EGU22-10082
https://doi.org/10.5194/egusphere-egu22-10082
EGU General Assembly 2022

Learning from subsurface migration profiles of an artificial radionuclide during a volatile migration period

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Artificial radionuclides emitted into the environment have become tools to understand the physical processes in the last half-century and model future geophysical phenomena. In the case of a high contamination event such as a nuclear accident, it is challenging to capture the three-dimensional subsurface migration behavior of radionuclides during the most dynamic and crucial period shortly after the initial fallout because of the risk to human observers. Thus, geophysical models often rely on stabilized radionuclides, hypothesizing the radionuclide mobility in the initial phase. This study aims to demonstrate the rapid changes of vertical profiles of Cs-137 in short years after initial depositions, using soil samples collected in a forest and on abandoned farmland in Fukushima, Japan, five to seven years after the Fukushima Daiichi Nuclear Power Plant Accident in 2011.

The subsurface migration profiles, including the actual migration head depth of Cs-137, were examined against local topographic indices. Some of the preliminary results show that actual subsurface migration of the FDNPP-derived Cs-137 was equal to or deeper than 30 cm depth in nine forest soil samples; the confirmed deepest migration was at 38 cm. Meanwhile, the actual migration depths in abandoned crop fields were less than 15 cm. Along a 500 m hillslope, deposition was observed at five locations. The interaction of the timing of deposition and erosion depths was deciphered from Cs-137 vertical profiles and surrounding topography. The findings from this study demonstrate the implications of radionuclides behavior during a dynamic migration period to natural and artificial environmental radioactivity analysis. To accurately estimate the activities of radionuclides years later, these initial losses and gains of target radionuclides in the soil need to be considered with temporal progress, along with nuclear decay.