Advancing the use of DWTRs in stormwater treatment features to enhance phosphorus removal for transportation projects

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Background

Prior laboratory and field research at University of Vermont has shown that drinking water treatment residuals (DWTRs), byproducts of drinking water treatment using aluminum-based materials, have high phosphorus (P) sorption capacity and can aid in the removal of dissolved P in stormwater treatment systems such as roadside bioretention.[1,2]

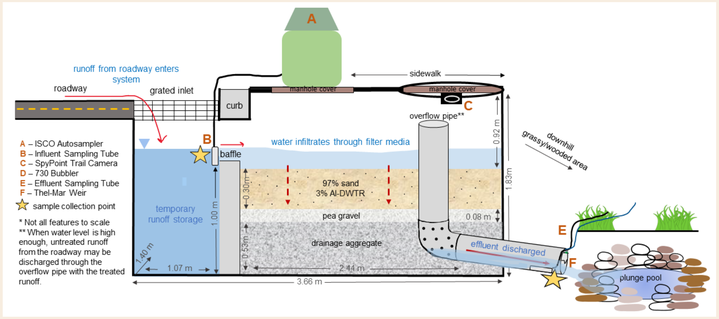

Figure 1. Sampling schematic for the smaller catchment sand filter showing the design and equipment used for stormwater monitoring. The larger catchment sand filter design differed but used similar media and was monitored using the same methods. Forty-seven events were monitored in total across the two sites by taking time-based sub-samples of stormwater inflow to, and outflow from, the sand filters.

Project Objective

Our objective was to evaluate P load reduction performance for two stormwater treatment sand filters amended with DWTRs. These filters were constructed with a uniformly mixed filter media consisting of ≥95% sand and ≤5% DWTRs. One filter receives runoff from a small catchment (1.8 acres) at a residential site (Fig. 1) and the other from a larger catchment (4.5 acres) in an industrial/commercial area (not pictured).

Results

The composition of stormwater runoff received at both sites was markedly different, dominated by dissolved P at the smaller catchment site, and mostly particulate P at the larger catchment site. Due to this difference in influent water quality, 99% of the total P removed by the sand filter at the smaller catchment site was dissolved P, while 4% of the total P load removed at the larger catchment site was dissolved P. Because dissolved P removal by sand filters without DWTR amendments tends to be negligible (i.e., non-DWTR sand filters mainly remove particulate P forms), dissolved P reductions observed at both research sites can be attributed to the addition of DWTRs. Overall, the two systems reduced total P loads by 65-78% (Fig. 2).

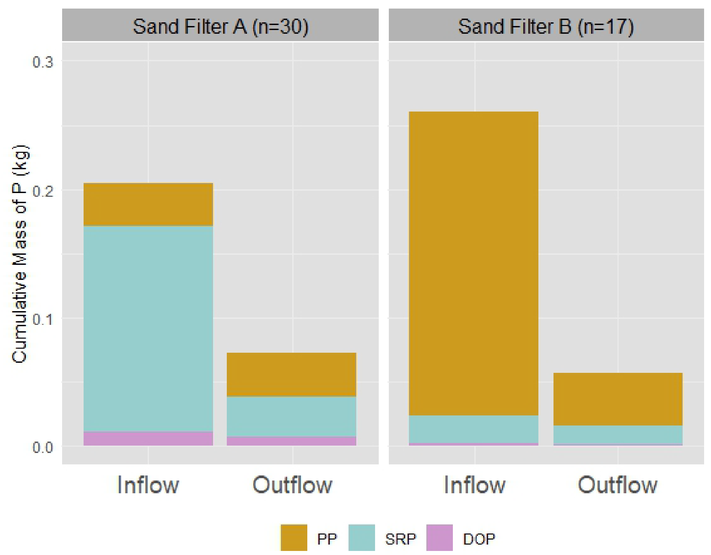

Figure 2. Cumulative phosphorus (P) inflow and outflow mass loads (kg) for each sand filter and P species, including particulate P (PP), soluble reactive P (SRP), and dissolved organic P (DOP). Bars represent the total mass of each P species for n=30 events at site A (smaller catchment) and n=17 events at site B (larger catchment).

Impacts and Benefits

Mixing DWTRs into sand media-based stormwater infrastructure can enhance P removal from stormwater. As the first field study of sand filters enhanced with DWTRs in VT, this study clarifies anticipated P load reductions for DWTR-amended sand filters and provides guidance for future stormwater treatment practices used in transportation projects. Anticipated benefits of this practice include: 1) no substantial additional cost, 2) reuse of local residual material that would otherwise be discarded/landfilled, and 3) increase in the longevity of P removal, targeting dissolved P that often passes through or is exported from stormwater treatment practices.

Acknowledgments

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References

[1] Ament, M. R., Hurley, S. E., Voorhees, M., Perkins, E., Yuan, Y., Faulkner, J. W., & Roy, E. D. (2021). Balancing hydraulic control and phosphorus removal in bioretention media amended with drinking water treatment residuals. ACS ES&T Water, 1(3), 688-697.

[2] Ament, M. R., Roy, E. D., Yuan, Y., & Hurley, S. E. (2022). Phosphorus removal, metals dynamics, and hydraulics in stormwater bioretention systems amended with drinking water treatment residuals. Journal of Sustainable Water in the Built Environment, 8(3), 04022003.