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Impact of Sustainable Urban Drainage Systems (SUDS) on Vadose Zone Water

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Sustainable Urban Drainage System (SUDS), like bioretention for stormwater runoff infiltration, offer several advantages compared to the traditional centralised sewage drainage. Such approaches maintain the natural water cycle in the urban critical zone and help to mitigate climatic extremes impact on urban areas by retarding, storing and evaporating stormwater runoff. Although SUDS are established since longer time (>25 years for example in Germany) we lack systematic investigations on the hydrological functionality and pollutant retention performance of these systems after long-term operation. We employed laboratory and field experiments coupled with numerical simulations to investigate three long-term operated bioretention systems in Germany with following objectives: (i) a detailed mapping of spatial contamination patterns; (ii) a soil hydrological and -chemical substrate characterisation; (iii) an event-based influent and effluent trace metal concentrations monitoring covering 36 months in total; and (iv) a soil water balance simulation using HYDRUS-1D. Regarding the pollution patterns, we found significantly enhanced trace metal contents in the soil substrate mainly as a function of the drainage area type and kind of inflow regime. Nonetheless, average free metal ion concentrations in the soil seepage water extracted below the upper soil layers (30-45 cm) fall below German trigger values considering the soil-groundwater pathway at all three investigated sites. Compared to influent concentrations, average load reduction of the major pollutants Cu and Zn was 55-95 % within the upper soil layers. With regard to infiltrated runoff volumes, simulated water balances revealed hydraulic load reductions of 10-40 % by evapotranspiration. Our current findings demonstrate no risk of groundwater degradation suggesting bioretention as a powerful tool in terms of maintaining the natural water cycle in the urban vadose zone even after long-term operation. Debatable might be the handling of soil substrates modified by stormwater infiltration showing enhanced trace metal contents and a certain amount of technogenic sediments like tyre wear. On the one hand, a big metal pool is specifically bound meaning it can easily turn into free ions during changing conditions like the application of de-icing agents. On the other hand, these substrates perfectly fulfil pollutant retention and water conductivity requirements as mandatory for an effective stormwater treatment using SUDS approaches.