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Permeability change estimated by using frequency property of the atmospheric effect on groundwater discharge

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The Rokko-Takao station in the southern Hyogo prefecture passes through the fracture zone of Manpukuji fault. Groundwater discharge about 550ml/s regularly takes place at this station. The groundwater discharge showed rapid changes due to earthquakes, as well as seasonal changes due to precipitation. For example, the groundwater discharge increased by about 50% just after the 2011 off the Pacific coast of Tohoku Earthquake. Mukai and Otsuka (2014) constructed one-dimensional groundwater migration model, in which groundwater flows in the confined aquifer from a source to the station, and estimated permeability change due to the 2011 Tohoku earthquake by using the observational data of groundwater discharge and pore pressure. The permeability just after the earthquake was about 20% higher than that before the earthquake. It was considered that the increase of permeability due to the earthquake was caused by the seismic motion that loosed or swept mud in the crack in the surrounding crust.

Permeability change is expected to have influences on the atmospheric effect of groundwater discharge as well. In this study, we constructed one-dimensional groundwater migration model with periodic atmospheric loading on the confined aquifer, and estimated secular change of permeability by applying the model to the atmospheric effect of groundwater discharge observed at the Rokko-Takao station. The atmospheric effect admittance of groundwater discharge is expressed to be 'a$*\sqrt{}$ (f)' when the atmospheric pressure varies with the frequency 'f'. Coefficient 'a' in this equation is proportional to ' $\sqrt{}$ (k$*$S)' that is square root of permeability 'k' and storage coefficient 'S'. Therefore, we can estimate permeability change by investigating the frequency property of the atmospheric effect for various periods.

We conducted frequency analysis by applying FFT to the groundwater discharge observed at the Rokko-Takao station and the atmospheric pressure observed at the Kobe local meteorological office in the range from 2001 to 2013, and calculated the atmospheric effect admittance of groundwater discharge with frequency domain. In this calculation, we obtained the frequency properties for 348 windows with size 2048 data (85.3 days), and the window was shifted from the former one by 240 data (10 days). After then, coefficient 'a' was estimated by applying the equation ' $\sqrt{}$ (f)' to the frequency property of the atmospheric effect admittance in the periodic band from 0.5 to 7 days, because there is high correlation between the groundwater discharge and the atmospheric pressure in that periodic band. The coefficient 'a' just after the 2011 Tohoku earthquake increased twice as high as that before the earthquake. This agrees to the conclusion of Mukai and Otsuka (2014) of based on time domain analysis. We could find the increase of the coefficient 'a', or permeability increase, after the great earthquake such as the 2004 off Kii Peninsula earthquake as well.

Precipitation as well as earthquakes have the influences on the coefficient 'a', which shows positive correlation with the seasonal change of accumulated precipitation during the almost period since 2011. It might be considered that pore pressure increase due to precipitation causes looseness or outflow of mud in the crack and permeability increase.

Keywords: permeability, groundwater discharge, atmospheric effect