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Surface and Subsurface Hydrology in Urban Residential Areas

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Editorial

Urbanization, notably land use change linked with the built environment, is notorious for interrupting natural hydrologic processes and posing management challenges for cities. Many urban surfaces (e.g., paved surfaces, roofs, and compacted soil) are less pervious than their natural counterparts (e.g., grassland, woodland, wetlands, and agricultural), resulting in more runoff. Historically, cities have addressed this issue by designing storm water sewer systems that drain runoff to downstream water bodies. Unfortunately, this results in a slew of problems at the other end of the pipeline known as "urban stream syndrome"; symptoms include "flashy" flows that raise flood risk and pollution, which harms ecosystem and reduces the public amenity value of streams. Cities desire to solve these issues and are sometimes legally required to do so (US EPA, 2005), but traditional end-of-pipe remedies are expensive and ineffective.

As an alternative, communities are increasingly aiming to manage storm water runoff through low-impact strategies spread throughout the watershed. Rain gardens, green roofs, disconnected downspouts, permeable pavement, and soil amendment are examples of local activities that catch, penetrate, and/or evapotranspiration rain and soil moisture. Although the effectiveness of these approaches has been established in case studies, adoption rates have remained modest. The answers are complex, but they are owing in part to knowledge gaps in our process-based understanding of urban hydrology, such as why outcomes differ in somewhat different environmental contexts or climates. Increasing our understanding of urban hydrologic processes may assist cities in determining how to develop rules, installation methods, and long-term planning to enable adoption of the most appropriate techniques at the most appropriate sites.

To address these policy and management demands, there is a considerable interest in employing process-based models to better our scientific understanding of where storm water runoff is generated and how it interacts with other urban hydrologic fluxes. Because runoff generation is influenced by processes such as saturation-excess or infiltration-excess overland flow, this study must rely on coupled surface-subsurface hydrologic models such as RHESSys, GSSHA, or ParFlow. CLM, which can represent three-dimensional soil water redistribution within the subsurface. These models are not as widely used as empirical models, which may not represent the subsurface at all, or models that cannot simulate 3-D subsurface hydrology (e.g., SWMM), due to their computational requirements, but process-based modelling studies have yielded practical insights into how complex spatiotemporal drivers affect urban hydrologic processes.

These insights include identifying where deteriorating water and wastewater infrastructure may be more strongly controlling subsurface hydrology than land surface characteristics, how impervious connectivity can be used to improve transpiration in arid settings, and how the spatial arrangement of low-impact practises can be used to improve runoff reduction. The pursuit of these catchment-scale research topics is beneficial to catchment-scale management goals, but the matching model domain size limits a full depiction of sub parcel characteristics and processes.

Lateral water exchanges on residential parcels across impervious-pervious interfaces

Unfortunately, simplifying sub parcel characteristics means ignoring a critical context in urban hydrology: the interfaces between impervious and pervious surfaces. These interfaces can be found in a residential parcel at downspout outlets as well as the margins of driveways, walkways, and front walks. They are persuasive scientifically because they are ecohydrological: zones that emerge dynamically in time ("hot moments" driven by precipitation) and space ("hot spots" of infiltration) that influence the interchange of water and other fluxes between the two types of land cover. Runoff can be moved laterally from impervious to pervious areas at these interfaces, potentially creating stronger wetting fronts that move through the root zone before evapotranspiration losses occur and allowing for localised groundwater recharging. At bigger scales, ecohydrological interactions can have a disproportionate effect and may present chances for successful management actions.

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