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# Treatment of Uranium-Contaminated Concrete for Reducing Secondary Radioactive Waste

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## 1. Introduction

Many nuclear facilities will be decommissioned or dismantled in the next decade. In Korea, a great amount of radioactive concrete waste has been generated from the decommissioning of a research reactor and uranium conversion plant at KAERI. A volume reduction of the concrete waste by appropriate treatment technologies will decrease the amount of waste to be disposed of and result in a reduction of the disposal cost and an enhancement of the efficiency of the disposal site.

Our group has developed a decontamination process for uranium-contaminated (U-contaminated) concrete, and some experiments were performed to reduce the second radioactive waste.

## 2. Methods and Results

Our decontamination procedure is divided into several processes such as assorting, heating, crushing, sifting, and washing. Since IAEA has recommended 1.0 Bq/g as the limiting value for the self-disposal of natural uranium [1], U-contaminated concrete pieces were decontaminated to below 1.0 Bq/g.

### *2.1 Assorting*

Since uranium has a very low solubility in an alkaline solution [2] and the cement in concrete makes a high pH solution, uranium will exist within a few mm of depth from the surface of the concrete. This phenomenon was proved from a depth profile analysis using an EPMA (Electron Probe Micro-Analyzer) in our previous experiment [3]. Thus, the concrete blocks were divided into three groups: one is a mortar block with epoxy generated from the floor surface of a laboratory and its radioactivity is high, another is a concrete block from the floor except the surface, having a lower radioactivity, and the other is a brick from the wall of a laboratory.

### *2.2 Filing and Burning*

The concrete waste of the wall is easily distinguished from that of the floor since it was made of bricks. The color of the brick surface contaminated with high concentration of uranium was changed to yellow or brown, as shown in Fig. 1, and uranium was easily detected by a survey meter (Ludlum, 2241/44-9). The colored surface was removed by a chisel in a glove box, and the radioactivity of the brick was then measured. The removal and measurement works were iterated until the radioactivity of the remaining block reached less than 1 Bq/g. The removed powder was gathered.

Fig. 1. The surface of a brick generated from the wall of a laboratory. A high concentration of uranium was found in the yellow or brown colored areas.

The mortar blocks coated with epoxy were directly burned by an oil flame for 15 minutes to remove the epoxy and binder. After burning, the removal of the surface and the measurement of the radioactivity were performed using the same decontamination method as for the bricks.

### *2.3 Crushing, Sifting and Washing*

Concrete blocks without epoxy are crushed to less than 30 mm in size using a jaw crusher. Then, the concrete pieces are sifted with a 1 mm pore-sized sieve. Since pieces smaller than 1 mm have to be washed several times for decontamination, and it takes too much time for filtering, separation is more useful.

Concrete pieces larger than 1 mm were consecutively washed using a ball mill in the order of clear recycle solution (around pH 1.0) and 1.0 M of fresh nitric acid. When the washed concrete pieces were sifted through a sieve and washed with a small amount of tap water, the radioactivity of the concrete particles above 1 mm in size generally reached below 1.0 Bq/g. If their radioactivity was greater than 1.0 Bq/g, they were washed with nitric acid one more time. Fine particles in a murky solution were treated with concrete particles smaller than 1 mm.

### *2.4 Washing of Fine Particle*

Concrete powder smaller than 1 mm, the murky solutions produced from the ball mill, and the powder removed from bricks and epoxy blocks were put together into a rotary washing machine. At a volume ratio of solution/solid = 2, the pH of the solution was adjusted to 0.5-1.0 by adding nitric acid. The solution was rotated for 6 hours, and then left for more than 6 hours. After removal of the supernatant, the remaining solution was centrifuged. The radioactivity of the dried solid was measured. If it was higher than 1 Bq/g, we used electrokinetic equipment [4] for the further continuous washing. Concrete powder reached 1 Bq/g within 10 days by the electokinetic equipment, and about 30% of its weight was lost.

### *2.5 Treatment of Washing Solution*

The supernatant produced from the washing process was adjusted to near pH 9 by adding CaO in order to precipitate the uranium. The precipitate was filtered using a filter pressure with a 25 μm pore size, and will be disposed of at a radioactive waste repository. When this filtrate was recycled, a high concentration of calcium in the filtrate created some problems. Thus, 20 mL of 98% sulfuric acid was added into 200 mL of filtrate to form a $CaSO_4$ precipitate. The addition of sulfuric acid reduced the concentration of calcium from 3.8% to 0.08%. Since uranium was not detected in the $CaSO_4$ precipitate, the precipitate can be used as an ordinary reagent. The recycling of calcium-removed waste solution finally reduces the amount of secondary radioactive waste.

## 3. Conclusions

A decontamination process was developed to remove uranium from concrete waste. The concrete pieces were divided into three groups: the surface of the floor, the floor except surface, and the wall brick of a laboratory.

The yellow or brown colored surface of the wall brick with high concentration of uranium was removed by a chisel until the radioactivity of remaining block reached less than 1 Bq/g. The concrete waste coated with epoxy was directly burned by an oil flame, and the burned surface was then removed using the same method as the treatment of the brick. The selective mechanical removal of the concrete block reduced the amount of secondary radioactive waste.

The concrete blocks without an epoxy were crushed to below 30 mm and sifted to 1 mm. When the concrete pieces larger than 1 mm were sequentially washed with a clear recycle solution and 1.0 M of nitric acid, their radioactivity reached below the limit value of uranium for self-disposal. For the concrete pieces smaller than 1 mm, a rotary washing machine and electrokinetic equipment were also used. The addition of sulfuric acid into a concrete washing solution reduced the concentration of calcium, which resulted in a decrease of the volume of the waste solution by the recycling of the washing solution.

## REFERENCES

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