IMPACTS OF SEA LEVEL RISE ON ARSENIC MOBILITY AND CYCLING IN CONTAMINATED COASTAL SOILS

by

Joshua J. LeMonte

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ABSTRACT

The impacts of sea level rise (SLR) on biogeochemical processes in contaminated soils and sediments along the world's coastlines remains poorly understood. Elevated levels of the carcinogen arsenic (As), from both geogenic and anthropogenic sources, are found along many coasts, most notably in south and southeast Asia, but also in the US, particularly along the Mid-Atlantic coast. In this work, a combination of laboratory and field techniques were used to ascertain the potential impacts of impending SLR on As mobility and cycling, and the current state of As mobility in a contaminated coastal zone of Delaware, USA. Advanced biogeochemical microcosm reactors were used to simulate inundation with natural sea and river waters on two historically As-contaminated Delaware coastal soils – a wetland soil and ditch sediment – across a wide range of redox potentials while monitoring chemical variables that are known to impact As mobility. Direct As speciation of the soils after reaction at different Eh values was obtained by bulk X-ray absorption near-edge structure (XANES) spectroscopy, μX-ray fluorescence (XRF) imaging, and μXANES spectroscopy. Reducing conditions led to As release and partial reduction of solid-phase As for both inundation scenarios and both soils. Sulfur speciation was also determined via XANES spectroscopy and showed evidence of sulfate reduction. Prolonged reducing conditions induced by SLR will drive the release of As from historically contaminated soils, but As release may be tempered when inundated by seawater as compared to river water for some soils (e.g. ditch sediment), possibly due to reduced microbial growth in high salinity conditions or

preferential sulfate reduction limiting reductive dissolution of As-bearing Fe oxides. However, other soils (e.g. wetland) may see ionic exchange driving pH shifts as a prominent factor driving As release in addition to Eh levels.

To assess the contaminant mobility at one of these former industrial sites along the Christina River, we conducted quantitative comparisons of hydrologic and biogeochemical dynamics across time scales ranging from hours to months, and throughout seasonal environmental variations. The use of synchrotron-based X-ray absorption spectroscopy as a geoforensic tool suggests that As from a neighboring Superfund site is likely contributing to recent accumulation of As at the site studied. Data were collected from pressure transducers in wells, multi-level redox sensors, and porewater samplers. Results indicate that groundwater surface interaction induced a tidally controlled redox gradient. In the tidally impacted variably saturated zone, redox potential varied between oxidizing and reducing conditions depending on the water table elevation. This strong correlation indicates that a rising water table may increase contaminant mobility. Porewater samples also confirm increasing arsenic (As) concentration during the rising tide.