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Investigating the sources of sediment in a Canadian agricultural watershed using a colour-based fingerprinting technique

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The development of beneficial management practises to minimize adverse impacts of agriculture on soil and water quality requires information on the sources of sediment at the watershed scale. Sediment fingerprinting allows for the determination of sediment sources and apportionment of their contribution within a watershed, using unique physical, radiochemical or biogeochemical properties, or fingerprints, of the potential sediment sources. The use of sediment colour as a fingerprint is an emerging technique that can provide a rapid and inexpensive means of investigating sediment sources. This technique is currently being utilized to determine sediment sources within the South Tobacco Creek Watershed, an agricultural watershed located in the Canadian prairies (south-central Manitoba).

Suspended sediment and potential source (topsoil, channel bank and shale bedrock material) samples were collected between 2009 and 2011 at six locations along the main stem of the creek. Sample colour was quantified from diffuse reflectance spectrometry measurements over the visible wavelength range using a spectroradiometer (ASD Field Spec Pro, 400-2500 nm). Sixteen colour coefficients were derived from several colour space models (CIE XYZ, CIE xyY, CIE Lab, CIE Luv, CIE Lch, Landsat RGB, Redness Index). The individual discrimination power of the colour coefficients, after passing several prerequisite tests (e.g., linearly additive behaviour), was assessed using discriminant function analysis. A stepwise discriminant analysis, based on the Wilk's lambda criterion, was then performed in order to determine the best-suited colour coefficient fingerprints which maximized the discrimination between the potential sources. The selected fingerprints classified the source samples in the correct category 86% of the time. The misclassification is due to intra-source variability and source overlap which can lead to higher uncertainty in sediment source apportionment.

The selected fingerprints were then included in a Bayesian mixing model using Monte-Carlo simulation (Stable Isotope Analysis in R, SIAR) in order to apportion the contribution of the different sources to the sediment collected at each location. A switch in the dominant sediment source between the headwaters and the outlet of the watershed is observed. Sediment is enriched with shale bedrock and depleted of topsoil sources as the stream crosses and down-cuts through the Manitoba Escarpment. The switch in sources highlights the importance of the sampling location in relation to the scale and geomorphic connectivity of the watershed. Although the results include considerable uncertainty, they are consistent with the findings from a classical fingerprinting approach undertaken in the same watershed (i.e. geochemical and radionuclide fingerprints), and confirm the potential of sediment colour parameters as suitable fingerprints.