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Enrichment Processes in Throughfall and Stemflow in a Mixed Temperate Forest

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Forest canopies redistribute precipitation by processes of interception and stemflow which also change the chemical signature of incoming precipitation. Understanding what controls these transformations and how they evolve across seasons is key to assess forest water cycling and nutrient transport. At the Waldlabor Zurich ecohydrological observatory (Switzerland) we measure the amount and chemical signature of precipitation since April 2020. Our measurement setup focusses on spruce (Picea abies) and beech (Fagus silvatica) trees, as they are the two most common species across Switzerland. In addition to the ion and isotope concentrations in precipitation, throughfall, stemflow as well as in the soil at different depths (10, 20, 40 and 80 cm), we also assess the canopy density in weekly resolution, groundwater depth and streamflow amount at the outlet of our forested catchment, as well as their chemical and isotopic composition

We assessed the seasonal variability of throughfall and stemflow and their relation to canopy density measurements for beech, spruce and young spruce trees. Canopy density had little to no effect on interception and stemflow fractions. We found almost half of the total annual precipitation is intercepted in the canopies of spruce and beech trees, this is because most precipitation events were quite small, resulting in almost no throughfall at all. However, in general, the fraction of interception decreased with increasing event size, on the other hand events below 4 mm did not produce significant amounts of throughfall and stemflow. Water chemistry is showing that major enrichment processes took place in the canopy, subsequently the ion signature was different in throughfall and stemflow compared to open field precipitation. Ion concentrations of sodium, chloride, nitrate, ammonium and potassium were 2 - 10 times higher in throughfall and up to 14 times higher in stemflow compared to concentrations measured in open field precipitation. We hypothesize this is the result of accumulation of wind deposits, especially of anthropogenic contaminants on the tree stem, branches and leaves, as we found concentrations where generally higher during events succeeding long periods without precipitation. In accordance with the much rougher surface of spruce needles and stems compared to beech leaves and stems, we found much higher concentrations in throughfall and stemflow below spruce trees and elevated ion concentrations in the soil waters up to 40 cm depth. Overall, our results highlight the importance of forests, not only in redistributing precipitation, but also in changing the chemical signal of precipitation and thus the forest water and nutrient cycle.