Experimental and numerical saltwater upconing investigation on heterogeneous coastal aquifer

Antoifi Abdoulhalik[1], **Abdelrahman M. Abdelgawad** [2] and Ashraf A. Ahmed[3]
[1] School of Natural and Built Environment, Queen's University Belfast, Belfast, UK
[2] Civil Eng. Department, Faculty of Engineering, Applied Science Private University, Amman, Jordan.
[3] Department of Civil & Environmental Engineering, Brunel University London, UK

ABSTRACT

This research is introducing a novel application to investigate the effect of critical or maximum pumping rate at which 1% of saltwater wedge reaches the well in heterogeneous coastal aquifer. Seven numerical and experimental tests were examined in triple layers stratified aquifer with different values of hydraulic conductivity (K) in the order of high-low-high pattern. Five experiments had incremental values of pumping rates and the first and seventh experiments were without pumping to present the initial and the receding conditions, respectively. Quantitative and qualitative matching showed that 2D numerical analysis using SEAWAT code validated the experimental results with a very good percentage of error (7.6%). The sensitivity of the critical pumping rate and the critical time (defined as the time needed for the upconing to reach the well) to the well configurations and aquifer heterogeneity was examined. Mainly three aquifer configurations were examined, contrast ratio of hydraulic conductivity, low K layer thickness, and low K layer location. Results showed that, critical pumping rate decreased with the increasing of the contrast ratio which reflects the vulnerability of the well to be salinized under the heterogeneous condition and the critical time decreased with the increasing of hydraulic conductivity contrast ratio. Low K layer thickness effect showed higher contribution to the critical pumping rate than contrast ratio effect. The percentage of the change in critical pumping rate in different low K layer location was less than 1%, however the critical time was significantly decreasing by the decreasing of the vertical distance between low K layer and the well.

Contact Information: Department of Civil & Environmental Engineering, Brunel University London, Kingston Lane, Uxbridge UB83PH, UK, Email: ashraf.ahmed@brunel.ac.uk

Efficient nutrient recycling in the subterranean estuary of an exposed sandy beach

Janis Ahrens[1], Melanie Beck[1], Janek Greskowiak[2], Nele Grünenbaum[2], Julius Degenhardt[3], Hannelore Waska[4], Bernhard Schnetger[1], and Hans-Jürgen Brumsack[1]
[1] Microbiogeochemistry, Institute for Chemistry and Biology of the Marine Environment (ICBM), University of Oldenburg, Germany
[2] Hydrogeology and Landscape Hydrology, Department of Biology and Environmental Sciences, University of Oldenburg, Germany
[3] Paleomicrobiology, Institute for Chemistry and Biology of the Marine Environment (ICBM), University of Oldenburg, Germany
[4] Research Group for Marine Geochemistry (ICBM-MPI Bridging Group), ICBM, University of Oldenburg, Germany

ABSTRACT

To date, most studies on the biogeochemistry of submarine groundwater discharge (SGD) were conducted on sheltered beach sites. In contrast, studies focusing on exposed sandy beaches, which cover wide areas of global ice-free shorelines, are scarce. At our study site – the mesotidal, high-energy beach of Spiekeroog Island, NW Germany – tide-induced seawater recirculation is the dominating process influencing SGD to the costal sea (Beck et al. 2017). The composition of SGD is set within the recirculation cell of the subterranean estuary. Main controlling factors are water residence times, microbial respiration rates, and the supply with fresh marine organic matter and electron acceptors. The response of biogeochemical processes to these driving forces was studied by performing different spatially resolved sampling techniques during different seasons, namely pore water profiling (a) along cross-shore transects and (b) on a high resolution grid (~200x200m) capturing the intertidal ridge-and-runnel-morphology.

Our results show, that pore water is successively being enriched in macronutrients (N, P) and micronutrients (Fe, Mn) compared to seawater. Nutrient concentrations in saline pore waters of discharge areas were found to be in the same order of magnitude or even higher than concentrations observed in deep groundwater wells of the inland freshwater lens. Thus, in our study area of comparably low anthropogenic influence, nutrient remineralization in the seawater recirculation cell – driven by the continuous delivery of seawater-derived electron acceptors and donors – may outmatch the conveyor of nutrients to the subterranean estuary by meteoric, old groundwater. The investigation results showed that the intensity of nutrient remineralization and their respective transformation changes with season, as well as with changes in beach morphology and seawater composition. It suggests that the high dynamics in hydrological and hydrobiochemical conditions at the beach have a profound effect on subsurface biogeochemical patterns. Flux calculations need to account for these effects, in order not to under- or overestimate the impact of SGD on coastal water chemistry.

REFERENCES

Beck, M., A. Reckhardt, J.Amelsberg, A. Bartholomä, H.-J. Brumsack, H. Cypionka, T. Dittmar, B. Engelen, J. Greskowiak, H. Hillebrand, M. Holtappels, R. Neuholz, J. Köster, M.M.M. Kuypers, G. Massmann, D. Meier, J. Niggemann, R. Paffrath, K. Pahnke, S. Rovo, M. Striebel, V. Vandieken, A.