Groundwater flow in freshwater tidal marshes: A comparison of a natural and a restored marsh

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Numerous tidal marsh areas are being restored for flood protection and ecological development along estuaries. Recently, however, questions arise about the extent to which restored marshes deliver ecosystem services. Due to the historical land use, soil properties and associated subsurface water flow might be altered in restored marshes, hereby affecting important ecosystem functions. In this study we mapped the physical movement of water in the soil of a natural and a restored freshwater tidal marsh for the first time. Furthermore, this research served as a pilot study to evaluate different methods to assess estuarine subsurface hydrology.

A newly developed method for *in situ* groundwater flux measurements (integrated passive flux sampler) was used in combination with measurements of soil characteristics and groundwater level time series along a transect. Special attention was paid to the presence of organic matter and macro pores (using CT-scanning) in the soil, and their effect on subsurface groundwater flow.

Our results indicate that the soil in the restored marsh consists of a layer of freshly accreted sediment, characterized by a large organic matter content and macroporosity, and an underlying layer of compacted agricultural polder soil with a low organic matter content and few macropores. Both layers differ significantly from each other and from the soil in the natural marsh. Furthermore, the underlying polder soil in the restored marsh was found to put constraints on the amount of pore-water that is exported to the creek in between tidal events.

As a result, fluxes of nutrients, the source-sink function and the development of vegetation in the restored marsh might be negatively affected. For new marsh restoration projects, we therefore suggest to explore the possibility to mix the agricultural polder soil with organic matter to induce the formation of macropores, which will ultimately lead to an improved ecosystem service delivery.

Keywords: Scheldt estuary; marsh restoration; pore-water; groundwater flux; macroporosity