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Linking sediment structure, hydrological functioning and biogeochemical cycling in disturbed coastal saltmarshes and implications for vegetation development

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Saltmarsh restoration undoubtedly provides environmental enhancement, with vegetation quickly re-establishing following the breach of sea walls and subsequent tidal inundation of previously defended areas. Yet evidence increasingly suggests that the restored saltmarshes do not have the same biological characteristics as their natural counterparts (Mossman et al. 2012) and this may be in part be due to physicochemical parameters at the site including anoxia and poor drainage. Hence, restored saltmarshes may not offer the range and quality of ecosystem services anticipated. These environments will have been ‘disturbed’ by previous land use and there is little understanding of the impacts of this disturbance on the wider hydrogeomorphic and biogeochemical functioning in restored saltmarshes and the implications for saltmarsh vegetation development.

This study examines linkages between physical sediment characteristics, sediment structure (using X-ray microtomography), sub-surface hydrology (using pressure transducers and time series analysis), and sediment and porewater geochemistry (major and trace elements, major anions) in sediment cores collected from undisturbed saltmarshes and those restored by de-embankment.

Sub-surface sediments in restored saltmarshes have lower organic matter content, lower moisture content and higher bulk density than undisturbed sites. Using X-ray tomography a clear horizon can be observed which separates relict agricultural soils at depth with less dense and structureless sediments deposited since de-embankment. Ratios of open to closed pore space suggest that while undisturbed saltmarshes have the highest porosity, restored saltmarshes have larger void spaces, but limited pore connectivity.

Sub-surface hydrological response to tidal flooding was subdued in the restored compared to the undisturbed site, suggesting that porewater flow may be impeded. Time series analysis indicated that flow pathways differ in restored saltmarsh sediments with preferential horizontal flows.

The undisturbed saltmarsh displayed typical vertical geochemical sediment profiles. However, in the restored sites total Fe and Mn are elevated at depth indicating an absence of diagenetic cycling, whilst porewater sulphate and nitrate increased at depth suggesting that vertical solute transport is impeded in restored sites. In surface sediments, though total Hg concentrations are similar, Hg methylation rates are significantly higher than in the undisturbed saltmarsh suggesting that surface anoxia and poor drainage may result in increased mobilization and bioavailability of Hg.

These findings have implications for the wider biogeochemical ecosystem services offered by saltmarsh restoration and the water-logged, anoxic conditions produced are unsuitable for seedling germination and plant growth. This highlights the need for integrated understanding of physical and biogeochemical processes.