Evolution of a young freshwater lens on a currently developing barrier island, 'Ostplate', Spiekeroog

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ABSTRACT

Freshwater lenses are of major interest for drinking water supply on barrier islands and play an important role in coastal ecosystems. The freshwater lens presented in this study is currently developing below the young eastern part of the North-Sea barrier island Spiekeroog ('Ostplate') since the 1970s. Designated as nature conservation area, the Ostplate is characterized by the absence of coastal protection measures. The formation of the freshwater lens, therefore, occurs unaffected by anthropogenic influences and is subject to dynamic changes. Especially during the winter months, the freshwater lens is exposed to storm surges. Except for preliminary numerical simulations of Röper et al. (2013), the vertical thickness, tidal and seasonal dynamics and in particular, the temporal evolution of the freshwater lens were so far unknown. Shallow and multi-level wells were installed along a profile from north to south, which encompasses beach, dune and salt marsh areas. Groundwater samples were extracted to locate the vertical thickness of the freshwater lens as well as to determine the groundwater residence times using the tritium-helium method. The additional application of direct-push sampling, thereby, enabled a depth-specific extraction of groundwater samples in high resolution. A 2-D groundwater flow model of a vertical cross-section of the profile was set up with the density-dependent software SEAWAT to simulate the present state of the freshwater lens and to reconstruct its temporal development. The model was calibrated with respect to measured groundwater levels and groundwater salinities as well as identified apparent groundwater ages. Results show that the vertical thickness of the freshwater lens is presently 4-5 m. Instead of being a sharp boundary, the transition zone between fresh- and saltwater is a diffuse zone of several meters of thickness. The apparent groundwater ages increase with increasing depth within the freshwater lens. The density-dependent numerical model enabled an estimation of the current extent of the freshwater lens along the profile and a reconstruction of the temporal development. Simulating the tritium input with the numerical model, additionally enabled an interpretation of apparent groundwater ages of brackish and saline groundwater samples. Wells at the dune base were exposed to storm tides, which salinized the uppermost well following inundation during winter.

REFERENCES

Röper, T., Greskowiak, J., Freund, H., Massmann, G., 2013. Freshwater lens formation below juvenile dunes on a barrier island (Spiekeroog, Northwest Germany). Estuarine, Coastal and Shelf Science 121-122, 40–50.

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