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Development of Practical Remediation Process for Uranium-Contaminated Concrete

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1. Introduction

A great amount of radioactive concrete waste was generated from the dismantlement of a research reactor and uranium conversion plant, and about 1500 drums of concrete waste are kept at the KAERI site. A volume reduction of the concrete waste by the 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 100 drums/year decontamination process and facilities for the decontamination of radioactive concrete. This practical scale process is little known.

2. Decontamination Processes and Results

Our decontamination procedure is divided into several processes such as assorting, heating, crushing, sifting, and washing (Fig. 1). IAEA has recommended 1.0 Bq/g (about 40 mg/kg) as the limiting value for the self-disposal of natural uranium, and this value is also considering in the revised disposal regulation in our country. Thus, U-contaminated concrete pieces are treated to reach below 1.0 Bq/g.

2.1 Selection/Assorting

Since uranium has a very low solubility in an alkaline solution and the cement in concrete makes a high pH solution, uranium can exist with a depth of a few mm from the surface of concrete without infiltration into a deeper depth of the concrete block. This phenomenon was proved from a depth profile analysis using an EPMA (Electron Probe Micro-Analyzer) in a previous experiment. The original floor of the laboratory was painted with epoxy. Thus we divided the U-contaminated concrete pieces into two groups: one is the mortar layer coated with epoxy and the other is the concrete block without epoxy.

Some waste other than concrete block or powder, such as wires, gloves, and plastics can also be found in a concrete container (200 L drum). These wastes are removed before the concrete decontamination. The sorting of concrete blocks and removal of other wastes are performed in a glove box to prohibit dust from flying out.

2.2 Removal of epoxy

When a concrete block coated with epoxy is directly burned by an oil flame for 15 minutes, the surface layer containing epoxy and binder is separated from the main block, and the radioactivity of the remaining block reaches below 1.0 Bq/g, whereas the heating of a concrete block with epoxy at 600℃ for 30 minutes in an electric muffle furnace removes only epoxy and the radioactivity of the block does not decrease. Therefore, the direct burning by flame is preferable to an electric heating method for the decontamination of a concrete block with epoxy.

2.3 Crushing and sifting

Concrete blocks without epoxy are crushed to less than 30 mm in size using a jaw crusher. The concrete pieces are then sifted by two sieves with pore sizes of 1 and 5 mm, respectively. Most of the pieces larger than 1 mm have 1.0 - 5.0 Bq/g for uranium; meanwhile, pieces smaller than 1 mm have higher than 5.0 Bq/g. Pieces larger than 1 mm are transferred to a ball mill for further breaking and washing.

2.4 Breaking and washing

Concrete pieces are broken and washed in a ball mill without balls using two solutions: a clear washing solution and about 1.0 M of nitric acid. The clear washing solution, supernatant generated from the precipitation of particles after a previous washing process, is reused to decrease the total waste solution volume. The detailed procedure for further breaking and washing is as follows:

① About 100 L (a half drum) of concrete pieces and a similar volume of a clear washing solution are added into a ball mill.
② The mill rotates at 100 rpm for 6 hours.
③ The lid of the mill is switched to a sieve with a pore size of 5 mm.
④ The solution is poured into a container through the sieve to separate small particles. Actually, very fine sand and cement are removed.
⑤ 100 L of 1.0 M nitric acid is added into the mill for the second washing.
⑥ The sieve is switched to a lid.
⑦ After 2 hours of rotation, processes ③ and ④ are performed.
⑧ After taking out a sieve, the radioactivity of Pa-234m for the remaining concrete pieces is measured

using a gamma spectrometer. The uranium concentration can then be calculated from the radioactivity of Pa-234m.

⑨ When the uranium concentration reaches below the self-disposal limiting value, the concrete pieces are washed with a small amount of water and stored in a big bag for self-disposal. If the uranium concentration is higher than the limiting value, the concrete pieces are washed with 1.0 M nitric acid again.

⑩ The concrete pieces smaller than 1 mm from the sifting in section 2.3, and the solutions produced from ④ and ⑦ in section 2.4 are added together into a big rotary washing machine. The pH of the solution is then adjusted to 0.5 by adding nitric acid.

⑪ After a 6-hour rotation, the solution is precipitated.

⑫ Supernatant is removed, and the gel-type solution is centrifuged.

⑬ After drying, the radioactivity of the solid is measured. If its radioactivity is higher than the self-disposal limiting value, it is put into an electrokinetic equipment for further washing.

⑭ NaOH is added into the supernatant from ⑫ to make the solution to pH 9.0 for the precipitation of the uranium.

⑮ The precipitation is filtered using a filter pressure. The sludge will then be disposed of at a radioactive waste disposal repository.

3. Conclusions

A practical decontamination process was developed to remove uranium from concrete pieces generated from the decommissioning of a uranium conversion plant.

The concrete pieces are divided into two groups: concrete coated with and without epoxy. For the removal of epoxy from the concrete, direct burning by an oil flame is preferable to an electric heating method. The concrete blocks are crushed to below 30 mm and sifted to 1 mm. When the concrete pieces larger than 1 mm are sequentially washed with a clear washing solution and 1.0 M of nitric acid, most of their radioactivity reaches below the limit value of uranium for self-disposal. The concrete pieces smaller than 1 mm are decontaminated in a rotary washing machine by nitric acid, and an electrokinetic equipment is also used if their radioactivity is high.

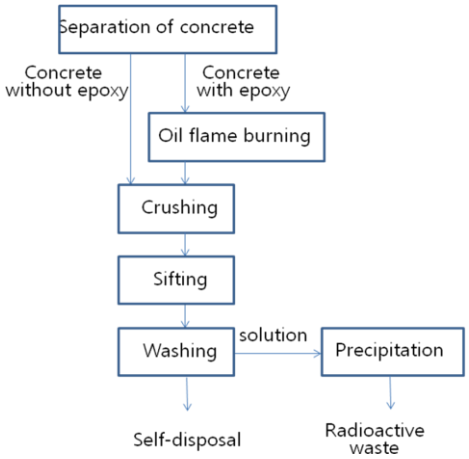

Fig. 1. Practical decontamination process for concrete