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Spatiotemporal patterns of iron and arsenic enrichment and speciation in rice rhizosphere under soil sulfate amendment and water management

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Uptake of arsenic (As) from soil poses a threat to the quality and quantity of rice produced in many areas worldwide. Minimizing uptake of As by rice plants is an important and challenging task for safe rice production. Water management and soil amendments (e.g., silicate and sulfate) have been shown to decrease plant uptake and/or grain accumulation of As for rice, although the mechanisms remain unclear. A challenge in understanding the soil-to-rice As transfer is the biogeochemical complexity created by the spatiotemporally varied radial oxygen loss (ROL) from a rice root system to the reduced soil matrix. The enrichment of iron (Fe) in the rhizosphere, the so-called (extended) iron plaque, resulting from Fe^{2+} oxidation by ROL also enriches As around rice roots. Although such rhizosphere Fe and As enrichment is commonly regarded to limit As transfer from soil to rice, recent evidence has suggested a dynamic formation and dissolution of iron plaque, which may alter its role from an As sink to a potential As source for rice uptake. To investigate how soil sulfate amendment and water management alter the spatiotemporal patterns of Fe and As enrichment around rice roots, we carried out a rhizobox experiment. We developed an *in-situ* imaging system for recording the development of rice root systems under three sulfate application rates (0, 100, and 200 mg/kg S; applied as K_2SO_4) and two water regimes (intermittent and continuous flooding). The iron plaque around roots was quantified via image analysis based on the relative intensity of red to blue and green channels (see figure). Porewater chemistry was monitored during rice growth and As concentration and speciation of rice shoots at booting stage were sacrificially analyzed. Additionally, rhizoboxes were sacrificially sampled at harvest to obtain rooted soil blocks which will be used for X-ray based elemental, and ideally also redox, mapping of Fe, As, and S. Preliminary results showed iron plaque formation and dissolution within four days around growing roots in the control soil. Our study will link the performance of two rice As mitigation strategies (i.e., soil sulfate amendment and water management) to spatiotemporal dynamics of rice rhizosphere.