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Analysis of runoff sources and water uptake by trees using isotopic data in a small forested catchment

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Plant transpiration is an important component of the hydrological cycle. Particularly, in densely vegetated areas, climatic and land-use changes might have significant hydrological (and ecological) implications. This leads to the need to identify the main water sources for tree transpiration and to evaluate how the flux exchanges between soil, vegetation and atmosphere possibly affect the runoff response of forested watersheds. Specifically, this study took advantage of the natural presence of water stable isotopes in the hydrological cycle to assess: i) the sources of water uptake by trees, and ii) the origin of water contributing to runoff in a small and densely forested catchment in the Italian Pre-Alps.

Field surveys were carried out during late summer and early autumn of 2011 in the Ressi catchment (1.9 ha, North-Eastern Italy, mean elevation of 660 m a.s.l.). Beeches, chestnuts, maples and hazels represent the main tree species in the area, with sparse presence of hornbeams and ashes. Stream water stage, soil moisture at 0-30 cm depth at four locations, and water table level at three locations were continuously recorded. Bulk precipitation was collected from plastic bottles sealed with mineral oil and weekly manual sampling of stream water, soil water (by means of suction cups), groundwater and water in the xylem conduits (sap) from six beeches was performed for isotopic analyses. Sap was extracted in situ from beech twigs by using a pressure bomb. The isotopic composition of liquid samples (δ^2H and δ^{18}O) was determined by laser absorption spectroscopy. Additionally, water electrical conductivity was measured in the field (only for stream water, groundwater and rainfall) by a portable conductivity meter.

Preliminary results showed a marked difference in the tracer concentration among the various water components in the catchment. Particularly, the average isotopic signal of tree water (-38.1 per mil δ^2H and -5.95 δ^{18}O) was statistically similar to soil water (-36.9 per mil δ^2H and -6.60 δ^{18}O), but significantly different from streamflow and groundwater (-58.1 per mil δ^2H and -8.96 δ^{18}O, -58.5 per mil δ^2H and -8.89 δ^{18}O, respectively). This suggested that vegetation (at least in the study period and during the inter-storm spells) might use the water available in the shallow soil, rather than the water stored in the saturated zone. Moreover, rainfall in the study period (-41.0 per mil δ^2H and -7.20 δ^{18}O) was isotopically similar to soil water and sap but more enriched in heavy isotopes compared to groundwater and stream water. This indicated a possible groundwater recharge in wintertime and springtime by precipitation likely mixed with snowmelt. Finally, the isotopic composition of sap was similar among the different beeches, even if located in different areas of the catchment, suggesting similar patterns of water uptake. Future investigations will be extended to the entire vegetative season, approximately from April to October 2012, in order to better assess the spatial and seasonal patterns of water utilization, including also sampling during specific rainfall events.

Keywords: stable water isotopes, sap flow, water uptake, water sources.