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The climate change impact of urban stormwater ponds: insights from whole-system carbon budgets

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Stormwater ponds (SWPs) are a common urban runoff best management practice that can also have positive impacts on downstream water quality. However, the emission of greenhouse gases (GHGs), such as carbon dioxide (CO_2) and methane (CH_4), from SWPs raises questions about their net climate impact. Here, we establish whole-system annual carbon budgets for two SWPs in the City of Kitchener, Ontario, Canada, to compare the open water CO_2 and CH_4 effluxes to the other external and within-system carbon fluxes. The assembled budgets include the fluxes of particulate and dissolved inorganic carbon and OC (PIC, DIC, POC and DOC) associated with the catchment-derived inflows and stormwater outflows, those associated with sediment burial, and those associated with soil erosion and litterfall from the embankment and riparian zones. The results indicate that the OC delivered to the permanent pool from the embankment and riparian zone via a combination of soil erosion plus vegetation-derived litter and organic detritus inputs, represent between 25 and 47% of the OC inputs to the permanent pool at the two SWPs. For the OC reaching the permanent pool, the two SWPs exhibit similar sediment OC recycling efficiencies, burying 86 to 88% of the OC delivered to the sediments, while decomposing the rest and releasing it as either DIC, CO_2, or CH_4. Despite the similar OC recycling efficiencies, the ratio of the sediment effluxes of CH_4 versus those of DIC plus CO_2 differ between the two ponds, indicating differences in the relative importance of mineralization and fermentation/methanogenic pathways. Altogether, the whole-system budgets reveal that the entire engineered SWP systems, including the permanent pool plus the embankment and riparian zone, act as net CO_2 sinks as well as net GHG sinks. These results point to the potential to design and manage SWPs for enhanced climate change mitigation. Examples of such solutions include: the targeted planting and maintenance of embankment and riparian vegetation, the strategic removal of SWP sediments, and geochemical amendments which reduce CO_2 and/or CH_4 emissions. Our results also provide insights for upscaling carbon budget flux estimates to other SWP systems.