Spatial evaluation of submarine groundwater discharge (SGD) on an island scale in a temperate coastal sea

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Submarine groundwater discharge (SGD) is defined as subsurface water flow at continental margins from the seabed to the coastal ocean. As a component of the hydrological cycle, SGD plays an important role in the overall coastal water budget, which can rival or even exceed surface runoff in some coastal areas. In addition, because it often contains higher nutrients than river water, SGD delivers comparatively large quantities of nutrients to coastal ecosystems. However, there are few studies to evaluate the spatial relation among SGD, nutrient condition and coastal ecosystem such as seagrass meadows. In the present research, we aimed to examine the spatial variation of SGD and its effect on coastal environment in an island scale.
The study area is Ikuchijima Island in Seto Inland Sea, southern Japan. The regional climate is mild, with an annual mean precipitation of 1,100 mm and temperature of 15.6 ˚C. The whole island is characterized by steep slopes and is widely covered by citrus farms with more than 40% of the island. To evaluate the spatial distribution of SGD at the small island scale, we performed a radon (^{222}Rn) monitoring survey along the coastline of Ikuchijima Island. Large variability in SGD was observed, with significant discharges seen in areas of steep topography and much lower discharges from low-lying areas. Topographic influences are likely to be the major driver of spatial variability in SGD. Based on a ^{222}Rn mass balance model, the SGD rates were estimated to range from 8.38 cm d^{-1} to 17.02 cm d^{-1}, with an average of 12.98 cm d^{-1}. The results were in good agreement with SGD estimated by the topographic model based on Darcy’ s law and inland topographic gradient near the coastline. Estimated nutrient loading through the SGD were comparable to or even higher than that from local streams. It suggests SGD is an important source of nutrients to coastal ecosystems in the area. Distribution of seagrass meadows tend to correspond totally to the spatial variation of SGD, especially the fresh submarine groundwater discharge (FSGD) estimated by the topographic model.

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