Predicting phosphorus release following wetland restoration

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Restoration of wetlands on reclaimed agricultural lowland has been recognized as one of the most important mitigation options in obeying the quality goals of the European Water Framework Directive. While the nitrogen removal efficiency of restored wetlands is well accepted, the impact of wetland restoration on phosphorus (P) is less obvious. An increasing number of studies have called to the attention that wetland restoration on former agricultural soils may result in phosphorus release. Despite the high priority of wetland restoration there is a serious lack in the documentation of phosphorus dynamics following wetland restoration, and predictive model tools are highly needed. Prediction of phosphorus dynamics in restored wetlands is extremely challenging because of the complex interactions and feedbacks between hydrology, hydrochemistry and sediment geochemistry. We hypothesized, however, that a P risk assessment tool to predict the potential phosphorus releases following wetland restoration could be developed based on easily accessible soil parameters.

A large number of riparian lowlands representing the variation in Danish lowland soil types and geochemistry was sampled and analyzed for a large number of soil parameters including contents and forms of P, Fe, Al. The results demonstrated very large variations in contents of total P (600-16.000 kg/ha in 1 m) in Danish riparian lowland soils, where high contents of TP were correlated with similar high contents of oxalate extractable iron (Fe_{ox}). Oxalate extractable aluminum (Al_{ox}) contributed to more than 50% of the P sorption capacity in 1/3 of the soils investigated, but these soils were generally lower in P-sorption capacity compared to the iron dominated soils. The high amounts of Fe-bound phosphorus in a large number of Danish riparian lowland soils, may be critical for the retention of P as wetland restoration most often facilitates reductive Fe(III) dissolution followed by P release.

Batch and convective-flow column experiments were carried out to investigate the iron reduction kinetics and phosphorus release following rewetting. Soil pore water was analyzed for pH, Fe(III), Fe(II), PO_4-P and total dissolved P (TDP) as a function of time following rewetting. Results indicated that the P release kinetics in organic lowland soils could be described by the soil Fe_{BD}:P_{BD}-molar ratio (BD – bicarbonate extractable), while organic carbon additionally contributed as a key parameter for mineral lowland soils. Predictive models describing potential P release based on key soil parameters will be presented and discussed.