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Constructing wetlands: measuring and modeling feedbacks of oxidation processes between plants and clay-rich material

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Interest is growing in using soft sediment as a building material in eco-engineering projects. Wetland construction in the Dutch lake Markermeer is an example: here the option of dredging some of the clay-rich lake-bed sediment and using it to construct 10.000 ha of wetland will soon go under construction. Natural processes will be utilized during and after construction to accelerate ecosystem development. Knowing that plants can eco-engineer their environment via positive or negative biogeochemical plant–soil feedbacks, we conducted a six-month greenhouse experiment to identify the key biogeochemical processes in the mud when Phragmites australis is used as an eco-engineering species. We applied inverse biogeochemical modeling to link observed changes in pore water composition to biogeochemical processes. Two months after transplantation we observed reduced plant growth and shriveling as well as yellowing of foliage. The N:P ratios of plant tissue were low and were affected not by hampered uptake of N but by enhanced uptake of P. Plant analyses revealed high Fe concentrations in the leaves and roots. Sulfate concentrations rose drastically in our experiment due to pyrite oxidation; as reduction of sulfate will decouple Fe-P in reducing conditions, we argue that plant-induced iron toxicity hampered plant growth, forming a negative feedback loop, while simultaneously there was a positive feedback loop, as iron toxicity promotes P mobilization as a result of reduced conditions through root death, thereby stimulating plant growth and regeneration. Given these two feedback mechanisms, we propose that when building wetlands from these mud deposits Fe-tolerant species are used rather than species that thrive in N-limited conditions. The results presented in this study demonstrate the importance of studying the biogeochemical properties of the building material and the feedback mechanisms between plant and soil prior to finalizing the design of the eco-engineering project.