

Innovation Description: Management of Munitions Constituents by Alkaline Hydrolysis through Lime Amendment

What the innovation is: Hydrated lime amendments are used in soil to increase the soil pH to approximately 11.5, which initiates an alkaline hydrolysis reaction between hydroxyl ions (from the lime) and munitions constituents (MCs) in soil such as the nitroaromatic, TNT, and the nitramine, RDX.

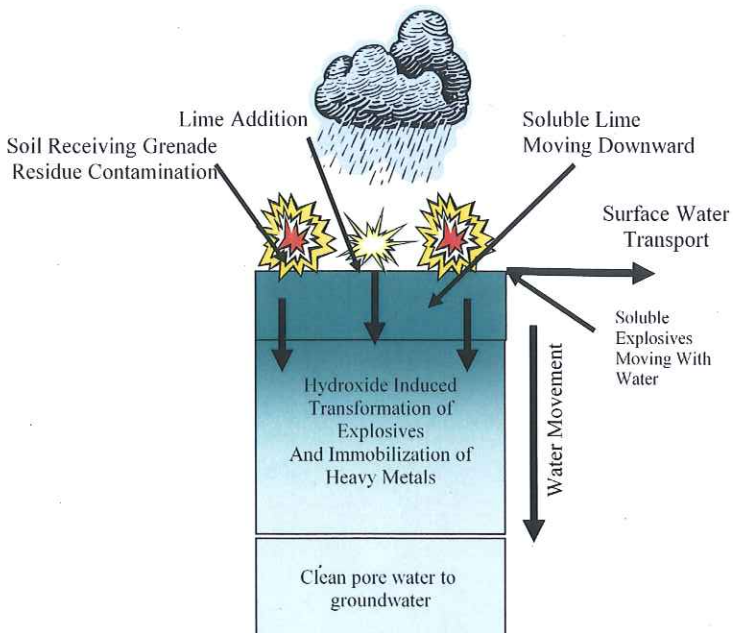
Why it is innovative: The reaction of MCs with lime results in the complete destruction of the MC with no toxic intermediate compounds or end products. The reaction, since it occurs in the soil pore water, also protects groundwater and surface runoff water. This method of managing MCs has gained regulatory acceptance for soil remediation activities and is a valuable technology for Department of Defense (DoD) and private sector environmental practitioners. During 2009, this technology was awarded the DoD Environmental Security Technology Certification Program (ESTCP) Demonstration/ Validation (Dem/Val) "Project of the Year," the Department of the Army Research and Development Achievement Award, and the U.S. Army Engineer Research and Development Center (ERDC) Director's Research and Development Achievement Award.

What it changed or replaced: Until this innovation, MCs in soil from weapons testing and training largely went untreated and resulted in soil, groundwater, and surface water contamination. The former standard remediation practices that this innovation replaces were: (1) removing contaminated soil from the site for costly treatment; and (2) pumping contaminated groundwater to the surface for granular activated carbon filtering, a costly procedure that results in a secondary waste. The combination of laboratory, pilot-scale, and field demonstrations performed to date using hydrated lime to treat MCs has demonstrated that lime amendment is a safe, effective, and cost-efficient method for treating MCs in soil, and indirectly prevents groundwater and surface runoff water from being contaminated.

Where/when it originated, has been used, and is expected to be used in the future: This innovative technology originated with a U.S. Army Corps of Engineers ERDC-Environmental Laboratory Environmental Quality Technology "Basic Research Program" investigation of the application of lime to destroy MCs. This provided an understanding of the reaction kinetics, intermediate and end products of the reaction, and a proof-of-concept study for lime-amended soil. The DoD Strategic Environmental Research and Development Program (SERDP) and the Environmental Quality/Installations (EQI) Program sponsored additional ERDC treatability studies. These studies were performed at a larger scale and examined the destruction of many different MCs in several different soil types. The ESTCP sponsored field Dem/Val studies of the lime amendment technology at a blow-in-place (BIP) operation (a single detonation), a hand grenade range demonstration (approximately 1 acre treated with lime), and a 9-acre demonstration, completed in 2010, at an open detonation facility.

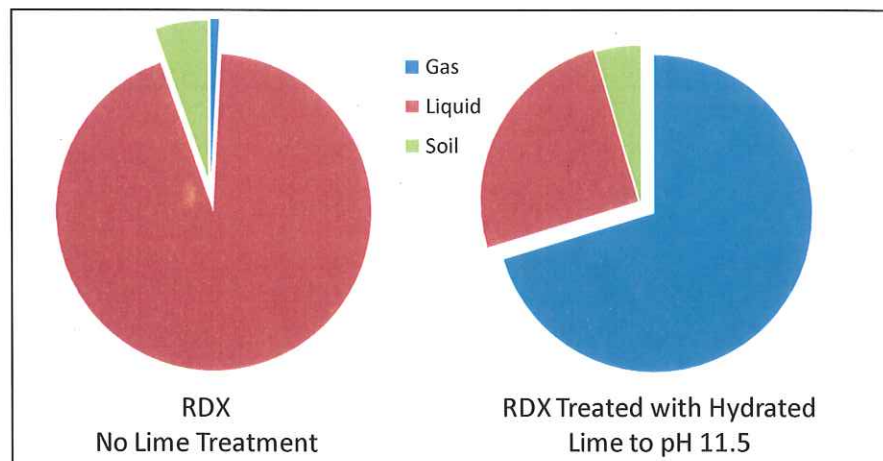
Data and experience gleaned from the above studies have allowed the development of guidelines for application of the technology in both military and civilian settings. Lime amendment has successfully been adapted for various test and training range activities, varying terrains, contamination levels, and climate conditions. These studies have demonstrated that lime amendments can be applied quickly during normal maintenance operations with standard maintenance equipment such as a tractor or ATV with drop spreader and disc. The health risk to personnel applying the lime is minimal, requiring only Level D personal protective equipment (PPE). The cost of the lime amendment is approximately \$400/acre per treatment. Bi-annual soil treatment is recommended but will vary depending on the level of range use and climate conditions. At field-scale, even with continuous loading of explosive residues from training activities, the lime amendment technology reduced MC concentrations in groundwater and surface water to non-detect levels, and reduced soil concentrations to below action levels. Surface water pH returned to normal before reaching the perimeter of the training area and the invertebrate population, studied as an indicator of environmental response to change in pH, was not affected by the addition of lime. It is expected that all training ranges with MCs, both military and civilian, will be amended with lime as an innovative approach to manage and/or destroy MCs, to minimize the loading of MC residues in soil and to prevent groundwater and surface water contamination.

Innovation Illustration: Management of Munitions Constituents by Alkaline Hydrolysis Through Application of Lime



This schematic illustrates the process of alkaline hydrolysis destruction of explosive residues. Rainwater wets the soil that contains the lime. The chemical reaction occurs in the soil pore water resulting in a chemically reactive zone that prevents migration of the explosives into the groundwater. Lime on the surface of the soil prevents transport of explosive particulates in the runoff water.

RDX residues are water soluble and left untreated will transport with runoff water or towards groundwater. RDX treated with lime to a pH of 11.5 is largely mineralized to CO_2 . Compounds remaining in the soil are small molecular weight and easily biodegradable.



Application of lime to the surface of the soil using an ATV and a drop spreader on a HGR (left) and application of lime in 50-lb bags around a detonation pile on an OD facility (below).