Tipping the balance: How Si addition to rice paddy soil promotes As methylation and affects As bioavailability in the rice rhizosphere

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Arsenic (As) is present in rice grain worldwide and negatively impacts rice yield and human health upon consumption. One emerging strategy to decrease As bioavailability to rice is addition of silicon (Si) to paddy soil. This strategy takes advantage of the shared root transporters between inorganic arsenite and silicic acid, Lsi1 and Lsi2, which are downregulated in response to increasing exogenous Si supply. However, Si addition to soil also influences the microbial community both directly and indirectly with consequent impacts on As bioavailbility.

As bioavailibity in the rice rhizosphere is affected by the extent of microbially-mediated As methylation and iron (Fe) oxidation/reduction, which are both affected by Si. Si addition has been shown to increase the presence of methylated As compounds in rice plants through a yet unknown process impacting arsenic methylating microbes (AsMM). Methylated As compounds are less acutely toxic to humans than inorganic As compounds, and some are volatile leading to less As bioavailability. Arsenic may further become less bioavailable through adsorpotion onto Fe (oxyhydr)oxide minerals that form on or near the root surface/rhizoplane or Fe plaque. This Fe plaque is influenced by Si addition because Si prevents crystalization of ferrihydrite to higher ordered phases, leading to more As retention, and Si addition leads to more radial oxygen loss from rice roots with consequent shifts in the abiotic Fe oxidation and biotic Fe oxidation via Fe oxidizing bacteria (FeOB).

Here, we report results from laboratory and field studies of the impact of Si addition to paddy soils on As bioavailability to rice using a multidisciplinary approach. We link shifts in geochemical parameters (pore water As speciation, solid phase mineralogy, As content in rice) and plant physiological parameters (expression of Lsi1 and Lsi2 transporters) to activity of AsMM through expression of the *arsM* gene. Our data show how Si addition to soil shifts the balance in favor of limiting As bioavailability to rice with consequent benefits to society.