

Enhancing urban runoff modelling using water stable isotopes and ages in complex catchments

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Abstract

Increased urbanization, coupled with the projected impacts of climatic change, mandates further evaluation of the impact of urban development on water flow paths to guide sustainable land use planning. Though the general urbanization impacts of increased storm runoff peaks and reduced baseflows are well known; how the complex, non-stationary interaction of the dominant water fluxes within dynamic urban water stores sustain streamflow regimes over longer periods of time are less well quantified. In particular, there is a challenge in how hydrological modelling should integrate the juxtaposition of rapid and slower flow pathways of the urban ‘karst’ landscape and different approaches need evaluation. In this context, we utilized hydrological and water stable isotope datasets within a modelling framework that combined the commonly used HEC urban runoff model along with a simple hydrological tracer module and transit time modelling to evaluate the spatial and temporal variation of water flow paths and ages within a heavily urbanized 217km² catchment in Berlin, Germany. Deeper groundwater was the primary flow component within less urbanized regions of the catchments, with increased direct runoff and shallow subsurface contributions in more urbanized areas near the catchment outlet. The addition of wastewater effluent in the mid-reaches of the catchment was the dominant water supply to the lower stream, and sustained baseflows during the summer months. Water ages from each modelling approach imitated flow contributions and opportunity for mixing with subsurface storage; with older water and lower young water contributions in less urbanized sub-catchments and younger water and higher young water contributions in more urbanized regions. The results form a first step towards more integrated modelling tools for similar peri-urban catchments, given the potential limitations of more simple model frameworks. The results have broader implications for assessing the uncertainty in evaluating urban impacts on hydrological function under environmental change.

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