Compound-specific isotope analysis with nested sampling approach detects spatial and temporal variability in the sources of suspended sediments in a Scottish mesoscale catchment

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Intensification of land use is a primary cause of increased suspended sediment load in freshwater systems, hence land-use-specific sediment source tracing is necessary to inform sustainable land and water management. Here we tested the application of compound-specific isotope analysis (CSIA) of vegetation biomarkers to fingerprint suspended sediment sources from the mesoscale agricultural Tarland catchment (74 km(2)) in NE Scotland. Our aim was to test a parsimonious nested sampling approach from a headwater sub-catchment to apportion suspended sediment sources across headwater to catchment-wide scales. Compound-specific carbon isotopic signatures (delta C-13) of long-chain fatty acids (LCFAs) from source soils were able to successfully distinguish between forest, heather moorland, permanent grassland, and arable land cover. Permanent grassland was a prominent source of sediment at both headwater and catchment scales, with an annual average contribution of 79% and 56%, respectively, indicating grazing pressure and runoff via preferential pathways. Increased sediment input from arable land at the catchment scale (40%) compared to the headwater sub-catchment (18%) indicated land use intensification in lowland areas. Forest and heathermoorland contributed marginally to suspended sediments (similar to 2%), despite covering 43% area of the catchment area. Temporal variability of sediment sources observed over fourteen months (May 2017 - June 2018) showed a higher relative contribution from arable land during summer and autumn and a higher contribution from permanent grassland during winter and spring, likely linked to seasonality of rainfall and agronomic activities.These results demonstrate a successful use of delta C-13 values of LCFAs to quantify land-use-specific suspended sediment sources. Comparison of two suspended sediment techniques showed usefulness of time-integrated mass samplers for representative and cost-effective sampling. We recommend that future nested sampling designs should include spatially distributed source soil tracer characterization covering the whole catchment area to reduce the uncertainty in sediment source attribution from headwaters to the catchment outlet.

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