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The removal of Cs-137 from soil using washing-electrokinetic decontamination equipment

Gye-Nam Kim, Seung-Soo Kim, Geun-Ho Kim, Hye-Min Park, Wan- Suk Kim, Uk-Ryang Park, Hyeok-Ju kwon, Oh-Ha Ryu, Jei-Kwon Moon
korea Atomic Energy Research Institute, 989-111 Daedeok-daero Yusong-gu Deajon
**Corresponding author: kimsum@kaeri.re.kr*

1. Introduction

The radioactive soil at the KAERI radioactive waste storage facility has slightly high hydro-conductivity, and was mainly contaminated with ^{137}Cs 30-35 years ago. Recently, a soil washing method has been applied to remove ^{137}Cs from radioactive soil, but it appears that the removal efficiency of ^{137}Cs had low and a lot of waste solution was generated [1]. Meanwhile, an electrokinetic decontamination method provides high removal efficiency of ^{137}Cs and generates little waste effluent. Thus, it is suggested that an electrokinetic decontamination method is a suitable technology in consideration of the soil characteristics near South Korean nuclear facilities [2].

2. Experiment

Washing-electrokinetc soil decontamination equipment was manufactured to remove cesium from lots of soil with high removal efficiency during a short time, and consists of soil washing equipment, electrokinetic equipment, and waste solution treatment equipment. Herein, the waste solution treatment equipment consists of a precipitation tank, concentration tank, and a filter press. 75-85% of the cesium was removed from the soil through the soil washing equipment, and the washed soil was then put in a soil cell in the electrokinetic decontamination equipment to remove the cesium at more than 95% from the soil. Meanwhile, the waste electrolytes released from the electrokinetic decontamination equipment, which have a low concentration of metal ions, are reused for soil washing with the addition of nitric acid. Waste solution released from the soil washing equipment flows into a precipitation tank for precipitation, and then flows into a filter press for filtration through a concentration tank, and the supernatant of the precipitation tank flows into a treated solution tank for reuse in the electrokinetic decontamination equipment.

A schematic diagram of the 200L soil washing equipment is shown in Fig. 1, and consists of a washing tank, an impellor, and a soil container. A drain pipe was attached to the side of the washing tank to drain the waste solution generated after scrubbing work in the washing tank. A drain valve was attached at the bottom of the washing tank to discharge soil after washing decontamination work. A schematic diagram of the 100 L electrokinetic decontamination equipment is drawn up in Fig. 1, which consists of a couple of anode rooms, 50 L electrokinetic soil cells, cathode rooms, soil cloth sacks, metal oxide separators, pH and pump controllers, an equipment support system, a power supply, and a nitric acid box. Each electrokinetic soil cell can contain 50L of soil. The washed soil contaminated with cesium was poured into a soil cloth sack in an electrokinetic soil cell. If the electricity is given at the anode and cathode by the power supply, $^{137}Cs^{+}$ in the cesium soil moves to the cathode room through electro-migration and electro-osmosis. The metal oxide separator removes metal oxide particles in the waste solution in the cathode room, and the pH controller controls the pH of the waste solution in the cathode room. An anode electrode was made with an expensive dimensional stable anode for the prevention of electrode dissolution, and a cathode electrode was made with titanium for safety. A soil cloth sack filled up with cesium soil is moved up and down by a crane.

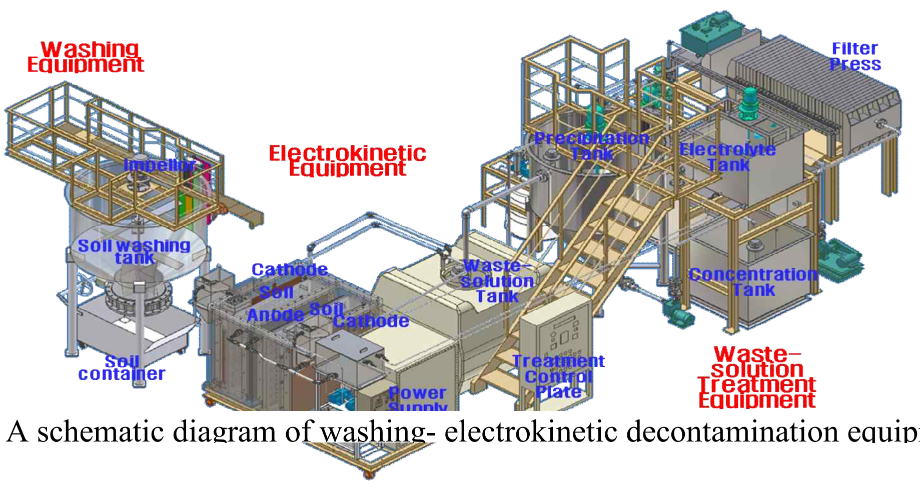

Fig. 1. A schematic diagram of washing- electrokinetic decontamination equipment

3. Results and discussion

The results of soil washing- electrokinetc experiment for 30 years aging soil are shown in Fig. 2. The electrokinetic decontamination experiments were performed with a 0.1 M HNO_3 solution using the manufactured 100L electrokinetic decontamination equipment.

First, the initial concentration of the cesium soil was 10.0 Bq/g. After secondary scrubbing in a soil washing tank, the residual radioactivity concentration of ^{137}Cs was reduced to 2.43 Bq/g. Then, for self-disposition of the contaminated soil, electrokinetic decontamination was performed until the residual cesium concentrations went down to below 0.1Bq/g. After electrokinetic decontamination for 10 days, the residual radioactivity concentration of ^{137}Cs in the soil cell was 1.32 Bq/g and the removal efficiency in comparison with the original radioactivity concentration was 86.8%. After electrokinetic decontamination for 40 days, the residual radioactivity concentration of ^{137}Cs in the soil cell was 0.26 Bq/g, and the removal efficiency in comparison with the original radioactivity concentration was 97.4%. After electrokinetic decontamination for 60 days, the residual radioactivity concentration of ^{137}Cs in the soil cell was 0.1 Bq/g, and the removal efficiency in comparison with the original radioactivity concentration was 99.0%. Therefore, second scrubbings in the soil washing tank and electrokinetic decontamination for 60 days with the manufactured 50L electrokinetic decontamination equipment, were needed for self-disposition of the soil contaminated with ^{137}Cs of 10.0 Bq/g.

Second, the initial concentration of the cesium soil was 19.4 Bq/g. After secondary scrubbing in a soil washing tank, the residual radioactivity concentration of ^{137}Cs was reduced to 4.3 Bq/g. After electrokinetic decontamination for 40 days, the residual radioactivity concentration of ^{137}Cs in the soil cell was 0.57 Bq/g and the removal efficiency in comparison with the original radioactivity concentration was 97.1%. After electrokinetic decontamination for 80 days, the residual radioactivity concentration of ^{137}Cs in the soil cell was 0.1 Bq/g, and the removal efficiency in comparison with the original radioactivity concentration was 99.5%.

Third, the initial concentration of the cesium soil was 40.0 Bq/g. After secondary scrubbing in a soil washing tank, the residual radioactivity concentration of ^{137}Cs was reduced to 6.8 Bq/g. After electrokinetic decontamination for 40 days, the residual radioactivity concentration of ^{137}Cs in the soil cell was 0.9 Bq/g and the removal efficiency in comparison with the original radioactivity concentration was 97.8%. After electrokinetic decontamination for 100 days, the residual radioactivity concentration of ^{137}Cs in the soil cell was 0.08Bq/g, and the removal efficiency in comparison with the original radioactivity concentration was 99.9%.

Fig. 3 shows the distribution of residual cesium concentrations in the cross-section and plane-section views of the soil cell after 80 days of decontamination. Residual cesium concentrations in the cathode part of the soil cell were higher than those of the anode part. This was considered to be due to the fact that the cesium ions moved from the anode part to cathode part.

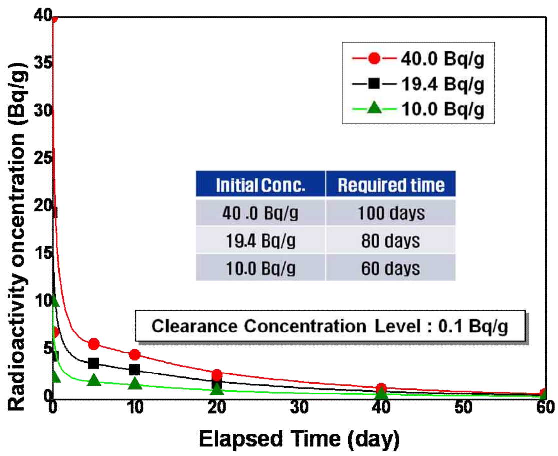

Fig. 2. Cesium radioactivity concentration versus elapsed decontamination time for 30 years aging soil

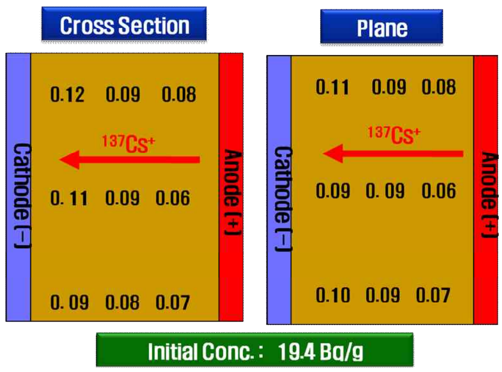

Fig. 3. Distribution of residual cesium concentration in a soil cell after decontamination for 80 days

REFERENCES

[1] G. N. Kim, W. K. Choi, C. H. Bung, J. K. Moon, J. Ind. Eng. Chem. 13 (2007) 406-413.
[2] G.N. Kim, Y.H. Jung, J.J. Lee, J.K. Moon, Journal of the Korean Radioactive Waste Society. 25(2)(2008) 146-153.