

Challenges of soil mixing using catalyzed hydrogen peroxide with rotating dual axis blending technology

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Abstract

Although known to be one of the most effective oxidants for treatment of organic contaminants, catalyzed hydrogen peroxide (CHP) is typically not used for soil mixing applications because of health and safety concerns related to vapor generation and very rapid rates of reaction in open excavations. In likely the first large-scale *in situ* CHP soil mixing application, an enhanced CHP, modified Fenton's reagent (MFR), was applied during soil mixing at the Kearsarge Metallurgical Superfund Site in New Hampshire. An innovative rotating dual-axis blender (DAB) technology was used to safely mix the MFR into low-plasticity silt and clay soils to remediate residual 1,1,1-trichloroethane (111TCA); 1,1-dichloroethene (11DCE); and 1,4-dioxane (14D). It was expected that the aggressive treatment approach using relatively "greener" hydrogen peroxide (HP) chemistry would effectively treat Site contaminants without significant byproduct impacts to groundwater or the adjacent pond. The remediation program was designed to treat approximately 3,000 cubic yards of residual source area soil *in situ* by aggressively mixing MFR into the soils. The subsurface interval treated was from 7 to 15 feet below ground surface. To accurately track the soil mixing process and MFR addition, the Site was divided into 109 10-foot square treatment cells that were precisely located, dosed, and mixed using the DAB equipped with an on-board GPS system. The use of stabilizing agents along with careful calculation of the peroxide dose helped to ensure vapor-free conditions in the vicinity of the soil mixing operation. Real-time sampling and monitoring were critical in identifying any posttreatment exceedences of the cleanup goals. This allowed retreatment and supplemental testing to occur without impacting the soil mixing/*in situ* chemical oxidation (ISCO) schedule. Posttreatment 24-hr soil samples were collected from 56 random locations after ensuring that the HP had been completely consumed. The posttreatment test results showed that 111TCA and 11DCE concentrations were reduced to nondetect (ND) or below the cleanup goals of 150 $\mu\text{g}/\text{kg}$ for 111TCA and 60 $\mu\text{g}/\text{kg}$ for 11DCE. Supplemental post-treatment soil samples, collected six months after treatment, showed 100 percent compliance with the soil treatment goals. Groundwater samples collected one year after the MFR soil mixing treatment program showed either ND or low concentrations for 111TCA, 11DCE, and 14D. Successful stabilization and site restoration was performed after overcoming considerable challenges associated with loss of soil structure, high liquid content, and reduced bearing capacity of the blended soils.

1 | INTRODUCTION

Soil mixing delivery techniques have been employed at an increasing number of sites in recent years to enhance reagent contact with contaminated soil and groundwater. Traditional *in situ* soil mixing applications have largely consisted of *in situ* soil solidification/stabilization for viscous organic contaminants and metals (Interstate Tech-

nology & Regulatory Council [ITRC], 2011; U.S. Army Corps of Engineers [USACE], 2003) and, to a lesser extent, *in situ* chemical/biological reduction using zero valent iron (ZVI; Olson, Sale, Shackelford, Bozzini, & Skeean, 2012) and *in situ* chemical reduction using polysulfides to treat hexavalent chromium (CL:AIRE, 2013). Although use of soil mixing to enhance *in situ* chemical oxidation (ISCO) has significantly increased in recent years with the evolution of "easier to handle"