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Understanding catchment scale sediment sources using geochemical tracers

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It is well-established that urbanization leads to increased erosion (at least locally) as well as enhanced overland flow and streamflow peaks. Less is known about how the spatial distribution of erosion sources and scale of increases in erosion vary with the nature of urbanization in different climatic and socio-economic settings. This is important in order to prevent or reduce adverse impacts of erosion on downstream sedimentation, channel siltation and shifting, and river pollution.

This paper adopts a sediment fingerprinting approach to assess the impact of partial urbanization and associated land-use change on sediment sources within a peri-urban catchment (6 km2), Ribeira dos Covões on the outskirts of the city of Coimbra in central Portugal. Urban land-use has increased from just 6% in 1958 to 30% in 2009. The urban pattern includes some well-defined urban residential centres, but also areas of discontinuous urban sprawl, including educational, health and small industrial facilities, numerous new roads and an enterprise park is under construction on the upper part of the catchment. The catchment has a wet Mediterranean climate and the lithology comprises sandstone in the west and limestone in the east. Soil depth is generally >40cm. The average slope angle is 8º (maximum 47º). Altitude ranges from 30m to 205m.

A sediment fingerprinting approach was adopted to help establish the relative importance of sediment inputs from different urban areas. During September 2012 current bed-sediment samples (0-3 cm depth) were collected from 11 channel sites along the main stream and in different tributaries. At sites where bed-sediment was deeper, additional samples were taken at 3cm intervals to a maximum depth of around 42cm. In addition, overbank sediment samples (0-3cm depth) were collected at 11 locations around the catchment. All samples were oven-dried (at 38ºC) and different particle size fractions (0.125-2mm, 0.063-0.125mm and <0.063mm) obtained, where the <0.063mm fraction was considered equivalent to the suspended sediment load during storm events. The elemental composition (33 elements) of each fraction was assessed using a Niton X-ray fluorescence analyzer. The results were used to identify distinctive composite signatures of each tributary catchment and their influence on the geochemistry of the catchment outlet bed-sediment was explored. An unmixing model was applied to estimate the relative contribution of each tributary to channel-stored sediment at the catchment outlet. Many of the chemical elements analysed, including Zr, Sr, Zn and Ti, showed significant differences between sandstone and limestone areas. The closeness of values at the catchment outlet to those of sandstone stream bed-sediment indicates that most of the current catchment erosion is derived from the sandstone area. This is supported by the higher measured discharges and suspended sediment concentrations in storm events from the latter. Eroded sediments from urban areas still under construction also showed distinctive characteristics. It is concluded that this methodology represents a potentially useful tool for river managers and policy-makers to detect and assess sediment sources in urbanized catchments.