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Quantifying the Source-to-Sink Transport of Microplastics in Urban Stormwater Catchments

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Urban stormwater runoff is a critical pathway for microplastic (MP) pollution entering aquatic environments. This study quantified MP loads, yields, and retention efficiencies across five stormwater catchments (SWCs) and their receiving stormwater ponds (SWPs) with different land-use characteristics in the City of Kitchener, Canada. We integrated an approach by combining Laser Direct Infrared (LDIR) spectroscopy, targeting particles between 20 and 500 µm, with hydrological modeling, sediment accumulation surveys, and particle-to-mass conversion calculations. Inflow MP concentrations to the SWPs ranged from 4.9×10^{6} to 4×10^{7} particles m^{-3} and total SWC area yields ranged from 1.7×10^{10} to 1.9×10^{11} particles ha^{-1} yr^{-1}. Fragments were the dominant morphology (94–98% by count) and, while particles <100 µm comprised over 92% of counts, they represented only 32–61% of MP mass. Notably, MP yields showed no correlation with broad land-use categories of the SWCs; instead, they were positively associated with specific land use characteristics such as residential population density and degree of imperviousness. Strong correlations were found with rubber and several polymer-specific yields, reinforcing the role of road traffic as a primary source. The SWPs functioned as significant sinks, retaining 39–91% of inflowing MPs on a particle basis and 36–89% on a mass basis. Retention was highly size-dependent. Surprisingly, smaller MPs (<100 µm) were consistently retained at >60%, whereas coarser fractions were captured less efficiently. Retention efficiency also varied by polymer type, with polypropylene and poly(methyl methacrylate) (PMMA) showing high retention (72–95% and 38–100%, respectively), while polystyrene exhibited usually lower and more variable retention. Despite these high efficiencies, outflow MP loads remained substantial, with one SWP releasing loads nearly an order of magnitude higher than the others. These findings demonstrate that while SWPs significantly attenuate MP loads, standardized monitoring protocols are essential to account for the complex interactions between polymer composition, size distribution, and catchment characteristics.