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Chemical characterization of sediment "Legacy P" in watershed streams – implications for P loading under land management

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Transfer of dissolved phosphorus (P) in runoff water via streams is regulated mainly by both stream sediment P adsorption and precipitation processes. The adsorption capacity of stream sediments acting as a P sink was a great benefit to preserving water quality in downstream lakes in the past, as it minimized the effects of surplus P loading from watershed streams. However, with long-term continued P loading the capacity of the sediments to store P has diminished, and eventually converted stream sediments from P sinks to sources of dissolved P. This accumulation of 'legacy P' in stream sediments has become the major source of dissolved P and risk to downstream water quality. Agricultural best management practices (BMP) for P typically attempt to minimize the transfer of P from farmland. However, because of the limitation in sediment P adsorption capacity, adoption of BMPs, such as reduction of external P loading, may not result in an immediate improvement in water quality. The goal of the research is to chemically characterize the P forms contributing to legacy P in stream sediments located in the watershed connecting to Cook's Bay, one of three basins of Lake Simcoe, Ontario, Canada. This watershed receives the largest amount of external P loading and has the highest rate of sediment build-up, both of which are attributed to agriculture.

Water samples were collected monthly at six study sites from October 2015 for analysis of pH, temperature, dissolved oxygen, total P, dissolved reactive P, particulate P, total N, NH4-N, NO_3-N, TOC and other elements including Al, Fe, Mn, Mg, Ca, S, Na, K and Zn. Sediment core samples were collected in November 2015 and will continue to be collected in March, July and October 2016. Various forms of P in five vertical sections were characterized by sequential fractionation and solution 31P NMR spectroscopy techniques. Pore water, sediment texture and clay identification were performed. The concentration of total P in water samples were ∼equal or less than the Ontario Provincial Water Quality Objectives (PWQO) of 0.03 mg P L-1 except at a site located in the stream in the Holland Marsh, which was ∼7 times greater. Forms and distribution of P varied with sediment section and sampling site. The range of total sediment-P was from ∼0.8 to 2.5 g P kg-1 sediment, and at some sites the mobile P forms accounted for > 75% of the total sediment-P.

The study will continue to examine the temporal spatial and vertical distribution of P forms to predict the rates of P release under varying water chemistries. This basic research provides a fundamental approach for characterization of the legacy P in stream sediments, ultimately providing a better understanding of the linkage between changes in agricultural management practices affecting P losses from terrestrial sources and observed changes in surface water quality.