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Estimation of distribution and discharge flux of submarine groundwater using Rn-222 in the Yatsushiro Bay

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Continuous Rn-222 monitoring method has been developed around a decade ago, and with this method, evaluation of spatial distribution and flux of submarine groundwater discharge (SGD) in/along ocean coastal bay/line is becoming popular worldwide. In this presentation, we will introduce a case study in Yatsushiro Bay, describing distribution and flux properties of SGD, deduced by Rn-222 data collected during recent four years. We try to show and confirm the merit and limit of Rn-222 monitoring method and propose a new approach to solve several potential problems on Rn-222 study.

Yatsushiro Bay is one of the largest inland sea in Japan, surrounded by Kyushu mainland to the east and Amakusa Islands to the west. Its total area is around 1,200 km2 with a total coastal line of around 220 km. The hinterland of this bay is composed of watersheds with various topographic and geological features. Therefore, Yatsushiro Bay should provide an ideal setting to understand the factors, i.e., watershed area, topographical gradient, presence of tidal flat, geological constituent materials and geological structure, controlling SGD distribution properties in wide scale coastal sea area. By summarizing these features, we can confirm interesting SGD distributing natures in coastal environments.

After analyzing Rn-222 samples of 61 flowing rivers into Yatsushiro Bay, we realized that river waters contain considerable Rn-222, which value cannot be ignored when interpreting Rn-222 signal in the sea. In order to evaluate the effect of river-originated Rn-222 in the coastal sea water, we developed sea water Rn-222 distribution model within whole Yatsushiro Sea, based on a previously constructed ocean currency simulation model. The net SGD-originated Rn-222 concentrations were estimated by subtracting simulated river-originated Rn-222 concentrations from the observed towing Rn-222 monitoring data.

A total SGD flux within the Yatsushiro Bay was evaluated following traditional box model concept, by multiplying advection rate deduced from continuous Rn-222 monitoring results at mooring survey sites, and SGD patch area estimated by Rn-222 towing survey results. Consequently, it was concluded that 15% of the total water transported toward the Yatsushiro Sea from the land is SGD origin. Furthermore, we tried to understand the possible components contributing to Yatsushiro coastal water, FSGD, RSGD, river water, and sea water, with their contribution degree quantitatively. Our analysis also suggested interesting aspect that wind velocity on the coastal sea surface would be an important triggering factor of SGD.

As a result of our study, it was suggested within the Yatsushiro Sea that Rn-222 concentration could not play as a direct tracer of groundwater because the Rn-222 in the coastal sea water can be partially derived from rivers flowing into the bay. Although previous studies have not taken this effect into account in interpreting sea water Rn-222 observation results, our findings, and our solution idea, would be essential to be incorporated in a future study in an area of similar climate and topographical condition like Yatsushiro area. With this topic, we will propose distribution property, estimated flux, and discharging mechanism of submarine groundwater comprehended by a recent Rn-222 study in the Yatsushiro Sea.

Keywords: SGD, Rn-222, simulation, tidal flat, discharge rate, distribution