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Land-Use Drivers of Carbon and Sediment Dynamics in Urban Stormwater Management Ponds

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Urban Stormwater Management Ponds (SWMPs) function as engineered biogeochemical reactors that intercept sediment and nutrient fluxes associated with the urban stream syndrome before they reach downstream aquatic systems. Although SWMPs are well recognized for sediment and nutrient retention, the extent to which upstream catchment land-use governs the dynamics of carbon speciation within pond sediments, particularly particulate organic carbon (POC) and particulate inorganic carbon (PIC), remains poorly understood. In this study, we quantified the influence of residential and industrial catchments on sediment quantity and carbon partitioning across 100 SWMPs in southern Ontario, Canada. By linking catchment characteristics, sediment properties, and carbon speciation, a process-based modeling framework was developed for land-use-informed sediment management, disposal planning, and evaluation of carbon burial potential in urban stormwater infrastructure. Event-based pollutant loads were estimated for the 100 selected SWMPs using SWMM and WinSLAMM and evaluated against empirical datasets from two intensively monitored SWMPs (Wabanaki and Activa ponds in the City of Kitchener). Total suspended solids (TSS) concentrations demonstrated strong predictive capacity as a surrogate for particulate carbon loads ($R^2 = 0.91$), supporting its use in scaling up the carbon fluxes across modeled systems. This study indicated pronounced land-use-dependent differences in sediment and carbon accumulation in urban SWMPs.