Effect of Groundwater and Nitrate Discharge Through Volcanic Rock Aquifer on the Eutrophication in Ariake Sea, Japan

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Groundwater discharge is an important subject not only for regional hydrologic cycles but also for the nutrient transport toward coastal areas. Although most of the nutrients discharge with river flows, the role of groundwater in the process of nutrient transport is significant in areas where high permeable aquifers exist and denitrification is less dominant.

Ariake Sea is surrounded by Nagasaki, Saga, Fukuoka, and Kumamoto prefectures in Kyushu Island, Japan. Ariake Sea is prosperous by fishery products. However recent deterioration of aquatic sea environment due to the eutrophication is emerging as threat to the sustainability of the area.

The surrounding land of Ariake Sea consists of four alluvial plains and three volcanoes. According to the field observations it was found that the three volcanic rock aquifers show higher discharge rates and nitrate concentrations than the alluvial plains. Therefore, the nutrient transport through high permeable aquifers need to be studied further to understand the phenomenon clearly.

In the volcanic mountainous area, the excessive application of fertilizer at the vegetable and fruit farmlands, and domestic untreated waste water are believed as the main cause of nitrate.

In order to analyze the hydrologic processes and to estimate the groundwater and nitrate discharge in the volcanic aquifer region, the present research attempted to develop a numerical model. The model aimed to estimate the surface runoff of three rivers and groundwater flow of the east slope of Mt. Tara extending 300 km^2, and secondly the nitrate discharge toward the coast. A two-dimensional groundwater flow model was coupled with a rainwater infiltration model in the simulation. The nitrate discharge was calculated as the multiplication of the groundwater discharge and the observed nitrate concentration which was provided by the Japanese Ministry of Environment (JME).

The simulated variation of groundwater head and the specific river water discharge for the calibration period were compared with the observed data. Interestingly, the specific river water discharge per 100 km^2 during the drought period of January to March was higher in the study area than that of other alluvial plains. The estimated groundwater discharge to the coast was 237 [mm/year] out of the annual precipitation 2,062 [mm/year], which accounts for 16% of the total water discharge of both river water and groundwater. It was larger than the estimated values in the range of 1.0 to 14.7 % for other alluvial plains. Besides, the direct surface runoff, groundwater recharge, and real evapotranspiration were estimated by the present model as 194, 1,256, and 612 [mm/year], respectively.

The nitrate discharge accounted for 84 [$t/100km^2$] corresponding to 9.8% of the total nitrate discharge by both three rivers and groundwater. This number may not be a crucial level compared to the total nitrate discharge by the rivers. However, the effect of nitrate discharge through groundwater still remains unclear for the coastal environment at the nearby coastal area.