

Recovery of Radioactive Cesium from Clay Minerals in Soil contaminated by Fukushima Dai-ichi Nuclear Power Plant Accident

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Following the accident at Fukushima Dai-ichi Nuclear Power Plant in 2011, Fukushima prefecture has been widely contaminated by radioactive nuclides, ^{137}Cs and ^{134}Cs . Since these nuclides are retained within the surface 5 cm of the soil as a result of their selective sorption on clay minerals, topsoil had been extensively stripped for reducing the radiation dose of contaminated area. Then a large amount of contaminated soil has been generated (19–28 million m^3) and stored at temporary storage sites. The remediation of these hazardous soils and their volume reduction should be implemented as soon as possible.

Cs interacts strongly and selectively with 2:1 clay minerals such as vermiculite (or vermiculitized biotite). Ion exchange method is applicable to the recovery of Cs from clay minerals. At first, adsorption of cesium (Cs) on phyllosilicates has been intensively investigated because natural soils have strong ability of immobilizing Cs within clay minerals resulting in difficulty of decontamination. After that we clarified how Cs fixation on vermiculite, is influenced by structure change caused by Cs sorption at different loading levels and how Cs desorption is affected by various replacing cations induced at different treating temperature. As a result, more than 80% of Cs was readily desorbed from vermiculite with loading amount of 2% saturated Cs ($5.49 \times 10^{-3} \text{mmol g}^{-1}$) after four cycles of treatment of 0.01 M $\text{Mg}^{2+}/\text{Ca}^{2+}$ at room temperature, but less than 20% of Cs was desorbed from completely saturated vermiculite. These distinct desorption patterns were attributed to inhibition of Cs desorption by interlayer collapse of vermiculite, especially at high Cs loadings. In contrast, elevated temperature significantly facilitated divalent cations to efficiently desorb Cs from collapsed regions. After five cycles of treatment at 250°C with 0.01 M Mg^{2+} , 100% removal of saturated Cs was achieved. X-ray diffraction analysis results suggested that Cs desorption was completed through enhanced diffusion of Mg^{2+} into collapsed interlayer space under hydrothermal condition resulting in subsequent interlayer decollapse and readily release of Cs^+ . In conclusion, the high-speed ion exchange under the hydrothermal condition is applicable to the recovery of radioactive cesium from clay minerals contained in soil. Furthermore, the applicability of the ion exchange method to real contaminated soil and the continuous Cs recovery system using column will be discussed in this presentation.