A hydrologically and geochemically based bioretention model for carbon sequestration

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Highlights

- Bioretention system.
- Carbon sequestration model.
- Soil CO_2 and N_2O fluxes

Introduction

Bioretention system is probably the most popular SCM among GSI implemented worldwide. Although its hydrology and pollutant removal mechanisms have been extensively studied, its potential capability of carbon sequestration has not been well studied. Several studies observed that bioretention system likely to be a sink, but another observed large emissions of nitrous oxide and methane. To understand whether the current bioretention system is a sink or source, and to optimize the design of the bioretention system such that its benefits can extend beyond stormwater control, a Bioretention system is probably the most popular SCM among GSI implemented worldwide. Although its hydrology and pollutant removal mechanisms have been extensively studied, its potential capability of carbon sequestration has not been well studied. Several studies observed that bioretention system likely to be a sink, but another observed large emissions of nitrous oxide and methane. To understand whether the current bioretention system is a sink or source, and to optimize the design of the bioretention system such that its benefits can extend beyond stormwater control, a hydrologically and geochemically based model is needed to simulate the long-term performance of the bioretention system model is needed to simulate the long-term performance of the bioretention system. In this paper we derived a system of differential equations that combines hydrologic process with nutrient influxes, plant root respiration, organic matter decomposition and microbial-mediated nitrification and denitrification. The model was tested in a block of bioretention cells designed for this study.

Methodology

Model development

The model consists of a system of differential equations that describes the hydrologic process of the bioretention system, the nitrogen transformation in the growing media and in vegetations, and microbial nitrification and denitrification process in macroscale.

Model test

The parameters in the model will be measured in a control experiment in lab and calibrated in a pilot field designed for this study. A continuous monitoring program will be setup at least for a year.

Results and discussion

Monitoring data will be analyzed first. Then the model will be calibrated using field monitoring data. A reasonable range of parameters in the model will be given for the users.

Conclusions and future work

The hydrologic process of the studied bioretention system can be adequately modelled. The carbon sequestration is a complex process, and the modelling results are within reasonable errors. The key points will be pointed out for the future studies.

References

Humberto BC and Rattan L. (2004). Mechanisms of Carbon Sequestration in Soil Aggregates. Critical Reviews in Plant Sciences, 23(6):481–504.

Olatunde J. A. and Hunter J. (2020). Stormwater Efficiency of Bioretention Functions and Reactor Modelling Systems. International Journal of Advances in Scientific Research and Engineering. 6(11), 1-9.

Samantha P.P. G., Cohan A, Chan H.S. and Livesley S. J., Beringer, J. and Daly E. (2013). Occasional large emissions of nitrous oxide and methane observed in stormwater biofiltration systems. Science of the Total Environment 465, 64–71.

Shrestha P., Hurley S.E. and Adair E.C. (2018). Soil Media CO2 and N2O Fluxes Dynamics from Sand-Based Roadside Bioretention Systems. Water, 10(185), 1-20.