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Probing Fe plaque in the rice rhizosphere: unraveling a dynamic and heterogeneous interface for contaminant and nutrient cycling

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Fe plaque is a heterogeneous assemblage of Fe (oxyhydr)oxide minerals on aquatic plant roots that impact the plant-availability of nutrients and contaminants. Fe plaque formation in the rhizosphere is dynamic, yet it is often only studied at plant maturity and/or via wet chemical technique. These approaches do not allow researchers to address how its dynamic nature and heterogeneity in space, time, and mineral composition impact mobility of solutes at critical stages of plant uptake. This is especially important for rice, which is prone to high grain As, and where treatments that decrease plant As also affect Fe mineral transformations and thus As retention in the rhizosphere.

It is crucial to understand when and where Fe plaque forms and transforms, and how these dynamic transformations influence As sorption and desorption processes in the rice rhizosphere. However, capturing Fe plaque formation *in situ* is challenging. We have developed several techniques to capture Fe plaque dynamics in the rice rhizosphere. These include 1) measurements of sonicated roots from whole plants collected over the life cycle, 2) rhizosphere (soil + root) sections collected over time, and 3) vinyl films inserted into the rhizosphere and removed at discrete time points over the plant life cycle, which passively capture Fe plaque deposits as roots grow along the film. Synchrotron XRF imaging and XAS techniques can then be used to elucidate Fe mineral composition and As speciation.

Using these techniques, we have observed that Fe plaque is comprised of a variety of minerals including ferrihydrite, lepidocroicite, goethite and siderite, with a higher proportion of ferrihydrite where Si amendments are used. Roots tend to have a halo of arsenite, which is prone to desorption and plant-uptake. Our passive sampling technique using vinyl films can capture the Fe plaque as the roots grow along the film and Fe minerals are deposited on the film itself. This method is superior to other methods because it is non-destrucive and thus allows for high frequency sampling of the same plant root system. These techniques will be discussed in relation to the broader issue of arsenic uptake and localization in rice grain.