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Using stable isotopes to quantify ecohydrological flux dynamics at the soil-plant-atmosphere continuum in urban green spaces

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Urban areas, more than many experimental catchments, are characterized by a markedly heterogeneous distribution of land covers, with different degrees of permeability that radically vary partitioning of precipitation into evapotranspiration ("green" water fluxes) and runoff and groundwater recharge ("blue" water fluxes). While the quantification of ecohydrological fluxes using stable isotopes in water as environmental tracers has been an established method for many years, surprisingly few studies have been applied to the highly complex urban water cycle. To determine the effects of representative urban green space "types" on water partitioning, we carried out plot-scale studies at a heterogenous field site in Berlin-Steglitz that integrates climate, soil moisture and sap flow data, with isotope sampling of precipitation and soil moisture on a regular basis. Soil moisture and isotope measurements were conducted at different depths and under contrasting soil-vegetation units (grassland, trees, shrub) with different degrees of permeability. Our investigations revealed uniformly decreasing soil moisture content during the dry summer of 2019, with only temporary re-wetting of the uppermost soil layers despite heavy convective precipitation events. Soils under trees were driest, whilst grassland soils were wettest, with shrubs intermediate. Isotope-based modelling indicated that this was the result, of greater interception, transpiration and – surprisingly – soil evaporation from forest sites. The isotope signatures of soil water also revealed stronger "memory effects" of summer drying in forest soils, which persisted until the major re-wetting of the system in autumn allowed drainage from the soil profile to contribute to groundwater recharge. Modelling showed that recharge under grasslands could be over 3 times higher compared to under trees and shrubs. Upscaling these findings with large-scale isotope studies of surface and groundwater across Berlin highlights the importance of the vegetation in urban green spaces to water partitioning in heterogeneous city landscapes and the need for careful integration of vegetation management in urban water and land use planning.