Challenges with an ISCO Application in the Unsaturated Zone: Case of the Missing Permanganate

INTRODUCTION
Ex-situ and in situ decontamination of contaminated soils is an effective technology for treating source area soils and has a high certainty of mass reduction. In-situ remedies, however, can be more cost effective in terms of aftercare and maintenance of applicable in-situ technologies for providing soil area was performed (including soil vapor extraction, multiwell treatment, enhanced reduction/denitrification, and in-situ chemical oxidation [ISCO]). ISCO was determined to have the highest potential of being a cost effective alternative for the chlorinated arenic-impacted soil in the unsaturated zone.

Although ISCO has been used extensively to treat the saturated zone, treating the unsaturated zone (and maintaining temporary saturated conditions) is an innovative approach.

OBJECTIVES OF PILOT STUDY
1) Evaluate feasibility of unsaturated zone (0 to 9 feet [2.7 m] below grade) treatment by permanganate solution distribution during and after oxidant placement.
2) Evaluate treatment of oxidant in the unsaturated zone.
3) Demonstrate cost effectiveness and feasibility of ISCO using permanganate on chlorinated VOCs in the unsaturated zone.

SITE CONDITIONS
Unsaturated soil and aquifer are impacted by TCE, cis-1,2-DCE, and VC.

Source area chlorinated VOCs:
- TCE = 66,000 ug/kg
- cis-DCE = 2,400 ug/kg
- VC = 450 ug/kg

Soil leaching criteria to meet are 23, 70, and 5 ug/kg.

Soil Boring

- TCE = 4,600 ug/kg
- cis-DCE = 4,400 ug/kg
- VC = 790 ug/kg

Soil leaching criteria to meet are 23, 70, and 5 ug/kg.

Grain Size Distribution Soil 6-8 ft

TCE Concentrations in Soil

ZONE

- Upper 5.5 feet [1.7 m] silty clay with rare pieces of sand and gravel (partially filling sandy layer from 1 to 2 feet [0.3 to 0.6 m] bgs)
- 5.5-9.0 feet [1.7 to 2.7 m] below grade gravelly sand with some cay and clay on thin discontinuous sandy and silty clay layer from 8 to 9 feet [2.4 to 2.7 m] below grade)

GSZ

- 9.0-14 feet [2.7 to 4.3 m] beneath grade gravelly sand with some cay and clay (with a discontinuous sandy and silty clay layer from 8 to 9 feet [2.4 to 2.7 m] below grade)

Geology:
- Upper 5.5 feet [1.7 m] silty clay with rare pieces of sand and gravel (partially filling sandy layer from 1 to 2 feet [0.3 to 0.6 m] bgs)
- 5.5-9.0 feet [1.7 to 2.7 m] below grade gravelly sand with some cay and clay on thin discontinuous sandy and silty clay layer from 8 to 9 feet [2.4 to 2.7 m] below grade)

The following points are for the 5.5-9.0 feet [1.7 to 2.7 m] GSZ:
- Advanced 6 visual bores (VBOs) to 9.0 feet [2.7 m] below grade gravelly sand with some cay and clay on thin discontinuous sandy and silty clay layer from 8 to 9 feet [2.4 to 2.7 m] below grade)
- Conducted performance monitoring 1 month after injection to evaluate groundwater for VOCs and cis-DCE and visual boring. Nash NOx detection in groundwater.