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Does Surface Matter? Bacterial Response to Amendments and Benzene Adsorbed to Iron Oxides

Kathlyne Hyde (kathlyne.hyde@usask.ca), Derek Peak, and Steven D. Siciliano (University of Saskatchewan, Saskatoon, SK, Canada)

Background/Objectives. The exact biogeochemical processes occurring in a soil matrix after a biostimulant solution is added to petroleum hydrocarbon (PHC) contaminated sites remains opaque. As part of the Sustainable In Situ Remediation Cooperative Alliance (SIRCA), biostimulant amendment solutions containing nutrients and electron acceptors to stimulate anaerobic microbial growth have been used on PHC contaminated sites. In anaerobic conditions, microbial communities use alternate electron acceptors, such as sulfate, nitrate, and iron. Traditionally, orthophosphate (ortho-P) is considered to be a limiting nutrient for respiration and only available to plants and microbes in a solution form. As such, adsorbed and precipitated forms of ortho-P are considered unavailable. However, bacteria will form biofilms on the surfaces of oxide minerals that also have adsorbed ortho-P and PHCs, so it is likely there are respiration and degradation processes occurring on the surface. The accessibility of the sorbed ortho-P and PHC will be assessed using controlled laboratory experiments. The aim of this work is to improve biostimulatory amendments by accounting for the effect of adsorbed ortho-P at contaminated sites.

Approach/Activities. A series of laboratory experiments will be used to determine different parameters of the microcosms used to simulate adsorbed phosphate and microbial degradation. The accessibility of ortho-P on oxide surfaces will be determined using a mixed bacterial culture that was isolated from oil sands process affected water (OSPW) in Alberta (i.e., the Ulrich culture) and grown in nitrate-reducing conditions with benzene as a carbon source. The laboratory experiment involves varying the degree of ortho-P surface coverage on the mineral and measuring electron acceptor use, benzene degradation, and ortho-P concentrations. We will be comparing the differences between treatments where i) a hematite mineral surface (α-Fe_2O_3) is oversaturated with ortho-P resulting in excess of ortho-P in solution, ii) ortho-P is adsorbed via inner-sphere complexes with approximately 80% monolayer hematite mineral surface coverage, and iii) a media control with no mineral and excess ortho-P. An additional experiment using ATR-FTIR spectroscopy will be done to assess the bonding orientation of benzene on the hematite surface with these different treatments.

Results/Lessons Learned. Culturing the benzene degrading consortia to obtain consistent degradation rates among experimental repetitions proved difficult at first, however, inconsistency issues have been resolved by increasing the scale in which we culture liquid inoculums. Upon culturing success, preliminary analysis suggests that the presence of hematite increases bacterial degradation rates of benzene. We hypothesize and will analyze using ATR-FTIR spectroscopy that benzene adsorbs to hematite with a vertical orientation, thus influencing the degradation rates because of increased accessibility of the benzene ring to bacteria co-occupying the surface.