



A multi-isotope (C, O, S, H) and trace metal study in coastal permeable sands affected by Submarine Groundwater Discharge

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Submarine groundwater discharge (SGD) is increasingly recognized to be an important source for fresh water and elements (e.g. metabolites, nutrients, metals) in coastal environments. In the present study, the impact of near-shore SGD on a coastal ecosystem of the southern Baltic Sea is investigated as part of the AMBER project within the BONUS+ initiative. The present study addresses the isotope biogeochemistry (C, O, S, H) in the water column and permeable sediments of Puck Bay, southern Baltic Sea. Results are compared to well waters of Hel Peninsula, a possible recharge area of the Puck Bay. During several field campaigns in the years 2009 and 2010, it was found that low-salinity groundwater escapes through seeps from permeable sandy near shore sediments to the bay. Salinity decreases in near surface pore waters down to 0.5 PSU along with distinctly increasing loads of metabolites. Mixing calculations indicate that the groundwater is anoxic, containing, CO₂, CH₄, PO₄, Mn and sulphide. The pore water gradients allow identification of zones where net biogeochemical processes occur, e.g. decomposition of organic material, Mn(IV) reduction or sulphate reduction. The $\delta^{34}\text{S}$ values of sulphate and sulphide in the pore waters indicate that seawater- or evaporite-derived sulphate is the original source of dissolved sulphide found in the essentially sulphate-free groundwater. Shallow pore water sulphate, on the other hand, is mainly derived from the mixing with brackish bottom waters of the Bay. Stable O and H isotopes and ³H activity are measured in the water column, pore waters and selected well waters for further source and age characterization. The application of a binary mixing model enables the estimation of the hydrogeochemical and stable isotopic composition of the groundwater end-member. Pore water $\delta^{13}\text{C}$ (DIC) values down to -25 ‰ are not only controlled by mixing processes but show a non-conservative behaviour, indicating an active carbon cycling in the surface sediments. Possible sources for DIC are oxidized organic material, and/or CH₄. $\delta^{18}\text{O}$ and δD values of Hel pore waters are positioned on the regional meteoric water line. Values for the seeping groundwater at Hel Beach, calculated by a two end-member mixing model, show isotope values around $\delta^{18}\text{O} = -11$ and $\delta\text{D} = 77\text{‰}$ results that are lighter than literature values for Holocene meteoric waters for this area. Furthermore, ³H measurements indicate that the ascending groundwater contains only a small fraction of post 1950s water. Further evaluation of processes leading to the groundwaters escaping the Hel sands will be based on biogeochemical modelling. In addition, further dating techniques will be applied to better define the evolution of the anoxic groundwaters at Hel Peninsula.