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Re-examining the basis for source discrimination and data corrections used by sediment fingerprinting studies in agricultural catchments

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The sediment fingerprinting technique has been widely used in agricultural catchments to quantify fine sediment contributions from various land use sources. This application of the technique depends on the key assumption that land-use source signatures imprinted on catchment soils are decipherable from those due to other landscape factors affecting soil and sediment properties. We re-examine this key assumption by investigating (i) the physical and chemical basis for source discrimination and (ii) potential factors that may confound source un-mixing in agricultural catchments, including particle size and organic matter effects on tracer properties. The study is situated in the River Tamar, a predominantly agricultural catchment in south-west England that has also been affected by mining. Source discrimination focused on pasture and cultivated land uses and channel banks. Monthly, time-integrated suspended sediment samples were collected across seven catchments for a 12-month period. Physical and chemical properties measured in source soils and sediment included fallout radionuclides, major and minor element geochemical constituents, total organic carbon and particle size. Source discrimination was entirely dependent on differences in tracer property concentrations between surface and sub-surface soils. This is based on fallout radionuclide concentrations that are surface-elevated, while many geochemical properties are surface-depleted due to weathering and pedogenetic effects, although surface soil contamination can reverse this trend.

Source discrimination in the study catchments was limited by (i) rotation of cultivated and pasture fields resulting in reduced differences between these two sources and (ii) the cultivated source signature resembling a mix of the pasture and channel bank sources for many tracer properties. Furthermore, metal pollution from abandoned historic mines and organic enrichment of sediment from areas of peaty soil resulted in the non-conservative behaviour of some tracer properties in several catchments. Confounding factors related to poor source discrimination and non-conservative behaviour are highly likely to affect sediment fingerprinting studies in many agricultural catchments. Most fingerprinting studies correct tracer data for differences in particle size and organic matter content between source soils and downstream sediment to account for selective transport effects. However, it was found that differences in the particle size and organic carbon content of source soils could explain much of the variation in these properties in downstream sediment. Inconsistent relationships between particle size, organic carbon and tracer property concentrations further undermined the basis for uniform application of corrections to all tracer properties. Careful consideration of the physical and chemical basis of tracer property behaviour should form an essential part of all sediment fingerprinting studies.