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Non-uniform but highly preferential stemflow routing along bark surfaces and actual smaller infiltration areas than previously assumed: A case study on European beech (Fagus sylvatica L.) and sycamore maple (Acer pseudoplatanus L.)

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Throughfall and stemflow are critical components of the hydrological and biogeochemical cycles of forested ecosystems, as they are the two hydrological processes responsible for the transfer of precipitation and solutes from vegetative canopies to the soil. Despite stemflow rarely accounts for >10% of the rainfall, its concentration over small areas at the base of trunks seems to affect the magnitude and timing of water inputs to the soil and biogeochemical cycling excessively.

Though substantial amount of literature on throughfall and stemflow research is available, recent reviews on eco-hydrology of forested ecosystems identified several key points of uncertainty where current knowledge is weak. These points especially address the role of canopy structure among tree species (i.e., interspecific variation) as well as within a single tree species (i.e., intraspecific variation as caused e.g. by morphology and age) for explaining the large variations in precipitation partitioning into throughfall and stemflow, the spatial variability of throughfall volume and chemistry as well as the temporal and spatial patterning of stemflow inputs to the ground. The latter two points are particular sources of uncertainty, since most sampling approaches fail to adequately identify the infiltration area of stemflow inputs at the trunk base resulting in incomplete or biased evaluations of tree species effects on rainfall partitioning.

Based on these deliberations we conducted a color tracer experiment with Brilliant Blue to identify flow patterns of stemflow water along the stem surface of two broad-leafed tree species (Fagus sylvatica and Acer pseudoplatanus) of the Hainich Critical Zone Exploratory (CZE) and to estimate the infiltration area at the trunk base and down to 12 cm soil depth. The trunk area was dye-stained up to 1.5 m height in advance and stemflow patterns along the trunk surface and soil infiltration zone were visually quantified following two natural rainfall events. Furthermore, we tested the relationship between color-stained zones of "high through-flow" and ecological soil characteristics such as fine root distribution and soil pH. This approach differs from common color tracer experiments, where stems are actively and homogeneously sprinkled with large amounts of color tracer solution.

We found distinct spatially restricted stemflow pathways on the tree trunks, which appeared specific for the tree individual exhibiting larger washed-off areas for beech (4441 cm²) compared to maple (1816 cm^2). The infiltration area of stemflow at the trunk base was smaller than the basal area (BA) amounting to 17% (226.2 cm^2) of the BA for beech and to 30% (414.4 cm^2) for maple. For beech, colored areas were restricted to a maximum extension of 13 cm distance from the stem and of 30 cm for maple.

Our investigation exhibited that stemflow infiltration was spatially more concentrated at the trunk base than commonly assumed. The outcome of this study will contribute to our understanding on hydrological and biogeochemical interlinkages between the surface and subsurface of the Critical Zone.