

Evaluation of shallow groundwater quality for use in an open-loop type, groundwater-based heat pump system in the Aseishi River watershed

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In cold snowy regions, a fossil fuel such like kerosene has been used for the heater and for snow-melting during winter season. Recently, the usage of geothermal heat has been closed up from the view of sustainable energy use and of minimizing greenhouse gas emissions. The heat pump system using shallow geothermal heat classified mainly into closed-loop system and open-loop system. The open system is more efficient than the closed system, however, for which the groundwater is needed to pump up. Once groundwater is pumped up, the formation of mineral precipitation (called as *scale*) could occur inside of the system due to temperature change and influence of oxygen, depending on chemical and physical properties of the groundwater.

It is well known that groundwater quality change spatially. In this research, regional differences of groundwater quality was examined to evaluate the possibility of scale formation at four sites, from the upstream to the downstream in the Aseishi River watershed. We conducted groundwater sampling from a total of four observation wells, in which the three have approximately 10 m deep and one has unknown depth in the Aseishi River alluvial fan on the Tsugaru Plain, Aomori Prefecture. In the field, pH, electric conductivity, and water temperature were measured. In the lab, Na^+ , NH_4^+ , K^+ , Mg^{2+} , Ca^{2+} , F^- , Cl^- , Br^- , NO_3^- , SO_4^{2-} , Fe, Mn, Sr, Ba, Si, and alkalinity were measured. Scale generation was evaluated thermodynamically using PHREEQC.

As a result, carbonate minerals and amorphous silica were found to be unsaturated and precipitation was unlikely to occur at all four sites. Iron was also unsaturated in respect with $\text{Fe}(\text{OH})_3$, thus the precipitation was unlikely to occur only at the most upstream location. We can conclude that the upstream of the fan has the most advantageous for utilizing groundwater heat from the viewpoint of scale formation.

Keywords: Aseishi River, groundwater quality, open-loop type groundwater-based heat pump system