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Response of metal contaminated Skagerrak sediments to changing oxygen conditions

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Heavy metals reach the North Sea via atmospheric and riverine transport or directly from shipping and industrial sources like oil and gas production or offshore wind farms. Most metals accumulate in the Skagerrak, which is the main sink for fine-grained sediments, adsorbed metals and organic matter from the North Sea. Hence, this region is most important for long-term carbon storage and offers the possibility to investigate the contaminant input to the North Sea during the last decades (Logemann et al., 2022; https://doi.org/10.1016/j.envpol.2022.119040).

We sampled sediment cores from four locations within the Skagerrak featuring different water depths, sedimentation rates, organic carbon densities and oxygen conditions. The sediments and pore waters were analyzed for their metal, carbon and nitrogen content, $\delta^{15}N$ ratios and nutrient concentrations. Additionally, the sediments were incubated with and without oxygen for up to one year to simulate the effect of changing oxygen conditions.

Elemental mass fractions of the sediment cores showed similar ranges but different sedimentation rates for most heavy metals like Cu, Pb and Zn (up to 24, 85 and 132 mg kg^{-1}; see Figure 1). Redox-active elements like As, Mn and Mo differed significantly between the locations with mass fractions of more than 80, 30000 and 60 mg kg^{-1} at the deepest location, respectively (see Figure 1). Pore water profiles indicated differing oxygen conditions between the locations, visible e.g., for Mn, Fe, As, NH_4^+ and NO_3^-. During the sediment incubation, metals and nutrients were mobilized in both anaerobic and aerobic incubations. Especially during aerobic incubations, organic matter was metabolized, indicated by increasing $\delta^{15}N$ ratios and decreasing organic carbon concentrations. During anaerobic incubations, the locations differed significantly in terms of carbon oxidation pathways: For two locations, SO_4^{2-}–reduction and CO_2 production were observed while the deepest location produced less CO_2, no S^{2-} but released Mn to the overlying water. Our results indicate that carbon sequestration processes, metal mobility and release of greenhouse gases might change if sediments with certain metal content and microbial community are suddenly exposed to different oxygen conditions. This might for example be the case if metal contaminated sediments are dredged from harbors.

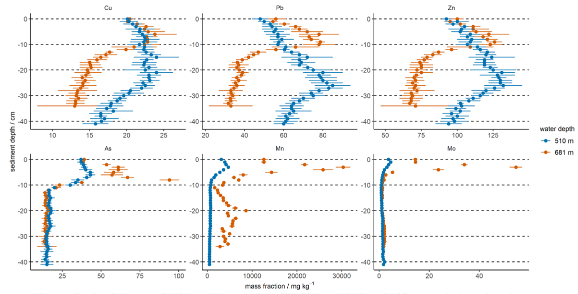

Figure 1 Element profiles of Cu, Pb, Zn, As, Mn and Mo for two sediment cores taken at different locations in the Skagerrak at different water depths. Error bars indicate the expanded uncertainty *U* (*k*=2) for *n*=3.