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New insights in the use of carbon isotopes as tracers of DOC sources and water pathways in headwater catchments

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Despite the significant importance of dissolved organic carbon (DOC) in aquatics ecosystems, the processes controlling DOC delivery to stream waters at the catchment scale are still poorly understood, in particular with regards to the relative importance of riparian versus upland soils as DOC sources. In this respect, the stable carbon isotopic composition of DOC (δ13CDOC) appears to be a promising tool as different δ13CDOC values are anticipated between wetland and upland soil DOC, because of differences in soil oxygenation, soil humidity and soil organic matter degradation scheme However, care must be exercised because of the possible occurrence of seasonal variations in the δ13CDOC values of both riparian and upland DOC , and because also of the possible mixing of DOC coming from spatially distinct sources.

The markedly different isotopic patterns obtained during high resolution monitoring (<hourly basis) of six successive storm events occurring between November 2010 and February 2011 in a small headwater catchment from western France illustrate this difficulty. Survey of the δ13CDOC values of the DOC during these storm events showed that the variability in intra-storm DOC isotopic composition markedly evolved through time, with some storms exhibiting strongly variable δ13CDOC values (> 2 δ units), while others showed no, or much more restricted isotopic variations. A comparison of these results with previously published data revealed that this temporal variability of intra-storm δ13CDOC values is the exact transposition of the temporal variability of δ13CDOC values that was found in the riparian soil waters of this catchment during the same period. The latter variability has been shown to arise from the combined effect of changes in the production mechanisms and ultimate sources of riparian DOC and of the lateral input in the riparian domains of an isotopically heavier DOC component coming from more upland areas.

Overall, results from this study confirm that upland domains may be significant contributors of stream DOC flux in headwater catchments. They also show that upland soils behave as a size-limited reservoir with respect to DOC production, whereas more highly productive soils in the wetland domains act as a near-infinite reservoir. Through this study, we show that the isotopic composition of DOC is an extremely powerful tool for tracing DOC sources and DOC transport mechanisms in headwater catchments, demonstrating in the meantime that the use of this tool requires that the temporal and spatial variability of the isotopic signatures of all potential DOC sources in the catchment is known accurately. Providing that this condition is fulfilled, the isotopic tool can allow up to quantify the proportions of DOC - and of corresponding water flows – coming from different contributing areas which may be of great importance for better understanding and better modeling of DOC transfer and water routing through the landscape.