Hydrogeological flow paths in coastal areas; a dismissed factor for the delivery of nutrients?

Carlos Duque[1,2], Søren Jessen[3], Thomas W. Brooks[4], Christopher Russoniello[5], Peter Engesgaard[3], Holly Michael[2,6]
[1] Department of Geoscience, Aarhus University, Aarhus, Denmark
[2] Department of Geological Sciences, University of Delaware, Newark, DE, USA
[3] Department of Geosciences and Natural Resource Management, University of Copenhagen, Copenhagen, Denmark
[4] Woods Hole Coastal and Marine Science Center, U.S. Geological Survey, Woods Hole, MA, USA
[5] Department of Earth Sciences. Syracuse University, Syracuse, NY, USA
[6] Department of Civil and Environmental Engineering, University of Delaware, Newark, DE, USA

ABSTRACT

Coastal areas are valuable ecosystems. Their position at the end of the terrestrial hydrological cycle makes them the final destination for nutrients that have not been degraded or captured before reaching the oceans. The consequences of an excessive input of nutrients such as nitrate, ammonium, and phosphate can trigger algal blooms and subsequent anoxic conditions and dead zones in surface waters. Thus, there is intense interest and activity for monitoring and quantifying nutrient inputs to estuaries and coasts. However, the delivery connected with groundwater fluxes is often overlooked. Nutrient transport is affected by physical and chemical processes in groundwater, including reactions that transform, release from sediments, or degrade to other species more or less harmful for the environment. In coastal aquifers, groundwater flowpaths are complex because of forces established due to salinity changes as the density-driven flow or the recirculation of saltwater in areas affected by waves and tides. These processes are highly location-dependent since they are taking place at different locations relative to various forcings, and also at different depths. This hinders the detection and the quantification of its effect. In this work, two new datasets with a high spatial resolution are presented (Indian River Bay, Delaware, USA and Ringkøbing Fjord, Denmark) with the objective of identifying subsurface hydrogeological flow paths and the resulting distribution of nutrients in groundwater discharging into two coastal areas. Information about fluxes, concentrations of nitrate, ammonium, phosphate and in-situ parameters are presented in connection with the freshwater-saltwater interface and the potential processes that can increase or decrease their presence in groundwater under bays and other coastal waters. Additionally the impact of groundwater discharge rates to surface water are analyzed together with the concentration of the different nutrients measured. The implications and the consequences are discussed for the two regions as a potential global phenomenon with a broader impact for the monitoring and the understanding of contamination in coastal areas.