Study of Salinity and Sodicity Effects on Soil Hydraulic Properties during Remediation by Salt Leaching

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Introduction

Produced water with high salt concentrations is a common by-product of the upstream oil and gas industry. Remediation of salt-affected soils is often required during reclamation of historic oil and gas facilities. Elevated levels of sodium in soil can result in deleterious sodic effects in soil. These effects include swelling and dispersion of clay, which can lead to decreased infiltration capacity and lower hydraulic conductivity, producing poorly drained soils.

A research site with salt-affected soil was selected for study. The main objective of this research is to examine the dispersive characteristics of sodium-affected soil undergoing remediation by salt leaching and to make recommendations to avoid disruption to soil structure. Results are presented from Year 1 of a three-year study.

Methods and Analysis

Soil dispersion testing was performed by the soil crumb test and the double hydrometer test. The clay mineral fraction is the portion of soil that undergoes soil dispersion. Both test methods yield results that are measures of the tendency of clay particles in soil to undergo dispersion. Soil crumb test results indicate that surface soil at the site is non-dispersive. Results of six double hydrometer tests on subsoil indicate a dispersion tendency ranging from slight to very high.

Soil particle size test results indicate a clay size fraction (<5 μm diameter) ranging from 35 to 77%. X-ray diffraction (XRD) analysis will be used to determine the clay mineral portion of clay size fraction

Soil hydraulic conductivity testing was conducted in the field to measure saturated and unsaturated hydraulic conductivity for different surfaces at the experiment site. The tests consisted of field saturated hydraulic conductivity using a Guelph Permeameter and soil matrix hydraulic conductivity using a tension infiltrometer. The tested surfaces are: untilled-unirrigated, tilled-unirrigated, and tilled-irrigated. The tilled locations were unvegetated, while the untilled locations were vegetated with pasture grasses. Results of the saturated hydraulic conductivity testing indicate an order of magnitude lower field saturated hydraulic conductivity for the tilled-irrigated location than for the unirrigated locations. In contrast, unsaturated hydraulic

conductivity test results indicate higher hydraulic conductivity for the tilled locations (irrigated and unirrigated) in comparison to the untilled locations. The unsaturated hydraulic conductivity results are consistent with an increase in matrix hydraulic conductivity by tilling. However, the saturated hydraulic conductivity results remain unexplained.
Developing hypotheses for the evolution of hydraulic conductivity during and after tilling and irrigation is required to develop an optimal flushing strategy.

Laboratory hydraulic conductivity experiments have been commenced to investigate the relationship between salinity, sodicity, and hydraulic conductivity. Elevated sodium levels can produce reduced hydraulic conductivity of soils, while elevated salinity tends to mitigate these effects. No results are available at the time of this presentation; however, laboratory hydraulic conductivity tests will continue in Year 2 of the study.

Conclusion

Significant progress has been made on all aspects of the proposed 3 year research plan. Priority work items have been identified for Year 2 to aid in making recommendations towards effective remediation of soil by salt leaching. These work items include: continue laboratory hydraulic conductivity experiments; perform additional double hydrometer dispersion experiments and field hydraulic conductivity tests to improve confidence in initial results; and, execute a revised methodology for XRD mineralogical analysis.

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