Impact of Microscale Energetic Residues on Range Contamination Issues

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Background/Objectives. Military training activities at operational ranges result in the production and dispersal of munition constituents (MCs). These compounds are persistent in the environment, and can serve as a source of contamination of groundwater and surface water. While the larger residues (>1 mm) produced from high- and low-order detonations are being studied with regards to their dispersal and dissolution, the production, transport, and fate of microscale MC residues (especially the <50 µm sized material) has not been extensively examined. These microscale MC residues have the potential to be transported by percolation and surface runoff during precipitation events, and serve as a mobile and fast dissolving sources of explosive compounds (i.e., HMX, RDX, TNT) that can facilitate migration to groundwater and surface water receptors. This research used Composition B (Comp B) as the model MC for this research, given its widespread use and that it contains the widely detected explosive compounds TNT and RDX, and examined the main fate and transport processes believed to control the production, movement, and dissolution of microscale energetic compounds on testing and training ranges.

Approach/Activities. Laboratory experiments simulated the likely processes that allow distribution of Comp B detonation residues on testing and training ranges. Macroscale residues (>0.5 cm) were shown to breakdown under realistic simulated precipitation, producing a flush of microscale particles (mean particle diameter ~10 µm), followed by a sustained release of particulates. Microscale Comp B particles (20-45 µm diameter) applied to the surface of sand columns were shown to migrate into the sand farther than mm-sized Comp B particles upon application of artificial rainwater. The migration of the microscale Comp B resulted in a larger effective contact time with the infiltrating rainwater, and increased dissolved concentrations of explosives in the column effluent when compared to the mm-sized particles. When examined in flow-through dissolution chambers that did not allow for particle movement, the inherent mass transfer coefficients for microscale and mm-sized Comp B particles were similar on a surface area normalized basis. Additionally, microscale Comp B particles that were produced by aqueous weathering exhibited mass transfer coefficients that were up to 20-fold higher than dry-attritted particles, indicating that once the inherent low-wettability (e.g., hydrophobicity) of Comp B particles is overcome, more rapid dissolution is possible.

Results/Lessons Learned. This research demonstrated that microscale particulates can be generated from larger Comp B detonation residues. These microscale particles can migrate into the soil profile, giving rise to elevated dissolved explosives concentrations. Surface area normalized mass transfer coefficients are comparable between microscale and mm-sized Comp B residues. There are indications that the environment and manner in which particles form (e.g., dry versus wet attrition) also needs to be taken into consideration. This information should lead to better modeling of energetic compound fate and transport on testing and training ranges.