Decontamination of Uranium-Contaminated Soil in Various Particle Sizes

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1. Introduction

A great amount of uranium-contaminated (U-contaminated) soil had been generated from the decommissioning of a uranium conversion plant. Our group has developed a decontamination process with washing and electrokinetic methods to decrease the amount of waste to be disposed of. However, this process requires a long decontamination time and lots of electric power, and generates toxic gas such as NOx. Thus the decontamination of soil by washing alone without the electrokinetic treatment is preferable if it is possible. In the treatment of heavy metals-contaminated soil, fine soil particles were separated from coarse particles through a 100 mesh sieve [1] because the high concentration of copper, lead, arsenic, etc. is generally existed in the fine particles. Therefore the separation of fine particles after washing was performed in this work, and the radioactivity of remained coarse soil was measured.

2. Experiment and Results

2.1 Elemental analysis of solid and solution

The concentration of uranium in a solid and solution was indirectly analyzed using HPGe γ-spectrometry (Canberra, Genie 2000, USA) by measuring the radioactivity of ^{234m}Pa (Energy 1001 KeV). ^{238}U undergoes alpha-particle decay to daughter ^{234}Th (half-life = 24.1 days) to reach secular equilibrium in less than 1 year, and ^{234}Th decays to ^{234m}Pa (half-life = 1.17 min) by beta-particle emission [2]. Since the soil was contaminated by natural uranium decades ago, the secular equilibrium among ^{238}U, ^{234}Th and ^{234m}Pa in this study has already been reached. Some other elements in the solution were analyzed using ICP-AES (Inductively Coupled Plasma-Atomic Emission Spectroscopy, JY Ultima-2C, Jobin Yvon, France).

2.2 Soil washing

To efficiently extract uranium from uranium ore with sulfuric acid, oxidant was added at 65℃ in KAERI [3]. Thus the soil was washed by sulfuric acid solution with $NaClO_3$ at 65℃. To find the decontamination of remained coarse soil just by washing, U-contaminated soil was washed as follows.

① 100 g of U-contaminated soil with 26 Bq/g was added into 100 mL of 0.3 M sulfuric acid solution in a 1.0 L Erlenmeyer flask.

② The solution was shaken at 150 rpm and heated to 65℃ in a water bath.

③ After 15 minutes of shaking, 1 g of $NaClO_3$ was added into the solution.

④ After shaking for 3 hours, muddy solution was removed from soil.

⑤ The muddy solution was passed through a Whatman 4 filter paper.

⑥ The remained soil was briefly washed 2 times with filtrate obtained from ⑤ to remove more fine particles.

⑦ The remained soil was washed once more with 100 mL of 0.3 M sulfuric acid solution at 65℃ for 3 hours.

⑧ After washing, muddy solution was removed from soil.

⑨ The remained soil was dried, and its weight and radioactivity were measured.

⑩ pH and the uranium concentration in the washing solutions were measured.

From the above experiment, 75 and 70 g of soil were remained after 1st and 2nd washing, and their radioactivities were reached 1.6 and 0.88 Bq/g, respectively. Thus about 70% of soil was remained by t wice washing after the separation of fine particles and its radioactivity reached below 1.0 Bq/g, clearance level. An observation under a microscope identified the size of the remained soil to be larger than 0.1 mm

U-contaminated soil was examined to find the effects of temperature and oxidant on the soil washing in various conditions such as room temperature and 65℃, and with and without oxidant. The washing and separation of fine particles was performed by the same method described above. In this test, the highest washing efficiency is obtained in the condition with oxidant at the 65℃.

From the previous study, the large gravel was not decontaminated by washing alone. To limit the soil particle size for the washing, soil was sifted with 2, 5 and 10 mm pore-sized sieves, respectively. Then the sifted soils were washed according to above washing method.

When the sifted soils with 2 and 5 mm pore-sized sieves were twice washed by sulfuric acid solution, the radioactivity of the coarse particles in both soils reached below clearance level. The collected 2-5 mm sized soil was also decontaminated by the twice washing. However, the radioactivity of gravel with bigger than 10 mm was a little higher than the clearance level after the washing. This result indicates that the soil with the size of below 5 mm can be decontaminated to the clearance level by washing alone if the fine particles are removed by the separation of muddy solution.

3. Conclusions

When U-contaminated soil was washed twice by a sulfuric acid solution with $NaClO_3$ at 65℃ and the fine particles such as silt and clay were removed, the radioactivity for the remained coarse soil with size of larger than 0.1 mm can reach to below clearance level for the self-disposal.

REFERENCES

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