Decontamination of Soils by Using an Acid Leaching Process

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1. Introduction

Several hundred drums of radioactive soil wastes were generated after the decommissioning of research reactor in Korea. The site contamination is mainly due to the leak from the waste solution storage tank during operation and the main contaminants are Co-60 and Cs-137. Since the radioactive waste disposal costs in Korea is very high, it is important to minimize the waste volume to be disposed. In order to reduce the disposal volume, soil wastes should be remediated by using an appropriate decontamination method. Some soil decontamination technologies such as electrokinetic [1], electrokinetic-flushing [2] and soil washing [3] and heap leaching technologies have been developed for a soil waste remediation. However, as the soil contamination characteristics are very complex, the existing processes are not enough to remediate all kinds of soil wastes.

In this study, an agglomeration-leaching column process, which has characteristic advantages of process simplicity and treatment capacity, was developed and tested for remediation of a sand rich radioactive soil wastes contaminated with Co-60 and Cs-137.

2. Materials and method

2.1. Sample descriptions

2.1.1. Radioactive soil samples

In soil chemistry, contaminated soils are aged with the time under the various temperature, water content, organic mater, etc. Here, we used two kinds of soil waste samples depending on the degree of aging. One is in the initial stage of contamination (Not-aged soil) and the other is aged for more than 20 years (Aged soil).

Table 1. Description of the soil samples

Soils		Radioactivity (Bq/kg)			Contamination status
		Co-60	Cs-137	Sum	
Not -aged	0.075 - 2.0 mm	1,180	1,560	2,740	passed 1 month after contamination
	Agglomerated d < 0.075 mm	1,090	1,450	2,540	
Aged	0.075 - 2.0 mm	810	1,260	2,070	passed about 20 years after contamination
	Agglomerated d < 0.075 mm	2,950	2,010	4,960	

2.1.2 Agglomeration of fine soil (0.075 mm)

Soil wastes have some fine particles with the diameter less than 0.075 mm, which can be an impediment for column operation, Therefore, the fine soils were screened by using a 0.075 mm sieve and agglomerated by adding a 5 % of sodium silicate solution [4].

2.1.3 Radioactivity of each sample

Table 1 is the description of the soil samples and their radioactivities measured by MCA (Ortech co.).

2.2. Decontamination of radioactive soil wastes by acid leaching

Decontamination experiments for the four soil samples were carried out by using an acid leaching method. A glass column with a 25 mm ID and 150 mm height was packed with 30 g of the soil sample and the leaching reagent (0.1M HCl) was continuously supplied with a mean flow rate of 3.0 mL/min. The L/S (liquid to solid) ratio was varied in the range between 10 mL/g and 300 mL/g as shown in Table 2. After completion of the leaching, the residual activities were measured by MCA for an evaluation of the removal efficiencies.

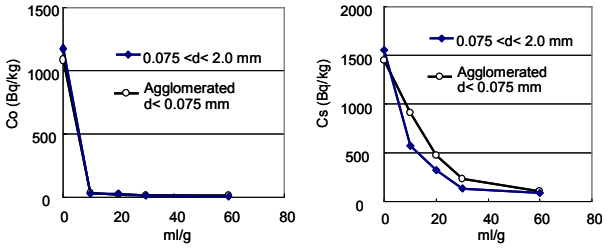
Table 2. Experimental conditions of each soil for acid leaching

Soils		Liquid to solid ratio (mL/g)
Not-aged	0.075 - 2.0 mm	10, 20, 30, 60
	Agglomerated d < 0.075 mm	
Aged	0.075 - 2.0 mm	10, 30, 60, 100, 200, 300
	Agglomerated d < 0.075 mm	

3. Results and discussions

3.1 Decontamination of Not-aged soil samples

Figure 1 shows the decontamination behavior for the Not-aged radioactive soil samples. The Co-60, as shown in (a), are removed easily from the soils, regardless of the particle sizes, by applying leaching solution with the L/S ratio of 10 mL/g. On the other hand, in the case of Cs-137, the radioactivities decreased to 100 Bq/kg by using 60 mL/g of leaching solution for both samples of the agglomerated soils and not agglomerated coarse soils. This is due to the high mobility of cesium ion in the soil matrix compared with cobalt ion.

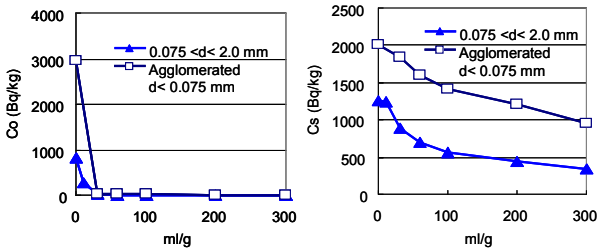


(a) Co (Not-aged) (b) Cs (Not-aged)

Figure 1. Decontamination behavior for the "Not-aged soil" samples

3.2 Decontamination of Aged soil samples

Figure 2 shows the decontamination behavior for the aged soil samples. In the case of Co-60 as shown in Fig. 2 (a), the radioactivities in both samples of the agglomerated soils and not agglomerated coarse soils decreased easily down to the almost ground level by using a leaching solution with the L/S ratio of 30 mL/g. In contrast, in the case of Cs-137 as shown in Fig. 2 (b), the radioactivities decrease from 2,000 Bq/kg to 1,000 Bq/kg for the agglomerated soil and from 1,250 Bq/kg to 400 Bq/kg for the coarse soil by applying 300 mL/g of leaching solution. Differently from the "Not-aged" soil samples, it is not easy to remove the cesium ion from a weathered soil waste aged for a long time. It is obviously due to that the highly mobile radioactive cesium ion diffuses deeply into the micropore of the soil particle.



(a) Co (Aged) (b) Cs (Aged)

Figure 2. Decontamination behavior for the "Aged soil" samples

4. Conclusions

A column type acid leaching process was evaluated to remediate the radioactive soil wastes generated from the decommissioned sites of TRIGA research reactors. The tests were performed for the samples of different aging conditions: one is "Not-aged" samples which are in the initial contamination stage and the other is "Aged" samples which are weathered for more than 20 years.

In the case of "Not-aged" soil wastes, the radioactivities decreased more or less easily down to potential unrestricted lease criteria in Korea by acid leaching method. However, in the case of the "Aged" soil wastes, more severe decontamination conditions would be required to meet potential unrestricted lease criteria.

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