Development of a Vertical Electrokinetic-Flushing Equipment to Decontaminate a Radioactive Soil

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1. Introduction

The radioactive soil generated from the Korean research reactor site is mainly contaminated with ^{60}Co and ^{137}Cs, and has been aged for more than 20 years. Recently, a soil washing method has been applied to remove ^{60}Co and ^{137}Cs from a radioactive soil but it showed lower removal efficiency for ^{137}Cs and generated a lot of secondary waste solution [1]. It has been suggested that an electrokinetic-flushing method, which has merits of both an electrokinetic method and a soil flushing method [2], is a suitable technology in consideration of the soil characteristics near a Korean nuclear facility. The electrokinetic process holds great promise for a remediation of a contaminated soil, as it has high removal efficiency and is especially advantageous over other processes for a soil with a low permeability. Also an electrokinetic remediation can be used to treat soils contaminated with inorganic species and radionuclides [3].

In this study, a vertical electrokinetic-flushing equipment suitable for the geological characteristics of Korean nuclear facility sites was developed for the remediation of a real radioactive soil. The optimum reagent and electric current were chosen by experiments by using the developed vertical electrokinetic-flushing equipment, which can obtain higher removal efficiencies during a short period. The effects of the particle size and the radioactive initial concentration of a soil on the removal efficiencies were analyzed.

2. Material and methods

2.1. Radioactive soil parameter measurement

The nuclear facilities in Korea have been constructed on a hard sandstone rock. The contaminated soil around such a nuclear facility contains a plethora of sand, which has a higher hydro-conductivity. The saturation degree of the surface at a nuclear facility site is about 26 ~ 27 % and the hydro-conductivity of the soil is a little higher. The average particle size of the radioactive soil is 1.2 mm.

2.2. A vertical electrokinetic-flushing equipment

A vertical electrokinetic-flushing equipment, which deploys hybrid process of an electrokinetic method and a soil flushing method, was manufactured, as shown in Fig. 1, for remediation of a soil near the domestic nuclear facilities.

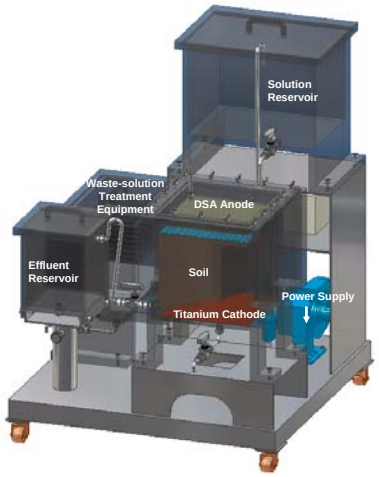

Fig. 1. Schematic diagram of a vertical electrokinetic-flushing equipment

2.3. Remediation experiment

The optimum reagent in this study was determined from a comparison of the removal efficiencies of acetic acid and nitric acid [4]. As a result, the removal efficiency of nitric acid is higher than that of acetic acid.

In this paper we have used nitric acid of 0.01 M as the reagent. And the removal efficiency versus the radioactivity concentration, the removal efficiency versus the soil particle size, and the removal efficiency versus the electric current were analyzed. Finally, the remediation time for reducing the soil radioactivity concentration to a clearance concentration (about 100 Bq/kg) was estimated through a verification of the experimental results.

3. Results and discussion

Fig. 2. (a) shows the removal efficiency versus the radioactivity concentration of a soil. The higher the radioactivity concentration of the soil is, the higher the removal efficiencies of ^{60}Co and ^{137}Cs increase. Namely, the removal efficiencies of ^{60}Co and ^{137}Cs of the soil with a high concentration increased by 13.7 % and 3.9 %, resepectively, compared with those of the soil with a low concentration. The removal efficiencies of

^{60}Co and ^{137}Cs by an electrokinetic-flushing remediation for 20 days are 98.5 % and 61.0 %, respectively.

Fig. 2. (b) shows the removal efficiency versus the particle size of soil. The larger the particle size of the soil is, the more the removal efficiencies of ^{60}Co and ^{137}Cs increase. Namely, the removal efficiency of ^{137}Cs from a total soil(average size: 1.2 mm) was decreased by about 2 % more compared with that of soil with average particle size of 0.6 mm. The reason is considered to be that a channeling was generated in the area of a large particle in a soil cell [5].

Fig. 2. (c) shows the removal efficiency from the soil versus the electric current in a soil cell. The higher the electric current in a soil cell is, the more the removal efficiencies of ^{60}Co and ^{137}Cs increase. Namely, the removal efficiencies of ^{60}Co and ^{137}Cs by the application of an electric current of 20 mA/cm^2 increase by 1.3 % and 4.2 % more than those by the application of 10 mA/cm^2.

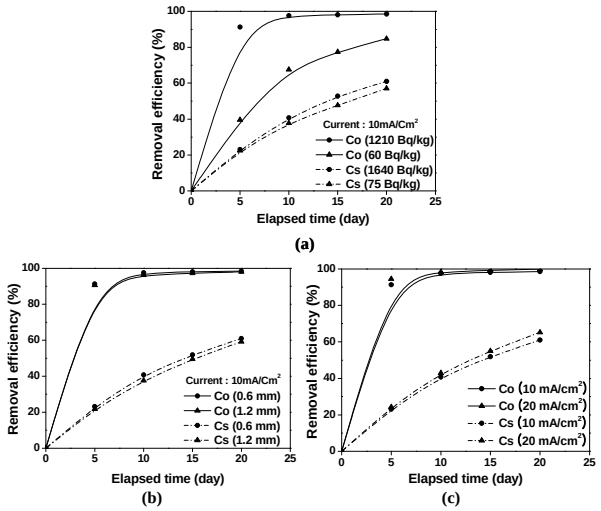

Fig. 2. Removal efficiency versus by electrokinetic-flushing

4. Conclusions

A vertical electrokinetic-flushing equipment suitable for the geological characteristics of Korean nuclear facility sites was developed for the remediation of a real radioactive soil. The optimum experimental conditions were obtained with vertical electrokinetic-flushing experiment and the results are as follows.

The removal efficiencies of ^{60}Co and ^{137}Cs by nitric acid were increased by 3.3 % and 2.0 % more than those by acetic acid. The removal efficiencies of ^{60}Co and ^{137}Cs from the soil of a high concentration were increased by 13.7 % and 3.9 %. The larger the particle size of the soil was, the more the removal efficiencies of ^{60}Co and ^{137}Cs were increased. The removal efficiencies of ^{60}Co and ^{137}Cs by the application of an electric current of 20 mA/cm^2 were increased by 1.3 % and 4.2 % more than those by the application of 10 mA/cm^2.

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