

Regulation of arsenic methylation and demethylation dynamics by organic carbon in rice paddy soil

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Microbial methylation and demethylation reactions influence the toxicity and mobility of arsenic in the environment. Despite this, the effects of organic carbon quantity and quality on these reactions remains poorly understood. Although the general convention is that greater organic carbon favors greater microbial methylation and an arsenic pool enriched in methylated species, several studies have identified upper bounds on the stimulatory effect of organic carbon on methylation. Further, recent pure culture efforts have shown that upper glycolytic substrates (e.g., glucose, xylose) can decrease methylation by repressing arsenite uptake into bacterial cells. Stimulation of methylotrophic methanogenesis using methanol has also been linked to arsenic demethylation, favoring inorganic arsenic production under carbon-rich conditions. In this contribution, we present a revised conceptual model integrating glycolytic and methylotrophic carbon substrates as key exceptions to the convention of greater organic carbon favoring methylated arsenic species – arguing that in some cases, greater organic carbon can favor net demethylation and the predominance of inorganic arsenic. We interrogated this model using greenhouse-scale rice paddy soil mesocosms amended with variable amounts of organic matter (dried leaves). Porewater monitoring showed that organic matter amendment resulted in less methylated arsenic during key stages of rice grain development (i.e. heading, grain filling, and maturation). Analysis of arsenic speciation in rice grains is underway to link soil arsenic dynamics to rice grain accumulation. Additionally, porewater dissolved methane concentrations were inversely correlated with arsenic methylation efficiency, suggesting that arsenic demethylation may have been linked with methanogenesis. This finding was supported by complementary soil slurry incubations, also amended with dried leaves. Interestingly, in incubations amended with soil and dried leaves, methanogens demethylated arsenic in equal amounts, albeit at slower rates, to incubations amended with soil, dried leaves, and a model methylotrophic methanogenesis substrate (i.e., trimethylamine), indicating that leaf-derived carbon may promote methylotrophic methanogenesis and associated demethylation of methylated arsenic species. Collectively, these results are consistent with the model that organic matter addition can result in inorganic arsenic species predominance due to enhanced demethylation and repressed methylation.