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Effects of Dissolved Organic Matter on Microbial Arsenic Transformations: The Role of Carbon Catabolite Repression

HYUN YOON[1], ALEXANDRE POULAIN[2] AND **MATTHEW REID**[1]

[1]Cornell University

[2]University of Ottawa

Presenting Author: mcr239@cornell.edu

The speciation and toxicity of arsenic (As) in the environment are influenced by microbe-mediated transformations catalyzed by intracellular enzymes. Trivalent arsenite (As(III)) is taken up into microbial cells through aquaporin channels that transport glycerol and other organic substrates. Microbial uptake and biotransformation of As are therefore tightly linked to cellular processes regulating the uptake of organic carbon substrates. Microorganisms are known to repress their transport and catabolic enzymes in systems that are rich in labile organic carbon (so-called “catabolite repression”), and here we examine the impacts of carbon catabolite repression on microbial As uptake and production of methylated As species. We use a whole cell As biosensor and a biomethylation assay to evaluate effects of different environmentally-relevant dissolved organic matter (DOM) sources (rice straw, algal biomass, riverine DOM) and DOM/As ratios on As uptake and biomethylation. Cellular uptake and biomethylation of As were strongly inhibited at high DOM/As ratios, and the extent of inhibition depended on DOM quality. Measurements of aqueous As-DOM complexation and expression of membrane transport genes show that these results are primarily due to a catabolite repression-like mechanism rather than extracellular complexation. We discuss these couplings between As and carbon biogeochemistry in the context of rice paddy soils, DOM-rich ecosystems where new understanding of As speciation and toxicity has direct linkages to human exposure to As through food chain contamination.