Bioremediation of Co-mingled Perchlorate and Nitramine Explosives in an Acidic Aquifer at an Active Military Range

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Overview. Perchlorate, hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) are common and often co-mingled contaminants in soils and groundwater at military ranges worldwide. These contaminants are mobile and persistent in groundwater under aerobic conditions. Although multiple studies have demonstrated *in situ* RDX and perchlorate biodegradation under anaerobic conditions individually, remediation of co-mingled plumes has not been reported. Most groundwater along the east coast of the United States is acidic, which can inhibit biodegradation of many contaminants, including perchlorate and explosives, so aquifer pH must be adjusted to promote robust biodegradation.

Approach/Activities. This project was undertaken to investigate the feasibility of using a passive emulsified oil biobarrier to remediate co-mingled perchlorate, RDX, and HMX at an active military testing range in a low pH aquifer. The approach selected was designed to minimize impacts to routine range activities. Laboratory column experiments constructed using site sediment and groundwater were performed to select the appropriate amendments and derive parameters required for biobarrier design. A pilot scale biobarrier was emplaced in early 2013, and dissolved perchlorate, explosives, and other relevant groundwater parameters have been monitored on a regular basis.

Results/Lessons Learned. During the initial laboratory-scale experiments, columns packed with subsurface sediment from a contaminated DoD range were fed a constant flow of groundwater to the columns contained perchlorate, RDX, and HMX at nominal concentrations of 40, 120, and 30 ug/L, respectively. Column amendments included a standard emulsified oil product, and emulsified oil mixed with an inorganic buffering agent. Effluent perchlorate and RDX concentrations were reduced by greater than 95% compared to influent concentrations, while HMX concentrations showed more modest 50 to >80% reduction. The buffered emulsified oil performed better both in terms of parent compound removal as well as presence of lower concentrations of potentially toxic nitroso breakdown products

Based on the column results, a field-scale trial of the passive biobarrier at the DoD site was performed. After installation of temporary injection and monitoring wells, a 100-ft barrier of buffered emulsified oil was created. A zone of increased pH and decreased DO was quickly established. Perchlorate, RDX, and HMX were observed to decrease markedly (>90%) compared to upgradient groundwater. Some nitroso breakdown products have been observed. An increase in dissolved metals (including As) has been seen, but these metals are expected to attenuate as the plume re-aerates. The project has resulted in no impacts to ongoing range activities. The field trial suggests that an emulsified oil biobarrier with pH buffering can be a viable alternative to remove perchlorate and explosives from shallow groundwater at this and other range sites.