Evaluation of Physicochemical Properties of ^{137}Cs in Geological Materials by X-ray Diffractometry

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1. Introduction

The Fukushima Daiichi Nuclear Power Plant (FDNPP) accident resulted in the release of huge amounts of radionuclides into the environment. Geological materials often contain radioactive cesium (^{134}Cs and ^{137}Cs) originating from the FDNPP accident. It is important to estimate physicochemical properties of radioactive cesium in geological materials. Understanding the chemical states of radioactive cesium is essential to evaluating their formation process and behaviors in environment. From the sequential extraction method, it was found that solubility behavior of ^{137}Cs depend on the elemental composition and crystalline phase in environmental materials[1,2]. In this study, we estimate physicochemical properties of radioactive cesium, especially ^{137}Cs in geological materials using the X-ray diffractometry (XRD) and gamma-ray spectrometry combined with the sequential extraction method.

2. Experiment

Geological materials (sand, scoria, soil, and fly ash) were collected in Japan. All of samples were dried at 105 ℃, 24 h in a DVS402 hot air rapid drying oven. After drying, these samples were sieved through 2 mm sieve. Crystalline phase and radionuclides in 5 g geological samples were fractionated into Water Soluble (WS), Bound to Carbonates (CB), Bound to Fe-Mn Oxide (OX), Bound to Organic matter (OB), and Residual (RES) by the sequential extraction method. Crystalline phase and radionuclides in raw samples, extract and residue were determined by the X-ray diffractometry using Rigaku RINT-2500 TTR-III diffractometer and the gamma-ray spectrometry with an HPGe spectrometer.

3. Results and discussion

From the XRD pattern of the scoria sample, Maghemite, Plasioclase, and Quartz were identified as main crystalline phases. Anorthite, Biotite, Calcite, Calcium chloride hydroxide, Gehlenite, Halite, Magnetite, Larmite, Quartz, Portlandite, and Sylvite were identified in the sand and the soil sample. Most of ^{137}Cs in scoria, soil, and sand existed as insoluble form. Aluminosilicate, clay minerals, and/or amorphous phase were detected in these samples. The insoluble radioactive cesium was existed in aluminosilicate and the interlayer of clay minerals, or captured amorphous phase. On the other hands, the fly ash sample has a lot of proportion of WS and OB. Result of XRD, most of the fly ash consisted of Silvite. This result shows that chemical form of most of ^{137}Cs is CsCl. The reason is that some studies reported that potassium in fly ash exists as KCl[3]. These results suggested that water-soluble radioactive cesium in fly ash existed as the CsCl. Our results would provide a great approach for understanding the adsorption process of radioactive cesium to behavior of geological materials.

4. Reference

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