MULTI-OBJECTIVE OPTIMIZATION OF AN *IN SITU* BIOREMEDIATION TECHNOLOGY TO TREAT PERCHLORATE-CONTAMINATED GROUNDWATER

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ABSTRACT

The horizontal flow treatment well (HFTW) system is an innovative technology that mixes chemicals into contaminated groundwater in order to effect *in situ* biodegradation without the need to extract the contaminated water from the subsurface. In the case of perchlorate-contaminated groundwater, the HFTW system may be used to inject and mix electron donor into the subsurface in order that indigenous bacteria can use the donor to reduce perchlorate to benign products. To facilitate technology implementation, a model was developed that combines the groundwater flow induced by HFTWs with the *in situ* biodegradation processes resulting from electron donor injection.

To apply the technology in the field, project managers need to understand how contaminated site conditions and technology design parameters impact technology performance. One way to gain this understanding is to use the technology model to select engineering design parameters that optimize performance under given site conditions. In particular, a project manager will desire to design a system that 1) maximizes perchlorate destruction, 2) minimizes treatment expense, and 3) attains downgradient regulatory requirements. Unfortunately, for a relatively complex technology like *in situ* bioremediation, with a number of engineering design parameters to determine, as well as multiple remedial objectives, system optimization is not straightforward.

In this study, a general multi-objective (MO) parallel evolutionary algorithm is developed and used to stochastically determine design parameter values (treatment well flow rate and spacing, concentration of injected electron donor, and injection schedule) under different site conditions in order to maximize perchlorate destruction while minimizing cost. Results indicate that the relationship between perchlorate mass removal and operating cost is positively correlated and nonlinear. For equivalent operating times and costs, the solutions show that the technology achieves higher perchlorate mass removals for a site having both higher hydraulic conductivity and higher initial perchlorate The optimization software developed in this study can serve as a tool for optimizing future applications of this innovative bioremediation technology, as well as helping us to better understand, in general, how groundwater remediation systems can be designed to achieve multiple remedial objectives.

Keywords: evolutionary algorithm, multi-objective optimization, bioremediation, perchlorate, groundwater contamination