Phosphorus sequestration in sediments populated by cable bacteria in the seasonally hypoxic Gulf of Finland

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Excessive anthropogenic nitrogen (N) and phosphorus (P) inputs to the Baltic Sea have led to eutrophication and widespread seasonal bottom water oxygen depletion ('hypoxia'). Filamentous cable bacteria can enhance the formation of manganese (Mn) oxides and iron (Fe) oxides and the sequestration of P in sediments. Here, we assess the Mn, Fe and P dynamics in sediments at seasonally hypoxic sites in the Gulf of Finland, using a combination of pore water analyses, sequential sediment extractions and synchrotron-based X-ray spectroscopy (XAS).

At sites where bottom waters are oxic in spring, the surface sediments were populated by cable bacteria at the time of sampling in early summer [1]. We argue that their metabolic activity led to pore water acidification in the preceding months, resulting in the dissolution of Fe monosulphides, Fe carbonates and Mn carbonates and the development of strong surface enrichments of Fe oxides and total Mn.

Strikingly, the sediment at one of the oxic sites was highly enriched in Mn oxides in a thin surface layer (0-2 mm). Using Mn XANES, we show that this enrichment consists of a mixture of mainly birnessite, hausmannite, manganite and bixbyite, which was likely deposited from the water column. Underneath this sediment layer, we found a ~3 mm thick, diagenetically-formed mineral layer that was highly enriched in P, Mn and Fe. Using Mn XANES and micro-XRF analyses, we demonstrate that a significant proportion of the P in this layer was associated with Mn(II)-phosphates, besides P bound to Fe oxides.

We conclude that cable bacteria activity can induce the formation of various Fe and Mn minerals that can contribute to efficient sequestration of P in sediments of seasonally hypoxic eutrophic systems.

[1] Hermans, M.; et al., Abundance and Biogeochemical Impact of Cable Bacteria in Baltic Sea Sediments (submitted).