Effects of Iron Speciation on Cadmium and Arsenic Availability in Paddy Soils

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Contamination of heavy metals and metalloids including arsenic and cadmium in paddy soils of South China has become a major environmental concern since rice is a staple food in that region. Soils in South China are characterized by high abundance of iron whose minerals and speciation are known to strongly interact with heavy metals and metalloids, reducing their mobility and bioavailability in soils. The goal of this study was to investigate intercorrelation between iron speciation in soil and uptake of cadmium (Cd) and arsenic (As) by rice. We collected 73 paired soil and rice plant samples from paddy fields contaminated by acid mine drainage containing both As and Cd. The rice plant samples were divided into grain, straw, and root fractions. Speciations of Fe, As and Cd associated with the soils were quantified following a sequential extraction procedure. Significantly negative correlations between amorphous Fe oxides-bound As in soil and As in rice grain were found, indicating that amorphous Fe oxides act a sink for As. The contents of Fe in the amorphous Fe oxides were negatively correlated with the As/Cd contents in rice grain or straw. Meanwhile, the concentrations of HCl-extractable Fe(II) derived from Fe(III) reduction were positively correlated with the As/Cd contents in rice grain or straw. The results suggested that Fe(II) oxidation may decrease As/Cd mobility, whereas Fe(III) reduction may promote As/Cd mobility. Statistical analysis showed that the contents of amorphous Fe oxides and straw As may contribute most to the As loading in rice grain, whereas soil pH value and the content of amorphous Fe oxides may be the most important factors affecting the Cd content in rice grain. It appears that red paddy soils may have elevated Fe redox reactivities due to alternate wetting and drying cycles during growth of rice. Such Fe redox cycling play unique roles in the biogeochemical activities of As and Cd in the paddy soil of our study area. Engineering such iron redox cycling may be necessary for control of heavy metal pollution in paddy soils.