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Remediation of Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA) Spiked Sands and Aqueous Film Forming Foam (AFFF) Impacted Soils by Ball Milling

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Per- and polyfluoroalkyl substances (PFAS) are chemically synthesized, fluorinated organic chemicals which have gained significant attention with researchers, governments and communities due to carcinogenic potential and neonatal immunosuppressant effects. Surface active properties have made PFAS suitable for applications in oil and water resistant products, as well as aqueous film-forming foams (AFFFs) used to fight fuel based fires. No feasible on-site remediation strategies exist to treat PFAS impacted soils, which has resulted in many sites in Canada, and worldwide, having persistent source zones of contamination to groundwater, which resultantly threatens drinking water resources for millions of people. Using mechanochemical destruction via planetary ball mill, the destruction of PFOS and PFOA spiked sand and AFFF impacted soils at environmentally relevant concentrations were evaluated with a factorial design. AFFF impacted soils were obtained from an unlined firefighting training area (FFTA) where fuel based fires had been extinguished for over 50 years. Milling trials for both spiked sand and AFFF impacted soils were carried out at a moderate milling speed of 275 rpm using stainless steel milling accessories. Spiked sand mass, water saturation and the use of potassium hydroxide (KOH) as a co-milling reagent were investigated as key factors at two levels to evaluate practicality and economic viability of the process. In more than one treatment, PFOS and PFOA concentrations in spiked sand were reduced below Health Canada's Soil Screening Values (SSVs) for agriculture, residential and park land use within 1 hour of milling. AFFF impacted soils milling trials resulted in PFOS concentration reductions of up to 96%. Where data permitted evaluation, destruction was best represented by first-order kinetics with respect to PFOS and PFOA concentrations in spiked sand. FFTA soils did not follow first-order kinetics, likely due to the inclusion of many PFAS, co-contamination and complex nature of the soils.