

Estimation of Lacustrine Groundwater Discharge (LGD) via two paths in Lake Biwa, Japan

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Lacustrine groundwater discharge (LGD) and nutrient flux into a lake has not been confirmed enough in terms of seasonal and spatial variation including those in deeper zone. Biwa Lake of biggest in Japan has different characteristics in northern and southern parts. In northern, the water depth varies up to 100m, and groundwater discharge is also expected not only in beach sides with shallower depth but in deeper zones. Our objective was to indicate spatial and seasonal variations of LGD and to compare with the results of seepage observations by Kobayashi (1993).

Radon radioisotope (Rn-222) concentrations were measured by a RAD7 at 500 m interval along the whole shoreline of the northern lake in the periods of irrigation and non-irrigation, and surface water samples were coincidentally collected. Oxygen stable isotope ratio ($\delta^{18}\text{O}$), Chloride, anion and nutrients (nitrogen, phosphorus, and silicon) concentrations were analyzed in the laboratory. In addition, groundwater, river, and headwater samples were collected at 20 sites.

Based on the comparative results with the seepage observations by Kobayashi (1993) and Rn-222 concentration, good correlation between Rn-222 concentration and seepage observation was confirmed. The LGD via shallow path was estimated by Rn-222 Budget model. At the sites of Yasu in southwestern, Hikone in southeastern and Takashima northwestern, high seepage rates were indicated. Seasonal variation was confirmed to be large discharge during the irrigation period. High concentrations of dissolved phosphorus phosphate (> 0.1 ppm) were detected from several wells out of 15 ones investigated. In addition, Rn-222 concentrations in lake waters were measured in the surface and bottom layers at the 4 stations with different water depths (5m, 10m, 20m and 60m) from 2015 and to 2017. The highest Rn-222 was observed in the bottom layer at 20m-deep site in both periods. The LGD from offshore lake floor via deep path was suggested. The seepage values were estimated by the budget model.

Keywords: Lacustrine Groundwater Discharge, deep groundwater, shallow groundwater