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Origin of the waters sourced by trees in a pre-Alpine forested catchment

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Stable water isotopes have proven to be useful tracers to determine the origin of water taken up by plants, quantify the relative contributions of water sources to stream runoff and investigate water flow paths. However, the presence of different water pools in a catchment and soil water allocation complicates our understanding of water cycling, and calls for research on processes governing soil water movement and storage, as well as interactions between soil and plants.

In this study, we used isotopic data from a forested catchment in the Italian pre-Alps to i) investigate the spatial and temporal variability of the isotopic signature of various water sources, and ii) determine which waters are used by beech and chestnut trees in the study area.

Ecohydrological and hydrometeorological monitoring took place in the 2.4-ha Ressi catchment (Northern Italy). Elevations range from 598 to 721 m a.s.l., while average slope is 31°. Average annual precipitation is about 1695 mm, while average annual temperature is 9.7 °C. The entire catchment is covered by deciduous forest, with beech, chestnut, hazel and maple as the main tree species.

Water samples for isotopic analysis were taken monthly from bulk precipitation, approximately bi-weekly from stream water, groundwater and soil water by two suction lysimeter cups in the riparian zone. Bulk soil water samples and twigs for xylem water extraction by cryogenic vacuum distillation were collected starting in June, 2017. All water samples were analysed by laser spectroscopy, except xylem water that was analysed by mass spectrometry.

Stream water, groundwater and soil water extracted by suction lysimeters were isotopically similar to precipitation and aligned to the local meteoric water line. Bulk soil water obtained by cryogenic vacuum distillation showed an evaporation signature, especially on the hillslope where soil moisture was lower and soil water had been extracted by suction lysimeters only during or just

after a large rainfall event. This indicates that soil water sampled by suction lysimeters and extracted by cryogenic vacuum distillation is stored differently in the soil layers due to the different soil tension, and hillslopes tend to store less mobile soil water compared to the riparian zone. At greater depths, bulk soil water extracted by cryogenic vacuum distillation was slightly less evaporated and less enriched in heavy isotopes compared to soil water extracted from shallower layers. The isotopic composition of xylem water had a large temporal and tree-species variability, with chestnut xylem water samples more enriched in heavy isotopes than samples obtained from beech trees. Xylem water was more similar to soil water obtained by cryogenic vacuum distillation, suggesting that in the study area trees likely use more bulk soil water than the mobile soil water, groundwater and stream water.

Keywords: stable water isotopes; soil water; xylem water; forested catchment.