Water flow and circulation in crater lakes of Kusatsu-Shirane volcano, Japan, as studied by using radioactive cesium as a hydrological tracer

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The Kusatsu-Shirane volcano, located in the main island of Japan and about 150 km northwest from Tokyo, is one of the famous active volcanoes in Japan. It has three crater lakes named Yugama, Mizugama and Karagama on its summit. The water chemistries of the three crater lakes have fluctuated according to the volcanic activity of the volcano. The water of Yugama, which is the largest and deepest one of the three, is strongly acidic due to the injection of hydrothermal fluids from the subaqueous fumaroles at the lake bottom. The waters of the other two crater lakes, which are small and shallow, are weakly acidic although there are no visible hydrothermal activities in those craters. The water chemistries of the three crater lakes are expected to be controlled by the hydrothermal system beneath the summit and the water circulation system at the summit area because there are no rivers flowing into and flowing out from the craters.

The Fukushima Dai-ichi Nuclear Power Plant (FDiNPP) suffered serious damage by the huge earthquake and subsequent tsunami on 11 March 2011, and released large amounts of radioactive materials into the environments. The FDiNPP is located in Fukushima prefecture, the northeast Japan, and about 240 km east-northeast from the Kusatsu-Shirane volcano. In this study, we carried out preliminary measurements of the radioactive cesium in surface soils, lake waters and sediments in and around the crater lakes of the Kusatsu-Shirane volcano, and investigated the potential of the radioactive cesium as a tracer of water circulation of the crater lakes and the surrounding environment.

Both Cs-134 and Cs-137 were detected in the majority of the analyzed samples. The detection of Cs-134 reveals that radioactive materials originated from the FDiNPP accident had been transported and deposited on the summit area of the Kusatsu-Shirane volcano. For example, the activities of Cs-134 and Cs-137 in the Yugama water were estimated to be about 50 and 60 mBq/L, respectively at the end of May, 2012. The secular change of the content of radioactive cesium and its content ratio to stable cesium, Cs-133, may be a good indicator of the water circulation in the crater lakes.

The activity of radioactive cesium in the Karagama water was about one-fifth of that in the Yugama water. In addition, non-uniform distribution of radioactive cesium in the surface soils surrounding the lake was observed. The vertical profiles of radioactive cesium in the soils suggest that the cesium from the FDiNPP accident has not penetrated into the soils at this time, staying at the ground surface. Meanwhile, Cs-137 most probably originated from the global fallout before the 1980s has distributed at around 20 cm below the surface. The horizontal and vertical profiles of radioactive cesium in the soils of the craters may give us hints on understanding for water flows in the crater of the Kusatsu-Shirane volcano.