

Multiyear Study on Phosphorus Discharge from Extensive Sedum Green Roofs with Substrate Amendments

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ABSTRACT

Green roofs are implemented for providing urban ecosystem services like stormwater management, but they have also been identified as a potentially significant source of phosphorus in the runoff, which may cause concern for downstream water quality. A multiyear evaluation of phosphorus in green roof discharge and alternatives for phosphorus mitigation was conducted using 32 pilot-scale experimental green roofs. The extensive green roofs were made from nonproprietary base substrates [90 volumetric percentage (%v/v) lightweight aggregate (either pumice or expanded clay) and 10%v=v compost] and planted with a variety of sedum species. The roofs were initially constructed in 2017, and 38 storm events were sampled over four growing seasons for precipitation, runoff volumes, and total phosphorus (TP) event mean concentrations (EMCs) in discharge from the experimental extensive green roofs and a reference roof. All extensive green roofs tested were a source of elevated TP EMCs compared with the reference roof for the entire monitoring period. The green roofs initially exhibited high TP EMCs and variability, ranging from 0.46 to 0.89 mg=L (first and third quartiles), compared with the reference roof (90% of TP EMCs were below 0.05 mg=L). Green roof TP EMCs decreased to 0.11 and 0.19 mg=L (first and third quartiles) by the fourth growing season. A combination of measurement and modeling determined that a net reduction in annual cumulative TP mass discharged from the green roofs compared with the reference roof may be achieved because of the stormwater retention capacity of the green roofs. Amending materials, including zeolite, wood-derived biochar, and oat hull-derived biochar, were tested as a downstream permeable reactive barrier or as an additive in the base substrate (zeolite only). A zeolite addition of 20%v=v resulted in lower TP EMCs discharged than the base green roofs (without amendments). None of the other materials tested showed TP mitigating effects. There was no difference in TP EMCs among base green roofs after one growing season. The study highlights the initial excessive phosphorus content of the substrates exceeds the needs of sedum species and results in rapid phosphorus release in runoff discharged from green roofs.

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