Geophysical Research Abstracts
Vol. 17, EGU2015-11098, 2015
EGU General Assembly 2015

Distinguishing biogeochemical processes influencing phosphorus dynamics in oxidizing and desiccating mud deposits from a freshwater wetland system

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Focus and aim: Currently, lake Markermeer (680 km^2) provides poor environmental conditions for the development of flora and fauna due to a thick fluffy layer that prevails at the lake's bed. To improve the conditions in the lake, large wetlands will be built from this fluffy layer, possibly mixed with sand or with the underlying Southern Sea deposit. The aim of this study is to distinguish biogeochemical processes influencing phosphorus dynamics in porewater during oxidation and desiccation of mud deposits from this lake. We focus on three important aspects that potentially influence these processes: granulometry, sediment type and modification by plants.

Material and methods: A greenhouse experiment was conducted with three types of sediment that potentially will function as building material for the islands: fluffy mud (FM), sandy mud (SM) and Southern Sea deposit (SSD). Reed (*Phragmites australis*) was planted in half of the pots to distinguish influence by plants. For six months, the porewater-, soil- and plant quality was monitored to determine important biogeochemical processes. Variables measured from the porewater include: Cl^-, NO_2^-, NO_3^-, PO_4^{3-} and SO_4^{2-} (IC); Ca, Fe, K, Mn, Na, P, Si, Sr (ICP-OES); as well as Fe^{2+}, pH, alkalinity and EC. A phosphorus fractionation was carried out on the sediment to determine the phosphorus pools and the major elements of the sediments were determined following an aqua regia destruction using ICP-OES. Plant tissue was analysed for N, P, K and C content as well as the above- and belowground biomass.

Results and discussion: It was found that sulfate production was the most important process influencing phosphorus availability in these soils. Due to oxidation processes in the mud, sulfate (SO_4^{2-}) concentrations rose drastically in porewater from 100 ppm at the beginning of the experiment to well over 2000 ppm at the end of the experiment. This effect was strongest in SSD soils, likely due to higher presence of pyrite that gets oxidized. Furthermore, SO_4^{2-} concentrations are higher in SM than in FM soils, likely due to oxygen presence as an increase in pore size leads to enhanced oxidation. Presence of reed also enhanced sulfate production by actively pumping oxygen into the soils. Almost twice as much phosphorus is present in SSD than in FM soils (1348 and 773 mg/kg respectively). This difference is explained by the amount of iron bound phosphorus in SSD and FM soils (28.9 and 11.7 μM/gr respectively), with the remaining 4 phosphorus pools being roughly the same. In combination with the high concentrations of SO_4^{2-}, it is expected that a lot of phosphate will be mobilized during flooding events. When oxygen is replaced by water, reduction of SO_4^{2-} to S_2^- will cause reduction of Iron(III) (hydr)oxides and iron bound phosphate leading to phosphate mobilization.

Conclusion: Due to a difference in intrinsic properties of the building material, especially in terms of sulfate and iron-bound phosphate, it is expected that the phosphorus dynamics (and concomitantly also ecosystem development) on the future island will greatly depend on the sediment type used.