



Decontamination of Soil Contaminated with Cesium using Electrokinetic-electrodialytic Method



Gye-Nam Kim^{*}, Seung-Soo Kim, Uk-Rang Park, Jei-Kwon Moon

Korea Atomic Energy Research Institute, 1045 Daedeokdaero, Yuseong-gu, Daejeon 305-353, Republic of Korea

ARTICLE INFO

Article history:

Received 22 November 2014
Received in revised form 10 March 2015
Accepted 28 March 2015
Available online 9 April 2015

Keywords:

Decontamination
Cesium
Removal
Soil
Electrokinetic
Electrodialytic

ABSTRACT

The soil contaminated with cesium was sampled at an area near a nuclear facility in Korea. Electrokinetic decontamination equipment and electrokinetic-electrodialytic decontamination equipment were manufactured to decontaminate the contaminated soil. The removal efficiency according to the lapsed time by the electrokinetic decontamination equipment and the electrokinetic-electrodialytic decontamination equipment was investigated through several experiments. The difference between the removal efficiency of the electrokinetic-electrodialytic equipment without an anion exchange membrane and that with an anion exchange membrane was investigated through several experiments. The removal efficiency of $^{137}\text{Cs}^+$ from soil by electrokinetic-electrodialytic decontamination technology was higher than that of $^{137}\text{Cs}^+$ from soil by electrokinetic decontamination technology. The removal efficiency of $^{137}\text{Cs}^+$ was sharply reduced after 7 days on using electrokinetic decontamination, because the $^{137}\text{Cs}^+$ on the surface of the soil particles had almost been removed for 7 days. The removal efficiency of $^{137}\text{Cs}^+$ was increased after 7 days on using electrokinetic-electrodialytic decontamination with soil stirring. The soil stirring accelerated the desorption of cesium ions from soil and an anion exchange membrane shortened the period for removing cesium from the soil cell by preventing the influx of cesium ions into the anode room. The more the initial radioactivity concentration of soil increased, the more the removal efficiency of $^{137}\text{Cs}^+$ from soil increased. When the electrokinetic-electrodialytic decontamination period of 0.3–7.0 days elapsed, $^{137}\text{Cs}^+$ in the soil was removed by about 12–83%. When the electrokinetic-electrodialytic decontamination period of 10–21 days elapsed, the $^{137}\text{Cs}^+$ in soil was removed by about 91–97%.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

The radioactive soil at the KAERI radioactive waste storage facility has a slightly high hydro-conductivity, and was mainly contaminated with ^{137}Cs 30–35 years ago. Recently, a soil washing method was applied to remove ^{137}Cs from the radioactive soil, but it appeared that the removal efficiency of ^{137}Cs was low, and a lot of waste solution was generated [1]. Meanwhile, an electrokinetic decontamination method provides a high removal efficiency of ^{137}Cs and generates little waste effluent. Thus, it was suggested that an electrokinetic decontamination method is a suitable technology in consideration of the soil characteristics near South Korean nuclear facilities [2]. The electrokinetic process holds great promise for the decontamination of contaminated soil as it has a high removal efficiency and is time-effective for a low permeability. Electrokinetic decontamination can be used to treat soil contaminated with inorganic species and radionuclides [3].

The main mechanisms of a contaminant's movement in an electrical field involved in electrokinetic technology are the electro-migration of the ionic species and electro-osmosis. Electro-migration probably contributes significantly to the removal of contaminants, especially at high concentrations of ionic contaminants and/or a high hydraulic permeability of soil [4]. The cathode reaction should be depolarized to avoid the generation of hydroxides and their transport in soil. The selected liquid, also known as a purging reagent, should induce favorable pH conditions in soil, and/or interact with the incorporated heavy metals so that these heavy metals are removed from the soil [5]. Recently, researchers have been investigating whether this method can be used to remove subsurface contaminants, and they have compiled published research on the use of electrokinetic techniques to decontaminate fine-grained soil and have discussed some of the problems that occur during this process [6–8].

Meanwhile, researchers have also tried to develop soil flushing techniques in which soil-bound contaminants are transferred to a liquid phase by desorption and solubilization. Several flushing solutions have been investigated, such as water, acids, bases,

^{*} Corresponding author.

chelating agents, alcohol, and other additives [9]. In practice, acid washing and chelator soil washing are the two most prevalent removal methods [10–11]. Recently, acetic acid or sodium dodecyl sulfate was used as an electrolyte for electrokinetic decontamination to increase the removal efficiency of metal [12–13]. In addition, most of the electrokinetic equipment has been manufactured as a horizontal type. Laboratory-scale electrokinetic decontamination has been performed for TRIGA soil during the past 5 years, but at this time, a study related to washing- electrokinetic decontamination was performed [14–15]. Jing-Yuan Wang (2007) started to develop vertical electrokinetic equipment to easily remove the contaminants accumulated at a cathode. The equipment has a cathode in the upper side so that the reagent in the soil cell might flow upward, and the contaminants in the soil cell might be accumulated in the upper side. Upward vertical electrokinetic equipment has already been used to remove heavy metal from kaolin [16] and to remove organic material from some of the soil [17]. Meanwhile, the electro-dialytic method has generally been used for treating waste solution and soil remediation, which attaches an ion exchange membrane at the anode room or cathode room [18–21].

In this study, the soil contaminated with cesium was sampled at an area near a nuclear facility in Korea. The electrokinetic decontamination equipment and electrokinetic-electrodialytic decontamination equipment were manufactured to decontaminate the contaminated soil. The difference between the removal efficiency according to the lapsed time by the electrokinetic decontamination equipment and the electrokinetic-electrodialytic decontamination equipment was investigated through several experiments. The difference between the removal efficiency of the electrokinetic-electrodialytic equipment without an anion exchange membrane and that with an anion exchange membrane was investigated through several experiments. In addition, the removal efficiency trend according to different cesium radioactivity of soil was drawn out through several experiments.

2. Materials and methods

2.1. Characteristics of contaminated soil

The soil in a drum was contaminated with cesium in a drum, and Table 1 shows the cesium soil hydraulic properties. The saturation degree of the surface at a nuclear facility site is small, and the hydraulic conductivity of the soil is a little lower. The pH of the soil is a little acidic.

2.2. Manufacturing of electrokinetic decontamination equipment

Electrokinetic equipment decontamination was manufactured for the experiments. Fig. 1 shows a schematic diagram of the electrokinetic decontamination equipment, and Fig. 2 shows the manufactured electrokinetic decontamination equipment. The electrokinetic decontamination equipment consists of a horizontal soil cell, two electrode compartments (anode/cathode rooms), a reagent reservoir, an effluent reservoir, and a power supply, and 480 g of contaminated soil was placed into a horizontal soil cell of

Table 1
Hydraulic properties of cesium soil.

Parameter	Value
Bulk density (g/cm ³)	1.51
Porosity (%)	41.8
Hydraulic conductivity (cm/sec)	3.8×10^{-5}
Water content (%)	23.4
pH	5.7

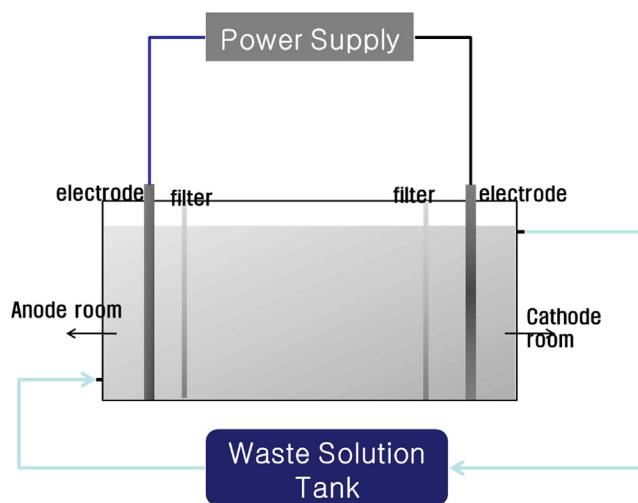


Fig. 1. A schematic diagram of electrokinetic decontamination equipment.

$4.5 \times 5.9 \times 14.5$ cm for Experiment 1. As Experiment 1, a paper filter was inserted between the electrode compartment and the contaminated soil to prevent an influx of soil. A pump supplies a reagent to the reagent reservoir at 0.5–1 ml/min, and the reagent reservoir supplies a chemical solution to the anode room. The electric current between electrodes is 0.6A, and the electric voltage between electrodes is 4.5–5.2 V. The temperature in the cathode room was below 65 °C. 0.5 M of HNO₃ was used as electrolyte reagent to accelerate the desorption of cesium from soil on stirring soil. Experiments 1 and 2 used a different soil sample radioactivity, and the electrokinetic decontamination period was 21 days without exception.

In Experiment 2, an anion exchange membrane was inserted between the anode room and the contaminated soil to prevent an influx of cesium ions, and a paper filter was inserted between the cathode room and the contaminated soil. 200 g of contaminated soil was placed into a horizontal soil cell, namely, the ratio of liquid (mg)/ soil (g) is 0.5.

2.3. Manufacturing of electrokinetic-electrodialytic decontamination equipment

To increase the removal velocity of cesium from the soil, electrokinetic-electrodialytic decontamination equipment was manufactured. This equipment mixed the electrokinetic and electro-dialytic concepts. Fig. 3 shows a schematic diagram of electrokinetic-electrodialytic decontamination. In this study, the

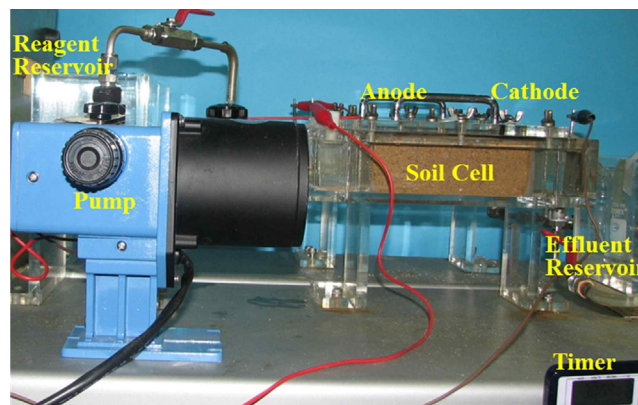


Fig. 2. Manufactured electrokinetic decontamination equipment.

Download English Version:

<https://daneshyari.com/en/article/183492>

Download Persian Version:

<https://daneshyari.com/article/183492>

[Daneshyari.com](https://daneshyari.com)