Dissolved Organic Matter as a Booster for Hydrocarbon Bioremediation: Insights from Positron Imaging and X-ray Spectroscopy

Tony Tian and Steven Siciliano, University of Saskatchewan

Bioremediation is among the most cost-effective remediation technologies, yet in calcareous soils of the Canadian prairies it often falters due to patchy microbial activity and short-lived efficacy of stimulants such as Fe(III) citrate. No current tool maps hotspots in soil at a microbially relevant scale non-destructively.

The objectives of this research are: 1) to evaluate if dissolved organic matter (DOM) can leverage and sustain the efficacy of existing biostimulants, e.g., Fe(III) citrate, and 2) to map microbial activity in live soil to enable targeted delivery of amendment solutions. To achieve these goals, parallel microcosms from eight contaminated sites across Western Canada were tracked for BTEX degradation. DOM accelerated biodegradation up to twice the rate by itself and nearly tripled the rate in conjunction with Fe(III) citrate. For benzene especially, DOM complemented Fe(III) citrate to enhance degradation in seven of the eight site soils. In another study, we developed [^{18}F] fluorobenzene, a radiotracer and BTEX analog, to vapor-dose intact soil and employ positron imaging to visualize microbial activities at sub-millimeter resolution, the scale at which microbes operate. X-ray spectroscopy techniques further revealed signature Fe transformations in active zones. A strong correlation between degradation enhancement by DOM and autoradiography intensity increase confirmed the effectiveness of our radiotracer imaging approach in spatially resolving microbial activities in soil.

Our work showcases the promise of DOM as a potent biostimulant, while highlighting a novel method to rapidly screen efficacy of biostimulents before committing to large scale field trials, and to potentially guide targeted delivery of amendments to reinforce active zones and jump-start stalled or inactive zones in contaminated sites, thereby increasing remediation efficiency and reducing trial-and-error costs.

Tony Tian

Tony Tian is a PhD student in Soil Science at the University of Saskatchewan. His research is focused on combining a collection of powerful tools, including cyclotron and synchrotron technologies, to elucidate the driving forces behind bioremediation in soil. He previously obtained an MSc in Physical Chemistry from the University of Colorado and another MSc in Financial Engineering from Columbia University.