放射性セシウムで汚染された土壌浄化のための亜臨界水イオン交換システムの開発
(4) 福島実汚染土壌からの Cs 高速脱離-カラムの動的挙動の解析

Development of Subcritical Water Ion Exchange System for Cleaning of Soil contaminated by Radioactive Cesium
(4) Rapid Desorption of Cs from Actually Contaminated Soil from Fukushima – Dynamic Analysis of the Column Treatment

*Xiangbiao Yin, Shinta Watanabe, Tatsuya Fukuda, Masahiko Nakase and Kenji Takeshita
Laboratory for Advanced Nuclear Energy, Institute of Innovative Research, Tokyo Institute of Technology

In the present work, the authors studied continuous desorption of radiocerium (Cs) from actual contaminated soil from Fukushima by the hydrothermal column treatment, coupling with its dynamic analysis of the Cs removal process.
Keywords: Cesium desorption, Column treatment, Dynamic analysis, Subcritical water, Ion exchange

1. Introduction

Widespread soil contamination following the Fukushima nuclear power plant accident in 2011 has motivated research on removing radionuclides, especially Cs, from soil. In this study, we detailly studied continuous Cs desorption from Fukushima actual contaminated soil by highspeed ion exchange through leaching with various cationic solutions in a column reactor, allowing the dynamic analysis of the Cs removal process.

2. Experimental

Continuous extraction of soil for Cs desorption was performed in a column-based reactor system as shown in Fig. 1. For the experiment, actual contaminated soil (~15,000 Bq/kg) sampled near about 9 km from Fukushima Daiichi Nuclear Power Plant was used. For the desorption test, 0.5g of radioactive soil was loaded into the column reactor and then flowed with same volume of various solutions (50 ml of 0.1M KCl, NaCl, $MgCl_2$, $CaCl_2$, $AlCl_3$, $LaCl_3$, $CeCl_3$) in rate of 0.25 mL/min at 150°C. The Cs desorption ratio for each solution was compared basing on the radioactivity reduction of the treated soils. To further study the desorption kinetics of column treatment, soil particles (10 g) were dispersed in CsCl solution (1L) with Cs^+ concentration of 1000 mg L^{-1} for 36 days, achieving a saturated Cs adsorption capacity of 7.6 mg-Cs/g-soil after three times of rinsing with water. Subsequently, as-prepared Cs-soil was loaded into the column reactor and leached with water or 0.01M $MgCl_2$ at 25 or 200°C. The Cs concentration in the effluent was measured with the time.

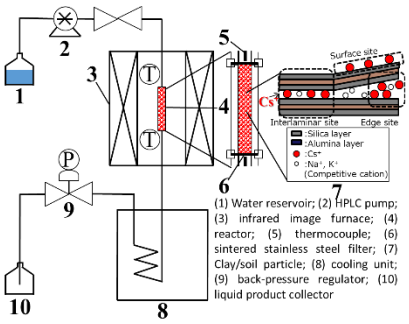

Fig. 1 Schematic diagram of continuous column system.

3. Results･Conclusion

Fig. 2 shows the radioactivity reduction of contaminated soil following column treatment with different solutions. It shows an order of Cs extraction ability as M^+ (K^+, Na^+) < M^{2+} (Mg^{2+}, Ca^{2+}) < M^{3+} (Al^{3+}, La^{3+}, Ce^{3+}), which is fully consistent with the order of their ability to exchange with Cs from collapsed interlayers of vermiculite in our previous studies, suggesting Cs in Fukushima soil would have been mainly trapped by micaceous clays onto interlayer-sites. Fig. 3 shows the continuous Cs desorption by column treatment with Mg^{2+} at different temperatures. It reveals slow and poor Cs desorption by only H_2O, with a desorption ratio lower than 30% and 60% in sum at 25 and 200°C, respectively. By contrast, the Cs desorption kinetic is improved significantly by Mg^{2+}-leaching even at 25°C, reaching a total desorption ratio over 80%. At 200°C, 100% summed desorption ratio was readily achieved within less volume of eluted Mg^{2+} solution. With the dynamic analysis of all these column treatment results, it allows for providing theoretical guidance for Cs removal from actual contaminated soil, thus inspiring new insights for treatment of post-accident soils in Fukushima.

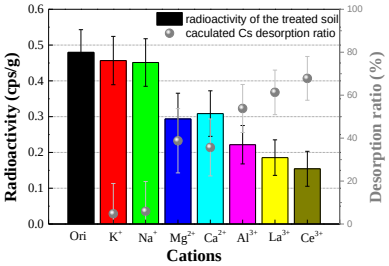

Fig. 2 Comparison of Cs removal by different cations.

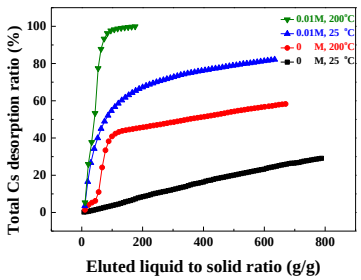

Fig. 3 Continuous Cs desorption from Cs saturated soil.

4. Acknowledgement

This work was financially supported by a Grant-in-Aid for Scientific Research from Ministry of Education, Science, Sports and Culture (18H03398) and Ministry of the Environment, Japan (1-1805).

*殷　祥標、渡邊真太、福田達弥、中瀬正彦、竹下健二
東京工業大学 科学技術創成研究院 先導原子力研究所