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Washing technology development for gravel contaminated with uranium

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1. Introduction

Before and after the dissolution of nuclear facilities and during the operation, a large amount of radioactively contaminated soil is generated. In addition, such soil includes a large amount of gravels. Currently, both a soil washing method and decontamination method using electrokinetic separation are known as the most effective ways to decontaminate radioactively contaminated soil. In particular, the soil washing method has a short decontamination time and is economical. In addition, methods including phytoremediation, solidification/stabilization and bioremediation exist. Phytoremediation and bioremediation are economical, but have low remedial efficiency. In addition, bioremediation causes washing wastewater because it requires a washing process for the separation of microorganisms from the soils. In addition, solidification/stabilization is a commonly used methods, but eventually increases the volume of wastes.

As mentioned above, many researches involved in the decontamination of radioactively contaminated soils have been actively processed. On the other hand, researches for decontaminating radioactively contaminated gravels are not being currently processed.

In this study, we performed basic experiments using decontamination methods to decontaminate radioactively contaminated gravel. First, we measured the concentration of uranium in gravel included in uranium-contaminated soils and performed a washing experiment to monitor the tendency of uranium removal. In addition, when managing gravel with a low uranium-decontamination rate, we tried to satisfy the radioactivity concentration criteria for self-disposal in the wastes (0.4Bq/g or less) by performing a washing experiment after only a physical crushing process.

2. Experimental and Results

We used the gravels included in uranium-contaminated soils as samples during the experiments, and measured the uranium concentration using a Multi-Channel Analyzer (MCA). During the washing experiment, we stirred a washing mixture under a solid/liquid ratio of 1g/2ml and a pH of less than 1 for 3 hours, fixed it and then separated the supernatant from it. We then dried the residue and measured the uranium concentration with the MCA.

We measured the uranium concentrations before and after the washing process by separating the gravels in the collected samples by weight. As a result, the average concentration of uranium before the washing process was 1.3Bq/g. Additionally, after two washing experiments on the gravel, the average concentration of uranium was measured as 0.8Bq/g. The results did not satisfy the radioactivity concentration criteria for self-disposal (0.4Bq/g or less) set out in this study. It is thought that during the oxidation of the gravels exposed to radiation for a long period of time, the uranium penetrated into the gravel and eventually contaminated their inside. We also decontaminated the uranium outside the gravel, but not inside. It was therefore determined that we cannot decontaminate the uranium inside the gravels by decontaminating the gravel itself.

Table. 1. Removal efficiency of different gravel weights using gravel washing

NO	**Ci**(Bq/g)	**1st**	**2nd**	**Weight**
1	2.25	1.04	1.01	154g
2	2.54	1.83	1.76	766g
3	0.97	0.91	1.03	1328g
4	0.61	0.4	0.37	1876g
5	0.72	0.32	0.3	2252g
6	0.76	0.72	0.54	3242g

To increase the decontamination efficiency of uranium contaminated gravels, the uranium contaminated inside the gravels should be decontaminated. We therefore performed a washing experiment after the physical crushing of the gravels. We crushed the gravel with a 4.1Bq/g initial concentration and classified them as more than 2 mm and less than 2 mm in size. As a result, the concentration of uranium in fine gravels with an initial concentration of less than 2mm was two-times higher than the concentration of uranium in gravel with an initial concentration of more than 2 mm. As the results of the washing experiments, the uranium concentration in the fine gravels with a size of less than 2 mm was lower than 0.4Bq/g during the three washing processes. However, the uranium concentration in the gravels whose sizes are more than 2 mm was higher than 0.4Bq/g. Gravel larger than 2 mm was not any cleaner after the first washing process. In addition, fine gravel smaller than 2 mm satisfied the radioactivity concentration criteria for self-disposal after the three washing experiments. It was shown that the larger the size of the gravel, the more restrictions on the washing and decontamination and that the rate of decontamination could be improved by decreasing the size of the gravel particles and by increasing the number of washing processes.

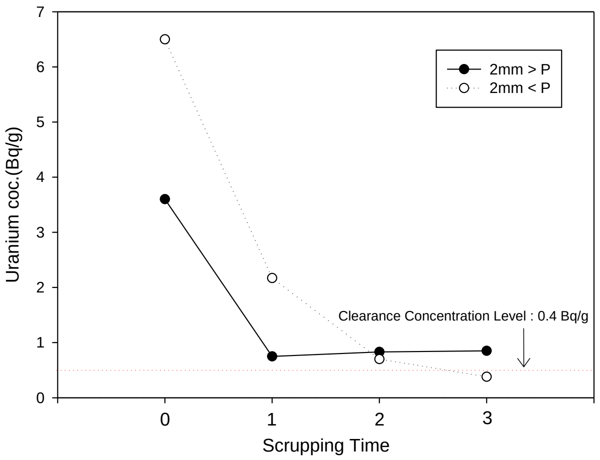

Fig. 1. Removal efficiency of different gravel sizes using gravel washing

Thus, in order to reduce the uranium concentration in uranium-contaminated gravels into less than the value of radioactivity concentration criteria for self-disposal, the washing experiment needs to be performed with smaller gravel sizes after the crushing process. We used mortar and pestle and crushed the gravel into fine pieces smaller than the gravel crushed a using jaw crusher. In ther words, the average size of the fine gravel was less than 1 mm. As a result of the washing experiment and measurement of the uranium concentration, the concentration of the uranium in the fine gravel decreased from 2.5Bq/g to 0.28Bq/g with only one washing process. Ultimately, it is thought that the smaller the size of the gravels, the easier the decontamination. In addition it was suggested that when the gravels is crushed finely, the surface area in the washable gravel is increased, and we can perform the decontamination more easily.

Table. 2. Removal efficiency for uranium based on gravel size (less than 1mm)

Size	**Ci**(Bq/g)	**1st**
1mm>P	2.5	0.28

3. Conclusions

We performed washing experiments to satisfy the radioactivity concentration criteria for self-disposal (0.4 Bq/g or less) in gravel included in radioactively contaminated soil. We performed washing experiments for gravel whose initial average concentration of uranium was 1.3Bq/g. In addition, the average concentration of uranium was 0.8Bq/g. Too increase the decontamination rate, we crushed the gravel with a jaw crusher and performed the washing experiments. The results were similar to the results without crushing. In addition, it was determined that the smaller the size of the gravel particles, the more efficient the uranium decontamination. Thus, we crushed the gravel and obtained fine pieces whose average size was less than 1 mm. We then performed the washing experiments. As a result, we performed only one washing process and reduced the uranium concentration in uranium-contaminated gravel into less than the radioactivity concentration criteria for self-disposal, i.e., 0.28Bq/g.

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