Carbon Budget of an Urban Stormwater Pond: Importance of Riparian Vegetation

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Motivation & Objective

Background

- Small inland freshwater bodies – natural and engineered – are reactive interfaces for carbon (C) and nutrient cycling (Fig. 1).
- While small ponds and lakes (<1 ha) only comprise about 15% of total inland water surface area, they have been estimated to contribute 24% of total CO_2 emissions from inland water bodies.

Objective

- Establish the C budget of an urban stormwater pond (SWP) to determine whether the SWP is a net CO_2 source or sink.

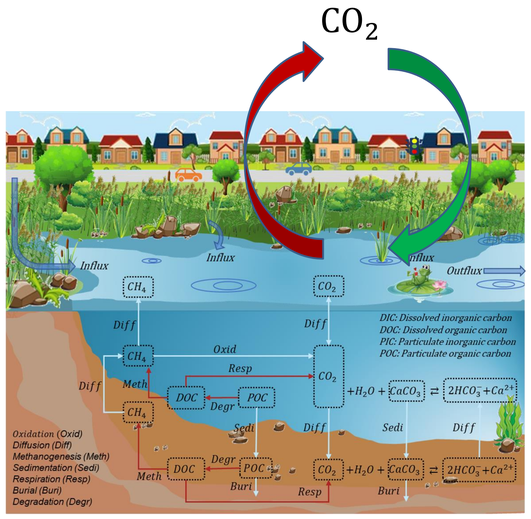


Fig. 1. Carbon cycling in SWPs

Materials and methods

- The studied SWP (0.21 ha) receives runoff from an urban residential area (12.5 ha) and drains into Lake Ontario through the Rouge River (Fig. 2)

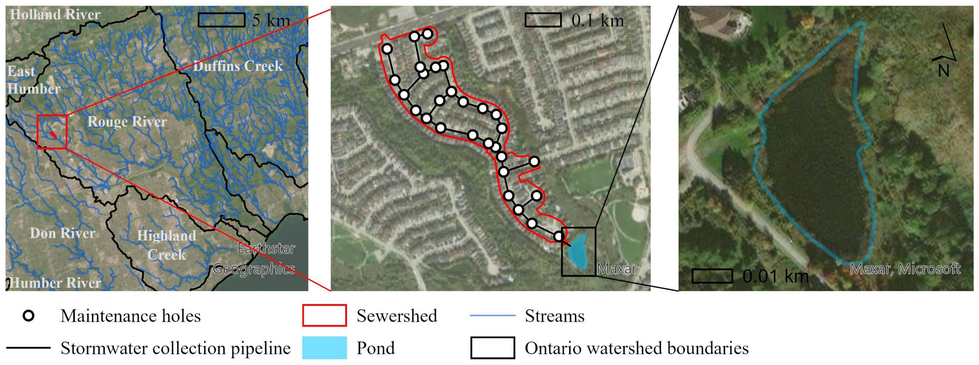


Fig. 2. SWP study site, Richmond Hill, ON, Canada

- Annual in- and output fluxes of different C species (DIC, DOC, PIC and POC) were calculated by multiplying the annual flow-weighted event mean concentrations with the water inflow simulated using the PC-SWMM storm water management model initially developed by the US Environmental Protection Agency.
- TIC and TOC burial fluxes in the SWP were estimated from the sediment burial rate and the respective sediment concentrations measured on sediment core samples.
- The CO_2 flux across the water-air interface (WAI) was estimated from the difference in the partial of pressure CO_2 (pCO_2) in the pond water and in the atmosphere according to:

$$F = k \times \alpha \times \left(pCO_{2(water)} - pCO_{2(atmosphere)}\right)$$

$$F = \text{flux}, k = \text{gas transfer velocity}, \alpha = \text{solubility constant of } CO_2$$

Results

- Pond water pCO_2 > atmospheric pCO_2 in majority of sampling times → SWP emits 55×10^3 moles CO_2-C/year CO_2 via the WAI → suggests SWM is a CO_2 source.
- Total sewershed input of organic plus inorganic C (34×10^3 moles C/year) into the SWP is nearly equal to the total output (33×10^3 moles C/year) from the SWP (Fig. 3).
- Burial of C in the pond sediments equals 31×10^3 moles C/year → missing C input of 29×10^3 moles C/year.
- In addition, the input of total suspended matter (SPM) with stormwater inflow is not sufficient to explain the sediment accumulation in the pond → missing sediment input !
- Solution: soil bank erosion is a major source of C to the pond and decomposition of soil POC produced by riparian vegetation generates most of the CO_2 emitted by the pond (~90%).

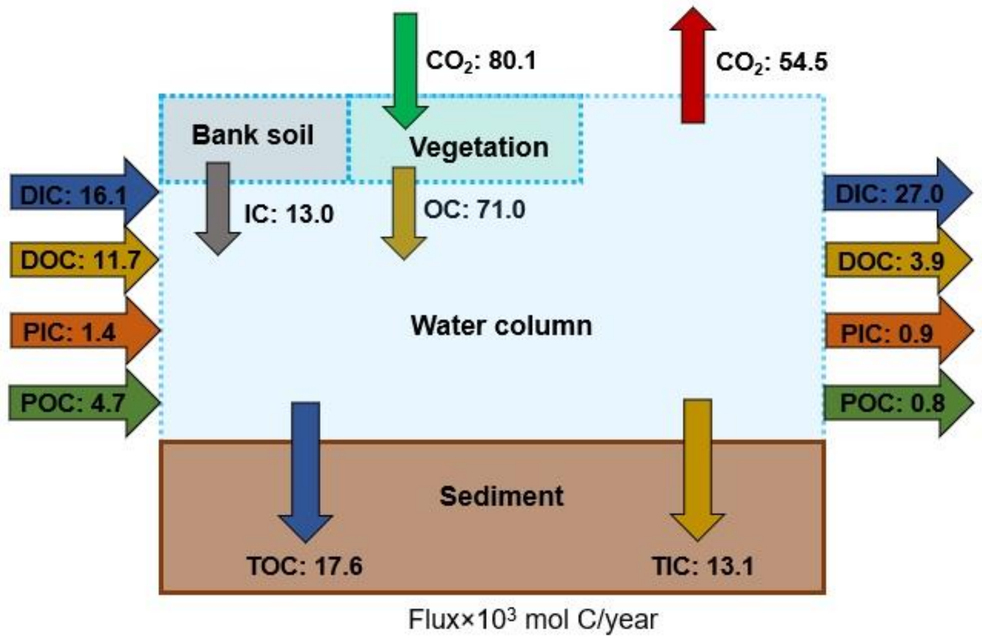


Fig. 3. SWP's carbon budget

Conclusions and significance

- The SWP acts as a net carbon sink although it emits CO_2. Carbon inputs from the catchment contribute only a small fraction of the CO_2 emission from the pond.
- Mineralization of OC generated photosynthetically by riparian vegetation and released to the pond by bank erosion is the most important pathway of CO_2 emission.
- If the vegetation surrounding the SWP is included in the C budget, the pond-riparian zone system becomes a net CO_2 sink.
- Next, emissions of methane and nitrous oxide will be considered.

Acknowledgements

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References

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