Monitoring and Modeling Phosphorous Fluxes from Urban Stormwater to Evaluate Potential Strategies for Reducing Phosphorous Export

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Abstract

Urbanization influenced increasing impervious area, altered hydrologic and ecological dynamics is contributing to increased rate of phosphorus accumulation and transportation to freshwater system through stormwater runoff. Degradation of water quality due to harmful algal bloom from surplus nutrient has led to regulations aimed at reducing phosphorus loading to urban rivers. To address phosphorus loading in stormwater runoff from dense urban areas, as per regulations, the City of Cambridge, MA, must incrementally reduce its annual phosphorus export over a period of years. Considering the dense urban setup, BMPs with large footprints are not feasible. One potential treatment approach for areas with separated sewers is to divert stormwater to some type of treatment system. However, it is not possible to treat all stormwater. To develop an optimized diversion and treatment strategy, a collaborative study between the City of Cambridge, Stantec, and Northeastern University conducted stormwater sampling to understand the variability in phosphorus export from different urban landscapes. We investigated the phosphorus loading associated with different particle size fractions during runoff events from varied land uses. The focus on particle size provides a connection to flow velocities required for transport (i.e., shear stress), which can be modeled and potentially used to trigger flow diversions. In this study, hourly stormwater sampling was performed during nine storm events in four different watersheds over the period June 2018 - April 2021. Each sample was divided into five subsamples based on particle size and were analyzed for total phosphorus and total solids. Hysteresis analysis on the different particle size fraction associated phosphorus content provided insight to the temporal variations of influx from a complex urban landscape. We evaluated four flow diversion strategies and determined potential pollutant removal efficiency for BMPs based on flow conditions and particle sizes. To further the application of the proposed division strategies, results are presented using the NRCS CN model to estimate runoff and a coefficient-based model to estimate Phosphorus export. Our findings suggest that common models have the potential to support efforts evaluating Phosphorus removal strategies.