

## Removal of radioactive Cs using aqueous sodium metasilicate with reduced volumes of waste solution

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Remediation of radioactive materials containing contaminants such as Cs is important for the reuse of protective garments. Herein, we report the effectiveness of using aqueous sodium metasilicate, prepared via a microbubble crushing process (JPAL), for the removal of radioactive Cs.

Radioactive Cs is adsorbed on soil particles through ion exchange with potassium<sup>1,2</sup>. Cleaning of protective fabrics contaminated by such soil is difficult, and currently, they are simply stored. Finding appropriate storage facilities for used protective fabrics is difficult; furthermore, the large quantities of contaminated fabric in eastern Japan, including Fukushima Prefecture, make storage impractical. Therefore, a new cleaning detergent that can effectively treat such fabric is needed. However, a large amount of waste solution is produced when washing contaminated fabrics, and reducing its volume by evaporation is not practical owing to the large specific heat of water. Thus, a facile method for reducing the volume of waste solution is in demand.

This research focuses on aqueous sodium metasilicate as a new detergent and possible decontamination agent. Since aqueous sodium metasilicate is not a surfactant, it has a low environmental load and does not have foaming characteristics. It can be used with hard, soft, and sea waters. Furthermore, it is a “peeling detergent” in terms of its cleaning characteristics, which differentiates it from dissolving detergents such as organic solvents. As a peeling detergent, sodium metasilicate is suitable for foaming, jet streaming, and high-pressure, ultrasonic-wave, and spray cleaning. Using microbubble crushing<sup>3,4</sup>, precipitation during long-term storage can be suppressed<sup>5</sup>. To decrease the volume of the waste solution, co-precipitation can be used; when neutralized with acid, sodium metasilicate turns to a gel<sup>6</sup>, in which Cs can be trapped. Co-precipitation following gel formation can be used to separate the Cs gel from the soil, thus resulting in decontamination.

As for making JPAL, sodium metasilicate nonahydrate ( $\text{Na}_2\text{O}_3\text{Si} \cdot 9\text{H}_2\text{O}$ ) was dissolved in filtered water (manufactured using G-20B from Organo Corporation) to obtain a 0.47 mol/kg solution. The microbubble generator (capable of generating >20,000 microbubbles per mL) was manufactured by Kyowa Engineering and used to interfuse microbubbles into the solution. Ultrasonic irradiation (40 kHz, ultrasonic wave generator UT-1204U and ultrasonic transducer UI-12R3, Sharp Corporation) was employed to crush the bubbles.

As we need to analyze the structure of sodium metasilicate in JPAL for understanding the dissolution stability at first, we measure the nanoparticles by using a measuring device for the concentration of microparticles (NANOSIGHT LM-10, Quantum Design, Inc.).

The measured samples are the JPAL and filtered water (Filtered) and the water with microbubble crushing process (MB) (Figure 1).

The results showed that the bubbles or other particles in water (Filtered and MB) are decreased by microbubble crushing processes. The particles (air bubbles or sodium metasilicate clouds) of less than 100 nm in JPAL were also generated by the crushing process. This was a possible reason for the stability of sodium metasilicate.

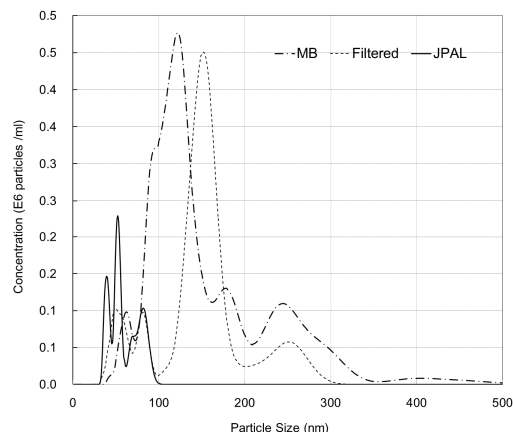


Figure 1. Distribution of nanoparticles in JPAL, raw water (Filtered), and water with micro-bubble treatment (MB)

The cleaning (washing granule conglomerate) experiment was performed by using the non-surfactant aqueous detergent (JPAL 100wt%, 10wt%). NaOH and aqueous sodium hydroxide with the same pH as JPAL (pH 13.1) were also prepared for comparison. To reduce the experimental error, the dried granule conglomerates were pre-washed with purified water to remove the clay and then dried in a vacuum oven. The radiation intensity of the granule conglomerates (Cs-137) before and after washing with water was examined using a germanium semiconductor detector (GMX-18200-S, EG&G ORTEC). Figure 2 indicated that JPAL is more effective for decontamination.

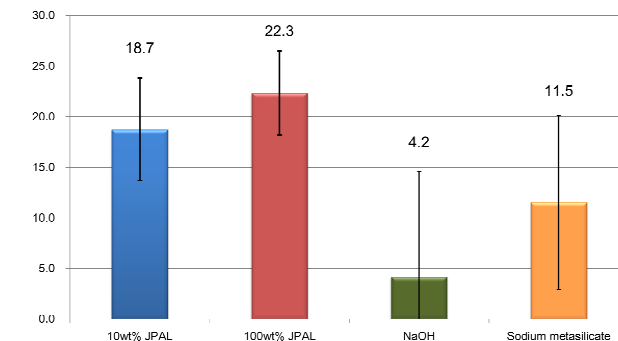


Figure 2. Decontamination factor of Cs-137 for granule conglomerate using JPAL (10 wt%, 100 wt%), NaOH, and sodium metasilicate.

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