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The improvement of Pilot-scale Electrokinetic for Radioactive Soil Decontamination

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1. Introduction

Most nuclear facility sites have been contaminated by leakage of radioactive waste-solution due to corrosion of the waste-solution tanks and connection pipes by their long-term operation, set up around underground nuclear facilities. Therefore it was needed that the method to remediate a large volume of radioactive soil should be developed. Until now the soil washing method has studied to remediate soil contaminated with uranium, cobalt, cesium, and so on. But it has a lower removal efficiency of nuclide from soils and generated a large volume of waste-solution. And its application to the soil composed of fine particle is impossible. So, the electrokinetic method has been studied as a new technology for soil remediation recently.

In this study, the original electrokinetic equipment of 50L suitable to soil contamination characteristics of Korean nuclear facility sites was manufactured for the remediation of soil contaminated with uranium. During experiment with the original electrokinetic equipment, many metal oxides were generated and were stuck on the cathod plate. Several methods to reduce the generation quantity of metal oxides in the electrokinetic equipment and to take off metal oxides from the cathod plate were improved. The soil with uranium was remediated with the improved electrokinetic equipment. The required time to remediate a radioactive soil to under a clearance concentration level was yielded through demonstration experiment with the improved electrokinetic equipment for its different radioactivity concentration.

2. Methods and Results

2.1 Impvement of 50L electrokinetc equipment

This electrokinetic equipment consisted of a reagent reservoir (50x30x25 cm), an anode room (50x50x10), an electrokinetic soil cell (50x50x20 cm), a cathod room (50x50x12 cm), an equipment support system, a power supply, pH controller and so on. In order to finish the soil remediation experiment within 2 month, the thickness of a soil cell was decided to be 15～20 cm in consideration of previous laboratory experiment results. The remediation period is proportional to the thickness of the soil cell. The injection rate of the reagent can be controlled by changing the hydraulic head difference of anode room and cathod room. Also, the electro-osmosis flow direction in the soil cell is the cathod side. The hydrogen gas generated at the cathod electrode plate, while the oxygen gas generated at the cathod electrode plate.

The original electrokinetic equipment was used for electrokinetic remediation. But after experiment of about 7 days, a lot of metal oxides were generated and covered the cathod plate as shown in Fig. 1. The uranium removal capability of the original electrokinrtic equipment was almost exhausted because the cathod plate covered with metal oxides did not conduct electricity in the original electrokinetic equipment. Therefore, the improved electrokinetic equipment was manufactured and the remediation experiments were carried out again.

Fig. 1. Cathod plate covered with metal oxides.

The original electrokinetic equipment was improved as follows. First, the immersion-washing equipment was manufactured for washing of metal oxides from the cathod plate. The cathod plate contaminated with metal oxides was periodically taken out of the cathod room in electrokinetic equipment and was immersed into 3.0 M nitric acid solution in the electrode immersion box of the immersion-washing equipment to separate metal oxides for 3 hours. And then the cathod plate was taken out of the cathod room and put into the washing box for the wipe of electrode surface. Second, a metal oxide separator for removal of metal oxide particles was manufactured. A metal oxide separator removed metal oxide particles of more than 0.075 mm in waste-solution under circulation in cathod room. Metal oxide particles accumulated on filter was periodically dumped in a radioactive waste drum. Third, the circulation system for pH control and waste-solution movement was manufactured. The circulation system controls the pH in cathod room to 1～2 to prevent the generation of metal hydroxide and circulates waste-solution in a cathod room to prevent the increase of metal oxides due to its stagnancy.

Type of metal oxides	Conc. (ppm)	Type of metal oxides	Conc. (ppm)
ZnO	1,400	NiO	2,700
MnO	5,300	CuO	1,300
Cr_2O_3	8,400	CaO	104,000
BaO	1,900	SiO_2	3,100
MgO	5,800	Fe_2O_3	229,000
Al_2O_3	189,000	UO_2	33,000

Table 1: Types and concentrations of metal oxides stuck on cathod plate.

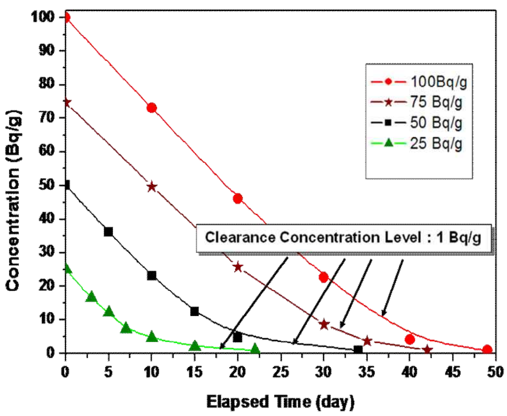

Fig. 2.Uranium radioactivity concentration versus remediation elapsed time per different initial concentration

2.2 Remediation experiment

After the completion of electrokinetic remediation experiments for radioactive soils of the initial concentrations of about 25, 50, 75 and 100 Bq/g. When the initial uranium concentration of soil was about 25 bq/g, after the remediation experience for 25days using the improved electrokinetic remediation equipment, the removal efficiency of uranium from the soil was 96.8% and its residual uranium concentration was 0.81 Bq/g. When the initial uranium concentration of soil was about 50 Bq/g, the electrokinetic remediation time required to remediate the uranium concentration below clearance concentration of 1.0 Bq/g was about 34 days and, at the same time, the generated waste-solution volume was 3.8 ml/g. When the initial uranium concentration of soil was about 75 Bq/g, the electrokinetic remediation time required to remediate below 1.0 Bq/g was about 42 days and, at the same time, the generated waste-solution volume was 4.4 ml/g. When the initial uranium concentration of soil was about 100 Bq/g, the electrokinetic remediation time required to remediate below 1.0 Bq/g was about 49 days and at the same time, the generated waste-solution volume was 5.0 ml/g. Fig. 2 shows uranium radioactivity concentration versus remediation elapsed time per different initial uranium concentration. Consequently, the improved electrokinetic remediation equipment has successfully remediated the uranium concentration of the contaminated soil to below clearance concentration of 1.0 Bq/g during appropriate period.

3. Conclusions

The uranium removal capability of the original electrokinrtic equipment was almost exhausted because the cathod plate covered with metal oxides did not conduct electricity in the original electrokinetic equipment. Therefore, the original electrokinetic equipment was improved as follows. First, an immersion-washing equipment was manufactured for washing of metal oxides from the surface of cathod plate. Second, a metal oxide separator for removal of metal oxide particles below 0.075 mm was manufactured. Third, the circulation system for pH control and waste-solution movement was manufactured. The circulation system controls the pH in cathod room to 1～2 to prevent the generation of metal hydroxide and circulates waste-solution in a cathod room to prevent the increase of metal oxides due to its stagnancy. After the remediation experience for 25days using the improved electrokinetic remediation equipment, the removal efficiency of uranium from the soil was 96.8% and its residual uranium concentration was 0.81 Bq/g. When the initial uranium concentration of soil was about 50 Bq/g, the electrokinetic remediation time required to remediate the uranium concentration below clearance concentration of 1.0 Bq/g was about 34days. When the initial uranium concentration of soil was about 75 Bq/g, the electrokinetic remediation time required to remediate below 1.0 Bq/g was about 42 days. When the initial uranium concentration of soil was about 100 Bq/g, the electrokinetic remediation time required to remediate below 1.0 Bq/g was about 49 days.

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