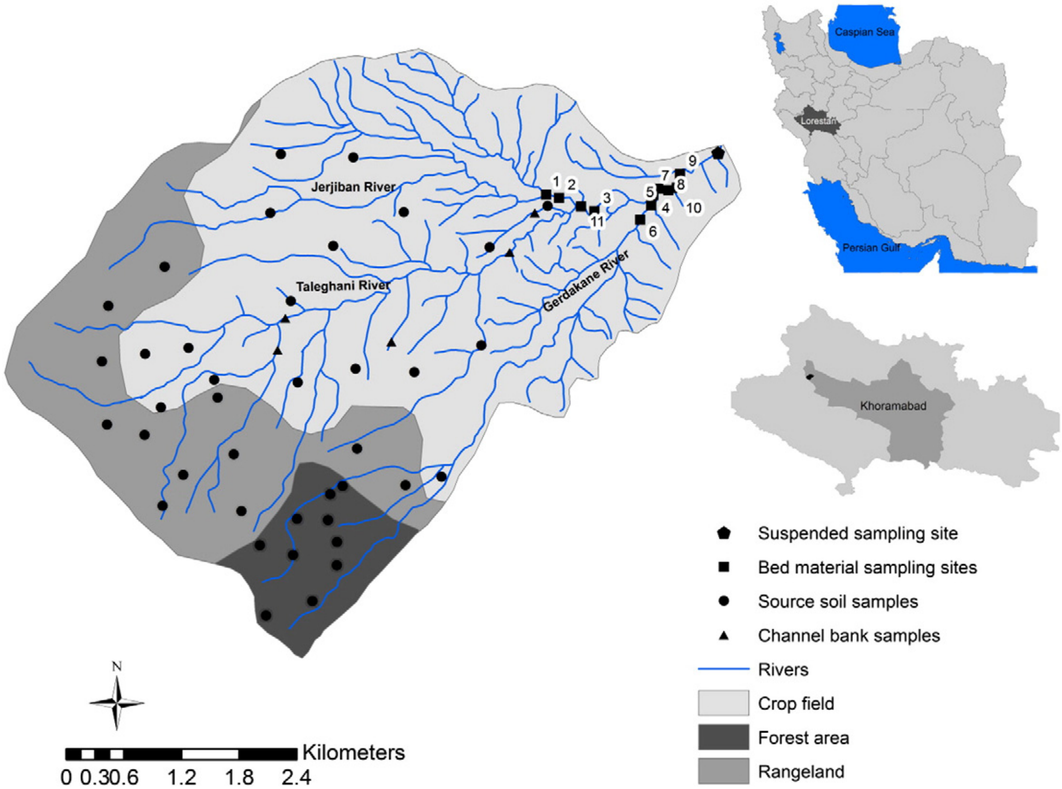

Fig. 1. Location map of the Taleghani catchment and sampling sites.

materials deposited during consecutive flood events. In addition, two statistical mixing models were used to accurately determine the relative sediment contributions.

2. Materials and methods

2.1. Study area

The Taleghani catchment covers an area of 26 km^2 located in Lorestan province, western of Iran (Fig. 1). The mean annual rainfall is 377 mm with most rainfall occurring between November and March (Fig. 2). Also, mean annual temperature fluctuate between 4 and 28 °C. The soils within the catchment are mainly Typic Xerorthents. Geological formations including Amiran (low weathered siltstone and sandstone), Taleh Zang (medium grained limestone) and Quaternary (low level pediment fan and valley terrace deposits) formations are exposed at the surface in the drainage basin. Three major land uses are crop field (61.5%), rangeland (26.5%) and forest (7.7%). Stream network cover almost 18.2 ha of the whole catchment area. The study catchment is composed of three main tributaries, Gerdakane, Taleghani and Jerjiban. Gerdakane River drains southern parts of the catchment, while Taleghani and Jerjiban rivers drain the northern catchment (Fig. 1).

2.2. Soil sampling and field data collection

2.2.1. Sediment source samples

A total of 44 soil samples were collected to represent various land uses, including 17 samples from different sits in cultivated area, 12 from pasture and 10 from forest area. Each soil samples (~1.5 kg)

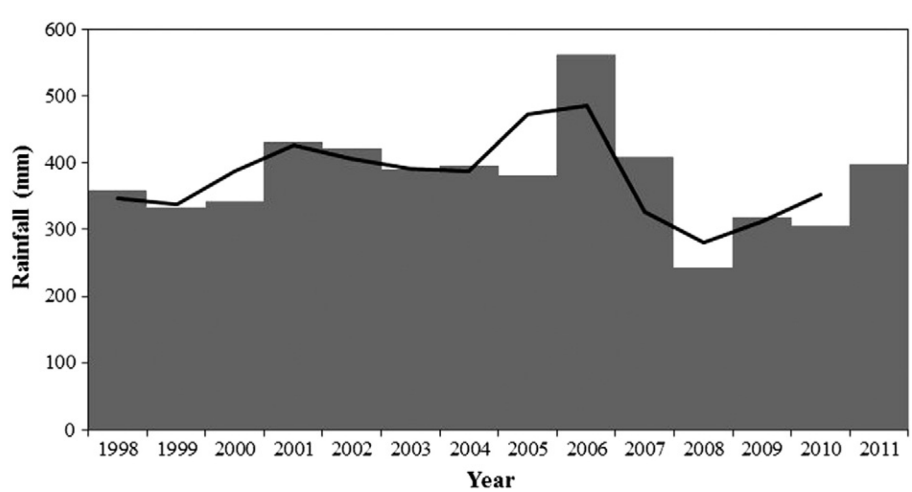

Fig. 2. Annual rainfall for the period 1998–2011. Solid line is a 2-year moving average.