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

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Introduction

Prior laboratory and field research at University of Vermont has shown that drinking water treatment residuals (DWTRs), a byproduct of drinking water processes 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] To provide additional field verification of effective P removal from stormwater and inform use of DWTRs in transportation projects, two stormwater treatment sand filters amended with DWTRs were studied. These filters were constructed with a uniformly mixed filter media consisting of ≥95% sand and ≤5% DWTRs in Chittenden County. One filter receives runoff from a small catchment (1.8 acres) at a residential site (A) and the other from a larger catchment (4.5 acres) in an industrial/commercial area (B) (Fig. 1). DWTRs were obtained from a local drinking water treatment facility. The UVM research team studied P inputs to and outputs from these DWTR-amended sand filters during rain events.

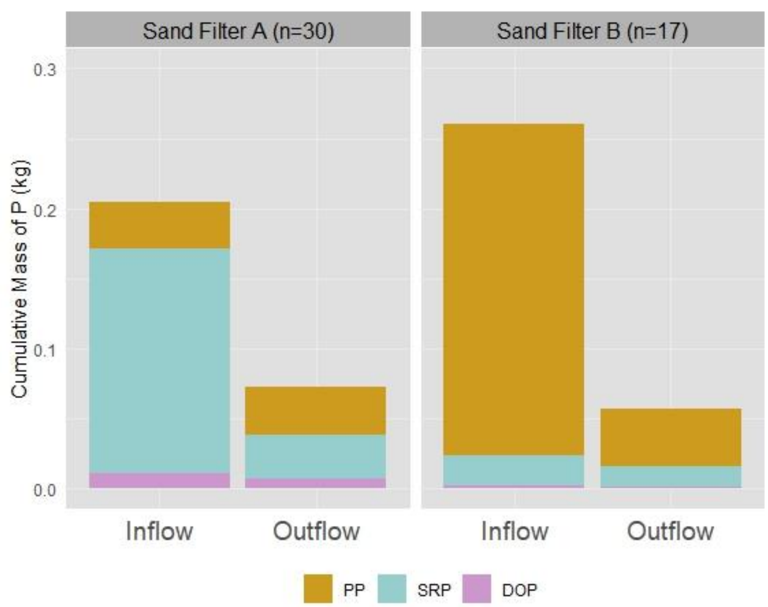

Figure 1. Cumulative phosphorus (P) inflow & outflow mass loads (kg) for each sand filter & P species, including particulate P (PP), soluble reactive P (SRP), & dissolved organic P (DOP). Bars represent the total mass of each P species for n=30 events at site A (smaller catchment) and n=17 events at site B (larger catchment).

Project Methodology

Events were monitored by taking time-based sub-samples of stormwater inflow to, and outflow from, the sand filters using auto-sampler equipment. Sub-samples were composited for each storm event and analyzed for concentrations of total phosphorus (TP), total dissolved phosphorus (TDP), particulate phosphorus (PP), soluble reactive phosphorus (SRP), dissolved organic phosphorus (DOP), and chloride (Cl^-). Concentration data, paired with flow data recorded from a combination of pressure transducers and volumetric weirs, were used to estimate influent and effluent P loads for each event. A total of 47 rain events between the smaller (A) and larger (B) sites were monitored as part of this project. Persistent low flow was observed between rain events at the larger site B but was not included in P load estimates.

Conclusions

The composition of stormwater runoff received at both sites was markedly different, dominated by dissolved P at the residential site, and mostly particulate P at the industrial/commercial site. Due to this difference in influent water quality, >99% of the total P removed by the residential sand filter was in the form of dissolved P, while 4% of the total P load removed at the industrial/commercial 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% (Figure 1).

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.

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.

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