Improving groundwater dynamics: A key factor for successful tidal marsh restoration?

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Introduction and goals

In the past centuries, many tidal marshes along estuaries and coasts have been embanked to gain land for industry and agriculture, leading to severe problems such as an increased flooding risk, loss of biodiversity and a deteriorating water quality. Nowadays, numerous of these former marshes are being restored to recover their ecosystem functions. There are, however, more and more indications that restored tidal marshes do not deliver these ecosystem services to the same extent as natural tidal marshes. In particular, we hypothesize that a reduced groundwater flow, caused by historical agricultural soil compaction, implies a reduced nutrient cycling and decreased contribution of restored marshes to water quality improvement. In a combined field and modelling study, we aim to get insight in how groundwater and biogeochemical functioning (e.g. retention of phosphorus and nitrogen and export of dissolved silica) are related in natural and restored tidal marshes. In an *in situ* mesocosm experiment, we are currently testing the effect of different soil amendments (see below) on groundwater and nutrient dynamics. the ultimate goal of this project is to formulate viable design criteria for future tidal marsh restoration projects.

Conducted research

We measured groundwater flow and soil properties in both a natural freshwater tidal marsh (De Plaat) and a restored freshwater tidal marsh (Lippenbroek) along the Scheldt. The soil in the restored marsh consists of a layer of freshly accreted sediment, underlain by compact relict agricultural soil. Our results indicate that groundwater level fluctuations are occurring over a deeper soil profile in the natural marsh compared to the restored marsh, where groundwater level fluctuations are restricted to the layer of freshly accreted sediment. Using X-ray CT-scans of soil cores, we found that the soil in the natural marsh and the upper layer of the restored marsh is intersected by macropores that increase the hydraulic conductivity of the sediment, whereas these macropores are absent in the compacted agricultural soil. As a result, the compact agricultural soil forms a barrier for groundwater flow and puts constraints on the amount of pore water that is exported to the creeks in between tidal events. By consequence, nutrient cycling in restored tidal marshes is expected to be negatively affected.

Ongoing mesocosm experiment

In a polder area, three different soil treatments were locally applied: ploughing, ploughing + adding reed cuttings and ploughing + adding wood chips. In each of the treatment plots and in one untreated (blanco) plot, an undisturbed soil monolith of 150 cm wide and 75 deep was excavated. The monoliths were then placed in a mesocosm construction in the Scheldt river. At high tide, the monoliths inundate and water can infiltrate into the soil. During low tide, water can drain out of the monoliths. We will compare groundwater level changes in the monoliths to see whether the soil treatments affect drainage. Furthermore, we will also compare the biogeochemical functioning of the treatment soils by comparing the nutrient concentrations in the drainage water of each monolith with nutrient concentrations in the flooding water.

Keywords: groundwater flow; tidal marsh restoration; biogeochemical cycling