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Editorial: Groundwater-Seawater Exchange and Environmental Impacts

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Editorial on the Research Topic

Groundwater-Seawater Exchange and Environmental Impacts

Coastal zones, also referred to as the land-sea interface, are dynamic zones where terrestrial freshwater biogeochemically interacts with seawater. Coastal zones have been recognized to be increasingly vulnerable to contamination due to dense human populations and anthropogenic activities (Michael et al., 2017). The groundwater-seawater exchange is one of the most important hydrological processes of land/sea interactions in coastal zones, including submarine groundwater discharge (SGD) and seawater intrusion (Geng et al., 2021). SGD transports fresh groundwater from the land to the ocean, which is an important source of nutrients, heavy metals, and carbon and organic pollutants in coastal waters. Therefore, SGD provides critical control in marine biogeochemical cycles and the budget of marine element deterioration of water quality and the coastal environment (Santos et al., 2021). Saltwater intrusion stresses coastal environments. Over-exploitation of fresh groundwater due to urbanization and industrialization developments may accelerate seawater intrusion into coastal aquifers, which salinizes nearshore fresh groundwater resources and adversely impacts vegetation growth.

Although significant scientific advances in coastal groundwater dynamics have been made, there are still many important scientific questions that need to be addressed such as groundwater composition in developed and undeveloped saltmarsh basins, geochemistry of neodymium (Nd) isotopes in subterranean estuaries, and seasonal dynamics of seawater-freshwater exchange in coastal lagoon aquifers. The objective of this Research Topic is to share recent advances in understanding groundwater-seawater exchange and their environmental impacts. This Research Topic features six articles, which are briefly introduced in the following.

Chevis et al. investigated the influence of SGD on Nd isotope composition in a subterranean estuary (the Indian River Lagoon, Florida). They found that Nd fluxes to the lagoon from fresh SGD (FSGD) and bio-irrigation were comparable to the local river-delivered Nd. However, Nd flux to the lagoon from recirculated saline SGD (RSGD) was 45 times higher than that from FSGD. Nd isotope composition of FSGD was similar to that measured in carbonate rocks from the Upper Floridan Aquifer, but was more radiogenic than RSGD. They concluded that the main source of Nd is RSGD that reacted with Fe(III) oxide/oxyhydroxide coatings on surficial aquifer sands. To our knowledge, this contribution is the first that examines the Nd isotope geochemistry of a subterranean estuary.

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Müller et al. explored the seasonal dynamics of seawater-freshwater exchange in a coastal lagoon aquifer on the west coast of Denmark using geophysical exploration and numerical modeling. They found that the seasonality in terrestrial freshwater fluxes had a direct effect on the saltwater-freshwater interface location. This study highlights the important role of groundwater flow and density dynamics in controlling the saltwater-freshwater interface in near-coastal aquifers. Those driving mechanisms are shown to occur in the shallow parts of the aquifer and have important implications on nutrient transport dynamics from land to sea.

Rozos et al. presented a high-efficiency method for simulating seawater intrusion, with mixing, in confined coastal aquifers based on uncoupled equations in the through-flow region of the aquifer. They simplified the solution procedure by resolving the flow field analytically and the tracer transport numerically. This proposed method is computationally efficient, much easier to automate, and provides a good trade-off between CPU times and accuracy.

Wilson et al. assessed the extent to which upland development affects groundwater composition in tidal creek basins. Groundwater samples from 15 tidal creek basins in South Carolina were collected to test the compositional differences associated with development and marsh width. They found that upland development can affect groundwater compositions in coastal groundwater and therefore may affect nutrient and carbon fluxes to coastal waters. They also found that salt marshes had the potential to act as buffers against upland development. The buffering capacity of salt marshes increased with width. As far as we are aware, this is the first large database of groundwater compositions established for tidal creek basins, and as such will provide a benchmark against which to compare other datasets (including future datasets from the same locations).

Wu et al. evaluated the effect of anthropogenic activities and natural events on the distribution of fresh and saline waters on a semi-arid coral-limestone island in Sri Lanka. Using a detailed isotopic and hydrogeochemical analysis, they found that the meteoric origin of groundwater with salinization was mainly caused by seawater mixing and slight evaporation. The salinization process was determined by multiple factors including the island's low-lying nature, the low hydraulic heads, the shallow depth of the marine water, the presence of lagoons in the center, and groundwater exploitation. Anthropogenic activities led to extensive pollution of nitrogen in groundwater. This field-based research highlights the importance of groundwater characterization for sustainable fresh water management of an island.

Jiang et al. analyzed the size distribution of natural seawater nanoparticles and their environmental impacts, the total number of bacteria, and plankton diversity, using the tangential ultrafiltration and asymmetric flow field analysis. They evaluated the relationship between nanoparticle size distribution and plankton diversity index, a bridge between nano-materials and the ecological system. They found that the biological activities-regulated nanoparticle sizes impacted the nutrient cycling in the estuarine areas, in turn affecting the stability and balance of biodiversity. The results from this study will improve understanding of the coastal biogeochemical cycling process and the environmental impacts of natural nanoparticles.

We are convinced that the presented advances in the field will improve the understanding of the environmental implications of groundwater-seawater exchange, which is of key importance to develop strategies for effective management of the coastal zone.

AUTHOR CONTRIBUTIONS

XW designed this Research Topic and invited the guest editors XG, MS-N, and YZ. All guest editors invited the authors and reviewed and edited the article. XW wrote the editorial, which was then reviewed and edited by the other three guest editors. All authors approved the submitted version.

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