Seawater recirculation versus karstic groundwater driven DSi fluxes to a coastal Mediterranean lagoon

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The recirculation of seawater through permeable coastal sediments is increasingly recognized as an important source of major nutrients, including DSi, to the coastal ocean. Here, we utilized a detailed Ra isotope (^{223}Ra, ^{224}Ra, ^{228}Ra) mass balance to quantify terrestrial and marine submarine groundwater discharge (SGD) driven DSi fluxes to a small shallow lagoon ($\leq$ 1.5 m; La Palme) located on the French Mediterranean coast, where seawater recirculation through the lagoon sediment is thought to be primarily driven by strong winds. A well-studied karstic spring discharges into the northern basin of the lagoon, allowing us to quantitatively separate terrestrial and marine solute sources. There was a clear Ra enrichment in the northern basin of the lagoon fed by the karstic groundwater spring, with relatively lower salinities (12 – 37). In the intermediate and southern basins of the lagoon, surface waters reached hyper-saline conditions (37 – 45), where Ra activities increased with increasing salinity, reflecting a hyper-saline pore water endmember. These same patterns were observed in spring, surface and pore waters for DSi, and to a lesser extent DIC. The marine SGD flux and associated DSi flux was approximately an order of magnitude greater than the groundwater spring. In contrast, karstic groundwater-driven DIC fluxes were an order of magnitude greater than the marine SGD-driven DIC flux. Surface water transects into the open sea revealed near-shore enrichments of Ra and DSi, likely driven by wave setup and exchange between the lagoon and the sea, with comparable DSi fluxes to that of the lagoon. We hypothesize that the observed linear relationship between short-lived ^{224}Ra and DSi in hyper-saline lagoon waters reflects a combination of the dissolution of biogenic Si and the dissolution of lithogenic lagoon sediment, constituting a "new" flux of DSi from seawater recirculation.