Sorption mechanisms of arsenic within aquifer sediments, and bioaccumulation of As in rice from West Bengal, India

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Geogenic arsenic (As) contamination in drinking waters continues to adversely affect the health of millions of people occupying the Bengal Delta. Naturally occurring processes contribute to the release and mobilization of As and thus control the spatial variation of As producing low and high-As regions within a few meters of mutual distance. This study on one hand focuses on As sorption within aquifer sediments and probes into the release mechanisms from sediment fractions to groundwater. On the other hand the study also focuses on the extent of bioaccumulation of As within rice grown (dry weight basis) in these soils in Murshidabad district of West Bengal, India. The results indicate organic matter (OM) within sediments to play a key role in sorption of As and dominance of iron (Fe) and manganese (Mn) within the sediments. Extractions from core sediments collected from low and high-As areas in Murshidabad indicate residual and Fe-oxyhydroxide fractions dominating As adsorption. OM-adsorbed As, Fe and Mn were quantified by NaOCl extractions on the sediments. Leftover dissolved organic carbon (DOC) from the extracts demonstrated sediment-bound organics varying from shallow to deep parts within the high-As areas. Positive correlations were observed between As_T in groundwater and dissolved Fe-Mn ratios; As_T and DOC in groundwater; and bulk As and TOC of sediments. ICP-OES analyses of sediment-bound organic carbon (OC) indicate As concentrations within the OC fraction upto 188 μg/kg. Rice samples collected from low and high-As areas within Murshidabad (n=14) and domestically purchased (n=10) were de-husked, dried, ground, and digested via microwave (MARSXpress, CEM, NC). IC-ICP-DRC-MS analyses show a diverse range of As uptake by rice grains cultivated in both dry and wet seasons. Grains with long and slender (LS) physical dimensions tend to bioconcentrate more As than short and stocky (SS) grains. Rice samples that exceeded 125 μg/kg total As (n=10) were selected for water digestion, and analysis via HPLC-ICP-MS for speciation. Organic As (MMA, DMA) and As (V) were undetectable at <1μg/kg. As (III) was dominant species detected in 40% of samples and ranged between 6.8 μg/kg and 52.3 μg/kg. Availability of water with safe As levels is less common when sourced from shallow (<25m) aquifers characteristic of OM-rich Holocene sediments. These are more abundant than deeper aquifers that typically contain highly oxidized older Pleistocene sediment and little-no OM, and generally contain lower As concentrations.