THE ROLE OF IRON PLAQUES IN IMMOBILIZING ARSENIC IN THE RICE-ROOT ENVIRONMENT

by

Cecily Eiko Moyer

A thesis submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Master of Science in Plant and Soil Sciences

Fall 2012

ABSTRACT

Geogenic arsenic (As) causes illness to millions of people in South and Southeast Asia via the consumption of rice grown in contaminated water. Arsenic is absorbed by rice roots, which is transported through the shoots and delivered to the edible grains. Researchers have found that iron (Fe) plaques, consisting mainly of amorphous iron oxides, grow on the surfaces of the rice roots. Iron plaques sorb As, immobilizing the toxin, preventing it from absorption into the plant body. Observational studies have been conducted on the occurrences and locations of iron plaques, but their characterization and association with As are only beginning to be studied. The goal of this study is to elucidate the sorption mechanism and capacity of As to sorb to the Fe-oxide, as well as to determine whether variable plaque formation is due to variable O_2 exudation. We conducted both synchrotron-based bulk and micro-XANES and EXAFS studies, as well as bench-top extractions. We set up two Fe-treatments to investigate whether increased Fe concentration promotes increased plaque growth, immobilizing more As. The primary oxidation state of As found in plaques was As(V). The molar ratio of sorbed Fe:As did not significantly depend on the Fe-concentration. This signifies a specific molecular ordering of the plaque—more plaques sorb more As, but not at an increasing rate. Plants can immobilize 0.86-0.93 mg of As per gram of dried root, and approximately 10% of the Fe-oxide plaque itself consists of As. Variable plaque formation is due to O_2 exudation patterns. Knowing the potential amount of As sorption to Fe-plaques supports the farming practice of composting rice straw—a low-cost and natural way of adding iron to paddy soil to promote the growth of Fe-plaques on rice roots.