Actual Soil Decontamination Using Supercritical CO_2 with Ultrasonic horn

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Introduction

Nuclear power is the greenest power resource in Korea, but there are several problems. One of the most important problem is the disposal of radioactive waste. Korea is facing to decommissioning Gori unit-1 and Wolseong unit-1, but there is a critical limitation of lack disposal facility space. In the cases of decommissioning nuclear power plants overseas, unexpected soil waste has resulted in an increase in radioactive waste disposal. Acid or organic solvents are used for conventional radioactive soil waste disposal. However, conventional technology generate large amounts of secondary waste. To solve the problems, supercritical carbon dioxide soil decontamination technology was used. Also, Ultrasonic horns are used to increase decontamination efficiency. In the case of soil contamination, decontamination efficiency was depended on particle size. Therefore, in this study, the actual soil is classified by size and the experiment was carried out. For comparison with previous experimental results, the difference in decontamination efficiency with Sea sand is compared.

Material & Method

► Preparation of Soil specimen

◆ Soil classified 4 size (Table 1)

◆ Cs ion standard solution was contaminated

◆ Mixing with ultrasonic cleaner for 60 min

◆ Drying with Desiccator for 24 hour on room temperature and 20% humidity

◆ Drying with vacuum oven for 24 hour on 90℃

Table. 1. Classification of sand and soil samples

Sample type	Size(mm)
Silica sand	1.0~
Coarse soil	0.5~1.0
Medium soil	0.2~0.5
Fine soil	0.2~

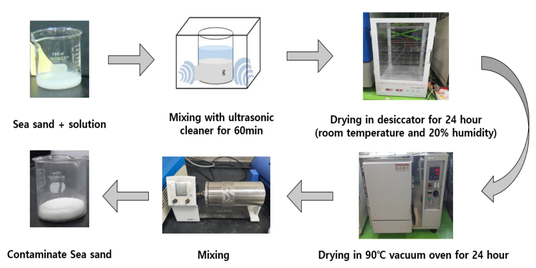
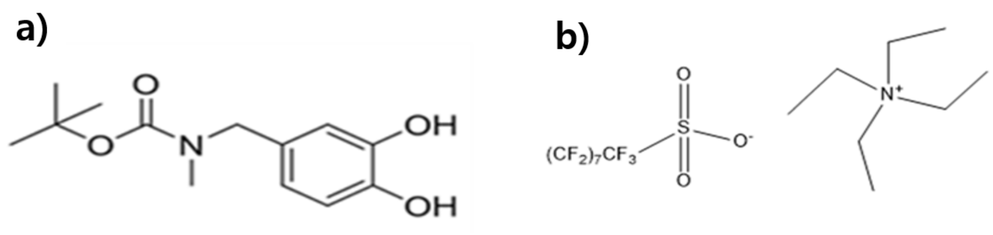


Fig. 1. Procedure for preparing contaminated sea sand

► Selection of Surfactant



◆ a) Catechol Amine (tert-butyl 3,4-dihydroxybenzyl (methyl) carbamate), 253.3 g/mol)

→ Ligand for extract metal ion from contaminated soil

◆ b) Net4pFOSA (Heptadecafluorooctanesulfonic acid tetraethylammonium salt, 629.37 g/mol)

→ Co-Ligands prevented counter anion effect and makes metal+ligands dissolved in CO_2

► Procedure of Decontamination experiment

◆ Total 1 hour reaction
→ 10 cycle (1 cycle : 3 min of ultrasonic wave + 3 min of stabilize)

◆ 5g of soil specimen

◆ 200 bar and 40 ℃ remain until experiment

◆ Ligand : Co-ligand = 1:1 molar ratio

◆ 3 experiment cases

- Case 1 : Closed cycle + min ultrasonic power
- Case 2 : Closed cycle + 30 % power of max ultrasonic power
- Case 3 : open cycle + 30 % power of max ultrasonic power

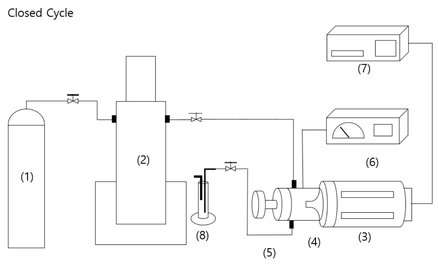


Fig. 3. Closed cycle experimental apparatus for Soil decontamination experiment using $SCCO_2$ (1) CO_2 cylinder (2) syringe pump (3) ultrasonic generator (4) ultrasonic horn (5) specimen container (6) heating controller (7) ultrasonic controller (8) collector

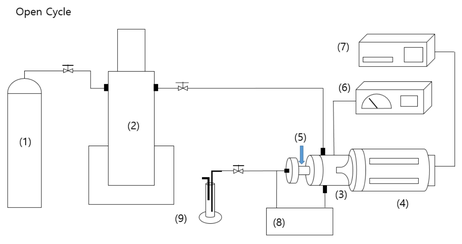


Fig. 4. Open cycle experimental apparatus for Soil decontamination experiment using $SCCO_2$ (1) CO_2 cylinder (2) syringe pump (3) ultrasonic horn (4) ultrasonic generator (5) specimen container (6) heating controller (7) ultrasonic controller (8) circulation pump (9) collector

► Procedure of Measurement

◆ Microwave accelerated reaction system (MARS 5, CEM Co., Matthews, NC, USA).

◆ Inductively Coupled Plasma Mass Spectrometry (ICP-MS, Leeman Labs, Lowell, MA, USA).

◆ Samples for measurement : 1g of soil specimen + 10 ml nitric acid solution

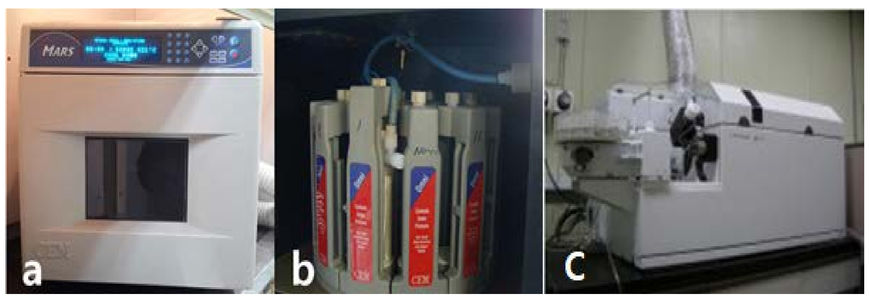


Fig. 5. Measurement apparatus for analysis the experiment sample a) MARS 5 b) reaction vessel c) ICP-MS

Experiment Results

◆ In Case 1, all three types of Actual Soil showed low decontamination efficiency of less than 50%.

◆ In case 2 with the same closed system but high energy, Coarse and Medium saw an increase in efficiency of about 20%. In the case of Fine, the overall low decontamination efficiency was confirmed.

◆ Case 3, an Open cycle, showed higher decontamination efficiency than the other two cases.

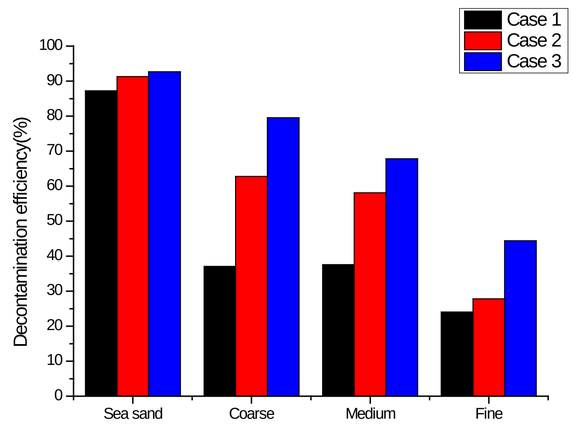


Fig. 6. Cs decontamination efficiency depending on the ultrasonic energy

► $Decontamination\ efficiency = \frac{C_B - C_A}{C_B} \times 100\%$ (1)

Conclusion

In this study, the feasibility of the supercritical decontamination technology as one of the decontamination techniques for extracting Cs from the soil was evaluated. This study was conducted by dividing the actual soil by size. In addition, the decontamination efficiency changes were identified according to the three experimental conditions. It was confirmed that the energy of the ultrasonic horn resulted in an increase in decontamination efficiency of the actual soil. The difference in decontamination efficiency between closed and open systems was identified. The decontamination efficiency of the open system was higher. Future research will continue to be conducted in an open system to resolve waste emissions.