

The role of shallow groundwater in river flow formation of the Nomigawa River, Ota, Tokyo, Japan

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The Nomigawa River, which flows through Ota-ku, Tokyo, is a typical urban river with a three-sided concrete revetment. To maintain the river's flow, 20,000 to 30,000 m³/day of the treated sewage is discharged into the river under the Kodaibashi Bridge in Ookayama, Meguro-ku, Tokyo. On the other hand, groundwater is discharged into the river through a number of pipes installed in the middle of the 5-meter-high revetment sidewall in the channel section up to the Kakurinnbashi Bridge, approximately 4 km downstream of the Kodaibashi Bridge. Yellowish-brown stained areas, which indicate constant groundwater seepage, can be seen along the concrete joints of the river channel. In addition, there are a considerable number of partially un-concreted riverbeds (approximately 1 m long by 2.5 m wide; the so-called "upwelling window") in a 1 km section upstream of the Kakurinnbashi Bridge. The shallow groundwater entering the Nomigawa River through these pathways is thought to contribute to the formation of the river flow.

From 2015 to 2019, the role of shallow groundwater in the formation of the river flow in the 4 km section between the Kodaibashi and the Kakurinnbashi Bridges (X_g) was evaluated by mixing analysis based on oxygen isotope ratio ($\delta^{18}\text{O}$) and electrical conductivity (EC) of the treated sewage and shallow groundwater. The estimated X_g based on $\delta^{18}\text{O}$ was about 12 % on May 12, 2018, before the beginning of the rainy season, and about 20 % on September 20, 2019, which corresponds to the summer flood season, suggesting that shallow groundwater plays a non-negligible role in the formation of the flow of the Nomigawa River throughout the year. This is consistent with the results of EC-based mixing analysis on both days.

To directly determine the amount of shallow groundwater inflow, we descended to the riverbed of the Nomigawa River on November 4, 2022 and observed the flow rate of the river. As a result, shallow groundwater inflow of 12,000 m³/day was observed in a 4 km channel section, which is equivalent to about 34 % of the 35,000 m³/day flow at the Kakurinnbashi Bridge. This flow measurement result clearly shows that the Nomigawa River still functions as an important part of the groundwater cycle in the Musashino Plateau, despite its concrete three-layer structure. This is an important finding for future groundwater conservation in the urban areas.

Finally, dividing the shallow groundwater inflow rate of 12000 m³/day by the catchment area corresponding to a 4 km channel section, the runoff height is 1.60 mm/day (580 mm/year). Considering that the average annual precipitation in the area is 1500 mm and that the surface coverage ratio in the catchment exceeds 95 % (Tokyo Metropolitan Government, 2017), we need to study what the origin of the urban groundwater.

Keywords: Urban river, Concrete-lined river, Stream flow formation, Shallow groundwater, Groundwater inflow