Nutrient transport process with submarine groundwater discharge in the coast of Ariake Bay

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The ecosystem and aquatic environment for human activities and fisheries in semi-enclosed bays as well as coastal areas have been deteriorating in the recent years. During the past few decades, submarine groundwater discharge (SGD) has been recognized as an important factor for environmental and ecological impacts in the coastal region. The Ariake Bay, a semi-enclosed inner bay located in the west of Kyushu Island, Japan, is concerned with such environmental deterioration induced by reclamation, sediment deposition and nutrient transport.

In this study, significant nutrient transport process with SGD to the Ariake Bay is revealed.

The SGD has been investigated by using seepage meter at the three sites of Ariake Bay located off the coasts of Oura of Saga, Kawachi of Kumamo and Fukae of Nagasaki prefectures.

Measurements of the SGD flux and water sample by the Lee-type seepage meter of 32cm in the diameter have been undertaken four times at the flood tide, High tide, ebb tide and Low tide during the one tidal cycle. Moreover, groundwater sampling was done in the coastal region. The chemical components of water samples of SGD, groundwater, and seawater in this observation were analyzed. Water temperature, electric conductivity, pH, dissolved oxygen, and oxidation-reduction potential (ORP) of water samples were measured in the field using portable meter. Water quality analysis comprised dissolved organic carbon , total organic carbon (TOC), major ion (cation (Na^+, K^+, Ca^{2+}, Mg^{2+}, Fe^{2+}, Mn^{2+}), anion (Cl^-, $HCO_3{}^-$, $SO_4{}^{2-}$)), nutrients (ammonium-nitrogen ($NH_4{}^-$-N), nitrate-nitrogen ($NO_3{}^-$-N), nitrite-nitrogen and Phosphate and silicate (SiO_2)).

As a result of the measurement using the seepage meter, a comparatively big amount of SGD rate was observed at the low tide and in near the shoreline. Similarly, the freshwater element of the groundwater origin in SGD was large.

The result of water quality analysis indicates the difference of the ORP between SGD and groundwater in the coast regions. The fact shows that the SGD is characterized by relatively reductive conditions as compared with the groundwater in the coast region. In Tara area, average $NO_3{}^-$-N concentration in the SGD was low compared to the upstream groundwater. And $HCO_3{}^-$ concentrations in the SGD was higher than those of the upstream groundwater. However, the significant difference in the concentration of $Mn^{2+}$and Fe^{2+} was not seen between SGD and the upstream groundwater. Thus, the denitrification was probable reduction-reaction process which can take place in the SGD whereas the Mn^{2+}, Fe^{2+} and sulfate reduction were unlikely to proceed. On the other hand, $NO_3{}^-$-N concentration in the groundwater in Kawachi area was higher than the other sites, and the $NO_3{}^-$-N concentration in the SGD decreases a little compared with groundwater. But, there were no big difference between that value and the value calculated from the mixture ratio of seawater. Therefore, it is unlikely that the denitrification has happened. The ORP mean value of SGD in Fukae area was the lower than that of other areas. The $NO_3{}^-$-N concentration in the SGD was lower than those of the upstream groundwater was observed. T-Fe concentration in the SGD was larger than those of the upstream groundwater. It tended similar of Mn^{2+}. Therefore, the reduction reaction in the site proceeds via denitrification, Mn^{2+} and Fe^{2+} oxide reduction. Finally, nutrients load such as T-N, T-P, SiO_2 through the SGD to the Ariake Bay was estimated by observed value. When the maximum values of T-N were compared in three points, Kawachi area was the biggest, and order of Oura area and Fukae area.

The results of the present study demonstrated that the SGD found in the area would be a significant source of nutrient to the coastal sea area in Ariake Bay.