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Seasonal Groundwater Flowdynamic within the Freshwater Lense in Coastal Dune on Hiddensee Island/Baltic Sea

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Freshwater bodies on islands serve as precious drinking water supply. The delicate equilibrium between ocean and groundwater with respect to salinity in the coastal dune zone of Hiddensee Island preserves a unique plant diversity in the dune valley heath. Scope of the investigation is to understand the seasonal dynamic of groundwater flow in the freshwater lense by means of geochemical and isotopic analyses.

The Island Hiddensee is situated off the western coast of Germany's biggest island Rügen in the Baltic Sea. It extends about 20 km in N-S direction with an average width of a few hundred, at maximum 2 km. The average salinity of the Baltic Sea is about 14 permil, however, at the island of Hiddensee a salinity of app. 9 permil, i.e. brackish water quality is observed. Two piezometer transects (North NT and South ST), each of 500 m length and eight shallow wells were constructed app. 1 km apart from each other in the dunes, perpendicular to the coastline. During two sampling campaigns in July 2012 and April 2013 the isotopes δ2H, δ18O, tritium and δ13CTIC were measured. In 2013 selected hydrochemical variables, e.g. sulphate and nitrate were determined. Additional hydraulic head measurements were performed in November 2012.

The investigated phreatic aquifer is about 7 to 8 m thick and consists of medium sand. The aquifer bottom is built by low permeable till silty, clayey sediments and mud. The ground level forms moderate dunes and valleys with heights between 1 and 3 m a.s.l.. The depth to groundwater varies spatially and seasonally between 1.77 m (August 2012) and -0.12 m (April 2013). The hydraulic gradient predominantly slopes westwards towards the sea (1.7 to 2.5 permil), however, the groundwater divide shifts up to 450 m towards the coast (November 2012). Depending on the hydraulic gradient and hydraulic conductivity, respectively, the average flow velocity was determined as 8 to20 cm/d.

The groundwater samples of the southern transect (ST) don't show any evidence for seawater influence, however, the northern transect (NT) shows decreasing chloride concentrations with increasing distance from the coast, which indicates minor seawater contribution of less than 1 percent. The tritium content of both sampling campaigns suggests groundwater ages of less than 6 years. Although based on two campaigns only, even seasonal fluctuations can be implied. These fluctuations are further substantiated by δ2H- and δ18O-variations, which are surprisingly pronounced considering the small extent of the investigation area.

Sulphate concentrations in at NT are distinctively higher (3.8 to 8.6 mg/L) than those at ST (0.8 to 3.5 mg/L), except for one piezometer close to the groundwater divide which shows a sulphate concentration of 13 mg/L. A close correlation between sulphate and δ13C of TIC at NT suggests small scale biogeochemical processes. This finding is further supported by similar spatial distribution of nitrate.

The first results suggest a surprisingly high spatial and seasonal variability of hydrogeochemical processes which in turn may significantly affect the plant diversity and its equilibrium.