Stormwater Research Summary Banner

Objective 3: Phosphorus Release from Stormwater Ponds

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Stormwater ponds are one of the mostly widely used approaches for mitigation of negative impacts of runoff in cities. There is growing concern that aging ponds may become net sources of phosphorus (P) to lakes and streams via release of P previously deposited to sediments. Stormwater ponds often have high external P loads, and thus have the potential for internal loading as ponds age. However, the ability of these systems to retain phosphorus over their lifespan is currently unknown. To address this issue, we combined information from analyses of a survey of surface water P concentrations in 98 ponds in the Twin Cities (Minnesota, USA), P release rates and characterization of sediment chemistry in five ponds, and annual mass balances and analyses of mixing regimes and oxygen status from three ponds.

As an initial assessment of the potential for internal loading in stormwater ponds, surface water total P concentrations in surface waters of 98 ponds in the Twin Cities area were compared to characteristic stormwater runoff concentrations in the region. In 1/3rd of these ponds, water column P exceeded that of mean stormwater runoff concentrations. Elevated P above runoff concentrations persisted in these ponds during much of the warm season, consistent with effects of release of P from the sediments back to the water column.

Measurement of P release from sediments (i.e. internal loading) were used to examine rates of rerelease of phosphorus within ponds and its environmental controls. Sediment cores sampled from five ponds showed that dissolved oxygen availability strongly controlled affected behavior of sediment P, with little release under oxic conditions and high release initiated with onset of anoxia. Characterization of sedimentary P fractions showed large pools of P present in redox sensitive and organic forms, from which P may be more readily released by variations in oxygen. Together, these data suggested that sediment oxygen status affected release of P via both iron binding and microbial recycling of organic P.

Annual mass balance estimates were used to assess retention of P within ponds. The three ponds had low to modest levels of P input and surface water concentrations that were lower than the elevated surface water P of ~1/3rd of surveyed ponds discussed above. These measurement compared P loading from runoff into ponds to that in their outflows. Strong net retention of P in three ponds was observed at annual scales with percentages of P removal by ponds falling into the range expected from previous studies. P retention at event scales depended on both P removal processes within ponds and the available storage volume of water in ponds, which was increased by water losses from evaporation or infiltration to groundwater prior to storm events.

The three intensively monitored ponds were strongly stratified, and did not mix vertically, over much of the study period, with full water column mixing confirmed only in the fall. During the ice free season mixing was inhibited by a combination of chemoclines (i.e. chemical gradients, observed in spring due to road salt runoff) and thermoclines (temperature gradients, due to warm temperatures during the summer and sheltering from wind by trees). Lack of mixing was surprising since stormwater ponds are shallow and designed to mix frequently to avoid hypoxic conditions in the sediments. Anoxia in the bottom waters persisted for over approximately 85% of the year in all three ponds, due to lack of mixing and high rates of heterotrophic respiration.

Results of our study reveal complex processes regulating the retention and release of phosphorus in stormwater ponds. Further research is needed to develop predictive knowledge and practical tools for identification and management of ponds that fail to meet intended water quality outcomes.

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