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Groundwater Level and Flow Rate Model and Barometric Response of Water Level of Well at Otomeyama Park in Shinjuku Ward

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Spring at Otomeyama Park in Shinjuku Ward is one of the 57 Great Springs of Tokyo, Japan. Recently, decreasing of the spring water quantity at Otomeyama Park has been at issue. In order to figure out long-term variations of the spring water quantity, the flow rate and the groundwater level have been continuously observed by Kaijo Earth Science Club since 2011. In this paper, we report the results of the examination concerning the groundwater level variation and the model, which can express the groundwater level and the flow rate simultaneously.

Otomeyama Park is located at Ochiai escarpment on the eastern part of Musashino plateau. The stratum near Otomeyama park are Kanto loam layer, Shimosueyoshi loam layer (tuffaceous clay layer), Musashino gravel layer, Tokyo layer (sand layer or clay layer) and Tokyo gravel layer from the top. Sato et al. (2013) estimated that the aquifer of the spring water is Musashino gravel layer and the catchment area is about 10-100 ha. The spring water finally joins Kanda River through the water way in the park.

Based on the flow rate observation at Otomeyama Park for more than one year, the arithmetic mean flow rate was about 20 L/min. The flow rate intensely responded to precipitation. The flow rate increased from 4 L/min to 50 L/min in 35 hours at the rainfall event in April 2-3, 2012, whose total amount of rainfall was 118 mm.

The water level of wells were observed at three stations: well No.1 (at Otomeyama park), well No.2 (at Otomeyama park) and Mejiro well (at Shinjuku Ward, 0.5 km to the north from Otomeyama park). The water level of the wells was calculated by subtracting atmospheric pressure from the water pressure in aquifer. The aquifer of well No.1 is Musashino gravel layer and is confined, while the aquifer of well No.2 is Tokyo gravel layer and is confined. The aquifer of Mejiro well is Kanto loam layer and is unconfined.

Semidiurnal fluctuation of water level was observed at well No.1 and No.2. The daily composites of water level of well No.1 in dry periods showed that the atmospheric pressure was at its top at about 9 a.m. and 9 p.m. (JST) in Tokyo by atmospheric tide, while the water level of well fluctuated anti-phase to atmospheric pressure. This barometric response caused by balancing the water level variation of well with atmospheric loading when pore pressure of aquifer is not affected by atmospheric loading (Rojstaczer, 1988). This is attributed to three reasons for the barometric response of water level of well No.1. The mouse of the well is open, so that barometric fluctuation is directly transferred to the water surface in the well. Since the well diameter is 51mm, small water exchange between the well and the aquifer can change the water level in the well. Simosueyoshi loam layer above the aquifer is difficult to infiltrate atmospheric pressure. In contrast, the water level of Mejiro well was not responded to atmospheric load, since there is no air-barrier layer above Kanto loam layer.

Better performance model is needed to figure out long-term variations of the spring water quantity. Sato et al. (2013) predicted flow rate from precipitation using two-tank model, but the model did not utilize groundwater level. We developed a model, which express both flow rate and groundwater level. Our model was based on three-tank model. The first tank of the model represents intermediate flow. The second tank infiltrates water into the third tank but does not have side outlet. The third tank corresponds to the groundwater level. The model parameters were estimated for the flow rate and the water level of Mejiro well by means of SCE-UA method (Duan et al., 1993). In the simulation, the model accurately reproduced the observed value.

Keywords: spring water, groundwater level, tank model, barometric response, atmospheric tides