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Decontamination of Radioactive Soil Wastes Using Underwater Microwave Plasma

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Cesium (Cs) is one of the fission products produced during the operation of nuclear power plants (NPPs). A relatively long half-life (~30.4 year) of Cs can be a significant source of radiation after being released and sorbed on the soils by severe nuclear accidents. Radioactive Cs contributes significantly to environmental pollution in the early stages of NPP accidents because Cs has similar physicochemical properties to potassium (K^+) and can be accumulated on the soils by an ion-exchange reaction. When Cs leaks into the soil environment, it makes strong and irreversible chemical bonding with clay minerals, especially at the frayed edge sites (FES). Therefore, the methods to remove radioactive Cs from the soils such as soil washing and electro-kinetic technologies are not very effective and generate lots of secondary radioactive liquid wastes.

In this research, a microwave plasma system in underwater conditions was developed to treat the radioactive Cs-contaminated soil wastes. Plasma technique is one of the Advanced Oxidation Process (AOP) technologies widely used for chemical cleaning, sterilization of wastewater, surface cleaning, surface etching, and decomposition of oil wastes. In the radioactive waste management field, not many studies are conducted to decontaminate the radioactive solid wastes using plasma technology. Using the microwave plasma in underwater conditions can provide 1) chemical etching process by reactive species like radicals, 2) physical etching process by mechanical collisions of high density of high-energy electrons and reactive species, and 3) exfoliation effect at silicate minerals and activation of clay minerals by production of H_2O_2.

This study shows the improved removal efficiency of Cs from the Cs-contaminated soils compared to other conventional chemical washing methods, and provides the alternative technology to reduce the significant amounts of secondary radioactive liquid waste.