Weathering of Biostimulatory Solutions Due to Surficial Interactions with Cold Region Calcareous Soils

Amy Jimmo (amy.jimmo@usask.ca) and Steven D. Siciliano (University of Saskatchewan, Saskatoon, Saskatchewan)

Background/Objectives. In cold regions, the natural attenuation of petroleum hydrocarbons is generally slow, due to low microbial activity resulting from lower temperatures. These slow rates result in a longer time frame to reach site closure. As a result, ex situ techniques are often utilized in northern latitudes to expedite remedial timeframes. Biostimulation, an in situ technique, involves the delivery of nutrients and electron acceptors to petroleum degrading microbes with the goal of increasing degradation rates. However, in situ effectiveness of this technique is variable due to the heterogenous nature of soils. The objective of this research is to further understand the role of carbonate mineralogy on the effectiveness of biostimulatory solutions delivered in cold-region calcareous soils. This goal will be achieved by evaluating the role of soil buffering capacity, which is regulated by soil carbonate content, on the adsorption of nutrients delivered via an amendment solution, the influence of an optimized biostimulatory solution on microbial activity under stimulated conditions and their interactions.

Approach/Activities. To test this goal, a horizontal flow through cell, used to mimic preferential flow paths in soils, was used to track the petroleum hydrocarbon degradation rates. Soils from Western Canada were analyzed for calcium and magnesium content and added to the flow through cell where a standard biostimulatory solution, consisting of consist of nitrogen, phosphorus, select electron acceptors and a low molecular weight organic acid, will flow over the soil surface until equilibrium is reached. The flow through cell was designed to maximize surface interactions while minimizing the effects of bulk soil to further understand how the minerals influence composition of the biostimulatory solution. Calcium dissolution, used as a surrogate for soil buffering capacity. Calcium dissolution was modeled for nine sites using a power function to determine the dissolution rate constant. The rate constant was then used to determine the influence of site-specific properties, specifically routine groundwater quality parameters, on the weathering of the biostimulatory solution.

Results/Lessons Learned. A redundancy analysis indicated that dissolved calcium, dissolved magnesium and bicarbonate, parameters that drive soil buffering capacity, were positively correlated. In addition, pH was opposite those parameters highlighting the importance of soil buffering capacity in the weathering of biostimulatory solutions. Faster dissolution rates were observed at three sites that were positively correlated with pH potentially indicating a lower soil buffering capacity and likely a higher degree of weathering. However, the results make it clear that other parameters are also likely influencing weathering. It is expected that the results of this research will highlight the role of carbonates in the effectiveness of biostimulatory solutions to increase petroleum hydrocarbon degradation rates in the cold-region calcareous soils. By using a variety of soils from Western Canada, we should be able to identify the influence of sorption and buffering capacity on the availability of nutrients delivered in the biostimulatory solution. The end goal of the research is to create a simple decision tree based on soil mineralogy that will increase effectiveness of in situ biostimulation in cold region calcareous soils.