Impacts of submarine groundwater discharge on a coral reef system

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To evaluate the effects of submarine groundwater discharge (SGD) on tropical waters with coral reef systems, naturally occurring radium isotopes (^{223}Ra, ^{224}Ra, ^{226}Ra, and ^{228}Ra) together with ^{222}Rn were utilized to trace SGD into Sanya Bay, China in the northern South China Sea. Higher activities of radium were present along the north coast and near the Sanya River estuary. Based on the mass balance of ^{226}Ra and ^{228}Ra, SGD was calculated to be 2.67-5.01×10^{6} m^{3} d^{-1} (or 4.1-7.7 cm d^{-1}), which accounts for 98% of the respective radium source flux into Sanya Bay. SGD associated fluxes into Sanya Bay were 3.06-5.74×10^{5} mol d^{-1} for nitrate, 6.32-11.9×10^{5} mol d^{-1} for silicate, 1.51-2.84×10^{7} mol d^{-1} for dissolved inorganic carbon (DIC), and 1.51-2.83×10^{7} mol d^{-1} for total alkalinity (TA). Strong diel changes were present throughout the spring to neap tidal cycle of DIC, TA, partial pressure of CO_2 (pCO_2) and pH, in the ranges of 1851-2131 μmol kg^{-1}, 2182-2271 μmol kg^{-1}, 290-888 μatm and 7.72-8.15, respectively. Interestingly, the diurnal amplitudes of these parameters decreased from spring to neap tides, governed by both tidal pumping and biological activities. Such tidal-driven SGD of low pH and high nutrients waters is another significant contributor to coastal acidification and source of DIC, TA, and nutrients for the reef system, posing additional stress on coastal coral systems, which would be even more susceptible in future scenarios under higher atmospheric CO_2 and more anthropogenic loadings of nutrients.