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Tracing stemflow infiltration with a simple experiment using geophysical surveys and stable water isotopes

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In forested catchments, stemflow affects the amount of precipitation reaching the soil, how water infiltrates and transports nutrients into the soil. Recently, the ecohydrological community has shown a renewed interest towards the methods used to quantify the stemflow infiltration area. Stemflow infiltration area is generally estimated based on the ratio between stemflow input rate and the mean soil infiltration capacity, whereas direct observations are rare. Direct estimations of stemflow infiltration areas are usually made by the application of dye tracers, which have proven to be useful for monitoring double-funneling. On the contrary, there are still few observations based on the application of electrical resistivity tomography (ERT) and isotopically-labelled water.

In this study, we present a simple experiment carried out for a beech tree, in a forested hillslope in the Italian pre-Alps. The aims of the experiment were to simulate stemflow by using salt and isotopically-labelled water, and to quantify stemflow infiltration area and volume.

The experiment was performed during a dry period in September 2022, in order to observe marked changes in the isotopic signature of soil water, as well as in electrical resistivity. Stemflow was simulated with a rainfall depth and intensity similar to typical summer storms in the catchment, and by using salt water with an isotopic composition very different compared to the composition of soil water during summer months. Before, during and after the stemflow application, 9 ERT surveys were performed to capture the infiltration dynamics. The collection of soil samples for isotopic analysis was carried out after the experiment, at different distances from the stem and at different depths (e.g., 0-15, 15-30, and 30-45 cm). Soil moisture was also measured at 0-6 and 0-12 cm depths at different distances from the stem.

Preliminary results showed a rapid infiltration of stemflow along the root system of the beech tree, and 24 hours since the start of the experiment the labelled water had infiltrated up to 80 cm into the soil. This simple experiment showed the usefulness of using time lapse ERT surveys, as well as isotopically-labelled water to simulate stemflow and trace double-funneling.

Keywords: stemflow, electrical resistivity tomography, stable water isotopes, soil water, forested catchment.