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Mobility of radioactive cesium in soils originated from the Fukushima Daiichi nuclear disaster; Application of extraction experiments

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The mobility of radioactive cesium (Cs) in contaminated soils affected by the Fukushima Dai-ichi nuclear disaster in 2011 was studied by single-step and sequential extraction experiments.
The Fukushima Dai-ichi Nuclear Power Plant (FDNPP) accident in March 2011 resulted in serious radioactivity contamination in areas adjacent to the FDNPP. Meanwhile, radioactive cesium originated from the accident was detected over a wide range of the northeastern half of Honshu, the main island of Japan. The chemical forms of the released radioactive materials are still not clear. However, it is highly probable that the behavior and mobility of Cs newly deposited on soils due to the accident are different from those of stable Cs that has existed in soils before the accident, because of the difference in chemical forms between them. In this study, we have conducted extraction experiments using several extractants on radioactivity contaminated soils collected in Japan after the accident, then discussed extraction behaviors of radioactive and stable Cs connected to their chemical forms.
The preliminary extraction experiments on non-contaminated soils revealed that stable Cs in soil was little extracted (less than 1 %) with Milli-Q water and 0.11M acetic acid (HOAc, pH 2.8), and that the extractants containing ammonium salts could partially extract Cs from the soils. The extracted portions of Cs with extractants containing ammonium salts are obviously higher than those with extractants containing cations other than ammonium like sodium, magnesium and calcium. This means that aqueous solutions containing ammonium salts are effective to extract Cs from soils.
Based on the findings from the preliminary experiments, we performed the three-step sequential extraction using Milli-Q water, 1 M NH4OAc solution (pH 7) and 0.11 M HOAc in this order as extractants on some contaminated soils. The results of the sequential extraction experiments indicate that only a few percent of radioactive Cs was extracted with the 1 M NH4OAc solution, and additionally radioactive Cs was partially extracted at the HOAc step after the NH4OAc step, whereas extracted portions of stable Cs in each step were less than those of radioactive Cs. The result reveals that radioactive Cs newly deposited on soils due to the FDNPP accident has apparently a higher mobility than stable Cs commonly existing in the soils, although most of the radioactive Cs is kept fixed in soils, surviving extraction processes.
We also performed single-step extraction experiments using several extractants on contaminated soils. The results of extractions with strongly basic solution suggest that humic acid plays an important role in the extraction of Cs from soils at least in the high pH range where it can dissolve, since the amount ratio of humic acid to fulvic acid and the content of total organic carbon (TOC) in the leachates seem to be correlated with the extracted portion of Cs from the soils. Thus the characteristics of the soils such as amounts of organic matters and their properties probably control the mobility of Cs in soils.

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