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Determining the sources of suspended sediment in a Mediterranean groundwater-dominated river: the Na Borges basin (Mallorca, Spain).

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Tracers have been acknowledged as a useful tool to identify sediment sources, based upon a variety of techniques and chemical and physical sediment properties. Sediment fingerprinting supports the notion that changes in sedimentation rates are not just related to increased/reduced erosion and transport in the same areas, but also to the establishment of different pathways increasing sediment connectivity. The Na Borges is a Mediterranean lowland agricultural river basin (319 km^2) where traditional soil and water conservation practices have been applied over millennia to provide effective protection of cultivated land. During the twentieth century, industrialisation and pressure from tourism activities have increased urbanised surfaces, which have impacts on the processes that control streamflow. Within this context, source material sampling was focused in Na Borges on obtaining representative samples from potential sediment sources (comprised topsoil; i.e., 0–2 cm) susceptible to mobilisation by water and subsequent routing to the river channel network, while those representing channel bank sources were collected from actively eroding channel margins and ditches. Samples of road dust and of solids from sewage treatment plants were also collected. During two hydrological years (2004-2006), representative suspended sediment samples for use in source fingerprinting studies were collected at four flow gauging stations and at eight secondary sampling points using time-integrating sampling samplers. Likewise, representative bed-channel sediment samples were obtained using the resuspension approach at eight sampling points in the main stem of the Na Borges River. These deposits represent the fine sediment temporarily stored in the bed-channel and were also used for tracing source contributions. A total of 102 individual time-integrated sediment samples, 40 bulk samples and 48 bed-sediment samples were collected. Upon return to the laboratory, source material samples were oven-dried at 40°C, disaggregated using a pestle and mortar, and dry sieved to $<63\ \mu$m to facilitate direct comparison with the suspended sediment samples. Suspended sediment samples were recovered by means of sedimentation. Concentrations of Ca, Cd, Cr, Cu, Fe, Mg, Mn, Na, Ni, Pb and Zn were determined using ICP-MS after HCl/HNO_3 microwave digestion. ^{137}Cs and total ^{210}Pb activities were measured by gamma spectrometry. Finally, the absolute grain size composition was measured using a Malvern Mastersizer. The quantitative composite fingerprinting procedure was used to establish the relative proportion of the potential sediment source types identified in each catchment, comprising three key stages, namely: (1) use of a statistical verification procedure to select the fingerprints able to discriminate between potential source types (Mann–Whitney U-test) and discard the others; (2) discriminant function analysis (DFA) to select an optimum composite fingerprint for discriminating the two primary source types (stepwise analysis); and (3) the use of a multivariate mixing model, based on mass balance equations, to establish the relative contribution of each source type to the suspended sediment flux. Model uncertainty associated to the spatial variability of source tracer values (i.e. fingerprints) will be estimated using a Monte Carlo simulation technique with 5,000 iterations. During the session, the implementation of this experimental design will lead to explain and discuss the main results and conclusions.