Evaluating tracer selection for catchment sediment fingerprinting

ABSTRACT

Purpose: Recent sediment fingerprinting research has shown the sensitivity of source apportionment results to data treatments, tracer number, and mixing model type. In light of these developments, there is a need to revisit procedures associated with tracer selection in sediment fingerprinting studies. Here, we evaluate the accuracy and precision of different procedures to select tracers for un-mixing sediment sources. Materials and methods: We present a new approach to tracer selection based on identifying and removing tracers that exhibit non-conservative behaviour during sediment transport. This removes tracers on the basis of non-conservative behaviour identified using (1) tracer-particle size relationships and (2) source mixing polygons. We test source apportionment results using six sets of tracers with three different synthetic mixtures comprising one, five, and ten mixture samples. Source tracer data was obtained from an agricultural catchment in northwest England where time-integrated suspended sediment samples were also collected over a 12-month period. Source un-mixing used MixSIAR, a Bayesian mixing model developed for ecological food web studies, which is increasingly being applied in catchment sediment fingerprinting research. Results and discussion: We found that the most accurate source apportionment results were achieved by the selection procedure that only removed tracers on the basis of non-conservative behaviour. Furthermore, accuracy and precision were improved with five or ten mixture samples compared to the use of a single mixture sample. Combining this approach with a further step to exclude additional tracers based on source group non-normality reduced accuracy, which supports relaxation of the assumption of source normality in MixSIAR. Source apportionment based on the widely used Kruskal-Wallis H test and discriminant function analysis approach was less accurate and had larger uncertainty that the procedure focused on excluding non-conservative tracers. Conclusions: Source apportionment results are sensitive to tracer selection. Our findings show that prioritising tracer exclusion due to non-conservative behaviour produces more accurate results than selection based on the minimum number of tracers that maximise source discrimination. Future sediment fingerprinting studies should aim to maximise the number of tracers used in source un-mixing constrained only by the need to ensure conservative behaviour. Our procedure provides a quantitative approach for identifying and excluding those non-conservative tracers.

Keyword: MixSIAR; Sediment fingerprinting; Sediment tracing; Tracer selection