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Submarine Groundwater Discharge as a Source of Elevated Radon and Nutrient Supply in Coastal Seas

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Submarine groundwater discharge (SGD) is a key pathway across benthic boundary interface, affecting both water and biogeochemical cycles in coastal zones. Globally, significant SGD-associated nutrient flux has been expected occurring in the coastal seas but is still far from being fulfilled. As a natural-occurring radioactive tracer, radon (^{222}Rn) is widely used to prospect groundwater hotspot and evaluate SGD flux, however its spatial distribution in China's coastal seas has not been systematically investigated. In this study, we mapped ^{222}Rn distribution and identified a prominent hotspot between 119.5-120.5°E along the 35°N transect in the southwestern Yellow Sea, with highest activity reaching ~280 Bq m^{-3}. SGD accounted for 57%±25% of the total radon inventory, a proportion comparable to the diffusive flux from widespread calcareous nodules in this region (43%±25%). Using the radon mass balance approach, we evaluated the SGD rate to the southwestern Yellow Sea at 3.2-15.7 cm d^{-1} during summer stratification. SGD-derived dissolved inorganic nitrogen, phosphate, and silicate fluxes to the bottom waters were (1.2-5.7)×10^{10} mol a^{-1}, (1.2-5.8)×10^{8} mol a^{-1}, and (0.6-3.0)×10^{10} mol a^{-1}, respectively, representing about one order of magnitude of local riverine loads. Our findings highlight the dominant role of SGD in shaping radon distribution and nutrient supply in coastal seas. Given the recurrent occurrence of harmful algal blooms in these regions, long-term SGD monitoring is essential to better understand its ecological impact for coastal ecosystem management.