

Estimation of water seepage from an active crater lake of the Kusatsu-Shirane volcano, Japan using radiocesium as a hydrological tracer

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The Fukushima Dai-ichi Nuclear Power Plant (FDNPP) accident in Mar 2011 resulted in serious regional radiological contamination in Japan. The accident has emitted large amounts of radiocesium, i.e. ¹³⁴Cs and ¹³⁷Cs, into the environments. Since Nov 2011, we have been measuring contents of radiocesium in crater lakes of the Kusatsu-Shirane volcano, Japan for investigation of mass balance of the lake water.

The Kusatsu-Shirane volcano, which is located about 240 km west-southwest from the FDNPP. It has three crater lakes on its summit. Yugama, the largest one of the three and the target of the present study, is well known as an active crater lake filled with acidic water due to the injection of hydrothermal fluids from the subaqueous vents. The volume of the lake water has been kept at a certain level with the balance of precipitation, evaporation, fluids injection from subaqueous vents and seepage through the lake bottom: the lake has no river that flows into and out of it.

We determined the contents of radiocesium in the crater lakes since Nov 2011 until Nov 2015. The activities of ¹³⁴Cs and ¹³⁷Cs in the Yugama water were 98 and 118 mBq/L, respectively, on Nov 1st, 2011, about eight months after the FDNPP accident. The activity ratio of ¹³⁴Cs/¹³⁷Cs revealed that the radiocesium released by the accident had reached the summit area of the volcano. The decay-corrected activities of ¹³⁴Cs and ¹³⁷Cs in the Yugama water have exponentially decreased over time at the same rate since May 2012. Since the observed apparent decreasing rate of the radiocesium is much larger than the rates based on the physical half-lives of ¹³⁴Cs and ¹³⁷Cs, it should reflect the residence time of water in the lake. Based on the rate, the average residence time of the lake water was estimated as about 1000 days. Accordingly, the seepage rate of the lake water is estimated to be about 0.1% of the total lake water volume per day. The results of this study could contribute to the precise estimation of the water balance in the crater lake and better understandings of the hydrothermal system of the volcano.