Hydrologic controls on nitrogen processing in a nearshore subterranean estuary: numerical simulations

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The role of the nearshore subterranean estuary in regulating nutrient fluxes to coastal waters is well recognized. Complex interacting biogeochemical and physical flow processes determine whether a nearshore subterranean estuary will be a net source or sink of nitrogen. Tidal fluctuations and waves strongly affect the nutrient processing as wave- and tide-induced recirculation across the sediment-water interface supplies oxygen and organic matter into the shallow beach groundwater.

A numerical model was applied to evaluate the influence of varying hydrologic conditions (tides, waves, fresh groundwater flux) on the nutrient biogeochemistry in a nearshore subterranean estuary. Due to its significant influence, different DOC mineralization rates were also examined for each of the hydrologic conditions simulated. Simulations were performed using the variable-density groundwater flow model SEAWAT-2005 combined with the reactive multi-component transport model PHT3D v2.10. The model considered the transport and transformation of both marine- and land-derived chemical species (NH_4^+, NO_3^-, PO_4^{3-}, Fe^{2+}, DOC and O_2). Reactions considered include DOC oxic mineralization, nitrification, denitrification, Fe oxidation, and P adsorption.

Simulations demonstrated that the magnitude of tidal and wave forcing, combined with DOC mineralization rates, regulate whether a nearshore subterraean esutary will act as a net source or sink of nitrogen. The rate of fresh groundwater discharge influenced the fate of land-derived nutrients in the nearshore aquifer but did not significantly affect the mineralization of marine DOC. Aquifer heterogeneities increased mixing between the recirculating seawater and groundwater and so also played an important role in regulating land-derived nitrogen fluxes. Damköhler numbers, based on the residence time for seawater to recirculate and also for land-derived groundwater to discharge through the nearshore aquifer, were calculated to provide insight into hydrologic controls on nitrogen transformations.