Monitoring Metals/Metalloid Reduction and Their Impacts in Aquatic Environments Through Molecular Genetic Tools

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Molecular genetic tools including targeted quantitative polymerase chain reaction (qPCR) tests and next generation sequencing (NGS) can be used to better understand and to optimize microbial communities involved in reduction of metals and metalloids. NGS provides comprehensive microbial profiles of a test sample including both metal and non-metal reducing microorganisms. Whereas, qPCR methods provide more specific and quantitative information by targeting functional genes directly involved in metals/metalloid metabolism.

Treatment of dissolved metals can involve direct microbial reduction, that reduces solubility and toxicity, for example the reduction of selenate to elemental selenium or hexavalent chromium conversion to trivalent chromium. The use of qPCR allows quantitative monitoring of specific genes involved in metal reduction processes such as selenium reductases, or mercury reductases. Selected metals and divalent cations (e.g., arsenic, zinc) can be precipitated as metal sulfides, this process is driven in part by sulfate reducing microorganisms, which can be monitored by qPCR. NGS can be used to monitor important microbial groups involved in metal treatment processes such as sulfate reducers, groups known to directly precipitate metals and to monitor other members of microbial communities relevant to aquatic systems such as nitrate reducers.

The combination of NGS and qPCR can vastly increase our ability to understand how microbiology impacts metals treatment processes. The deployment of molecular tools at metal-impacted sites can aid in the ongoing monitoring of impact assessment, as well as performance assessment of remedial water treatment and source control technologies and alert operators to upset conditions that could lead to increased ecological impacts. Molecular tools can also enhance ongoing monitoring of water treatment processes including solid bed reactors, providing valuable operational feedback to inform optimization of amendment delivery, such as electron donors, or other nutrients, and bioaugmented microorganisms. NGS can also be used to assess the ecological impacts of metals, using environmental DNA (eDNA) approaches which can be performed on water and sediment samples to monitor biota such as fish, aquatic insects and amphibians. Surveys using eDNA are relatively easy to perform, and inexpensive, when compared to traditional bioassessments that require collection and identification of a wide variety of organisms such as benthic macroinvertebrates.

This presentation will cover how increased knowledge of metal/metalloid metabolic pathways combined with the growing array of molecular tools is increasing our ability to advance biotreatment of metals/metalloids and to assess their environmental impacts.

Jeff Roberts

Jeff Roberts, M.Sc. Earth Sciences, University of Waterloo. Jeff is the Operations Manager at SiREM with extensive technical experience in the laboratory assessment and field implementation of soil, sediment and groundwater remediation technologies at sites containing contaminants including chlorinated solvents, petroleum hydrocarbons and other recalcitrant compounds. Over the past nineteen years he has conducted and managed hundreds of bench-scale batch and column treatability studies and also has technical experience in the growth, scale up and field implementation of several anaerobic microbial cultures for bioremediation remedies. Jeff has several years of passive sampling experience and was a lead member in the development and commercialization of the SP3™ and Speeper™ sampler.