Analyzing Relationship Between Environmental Conditions and Arsenic Absorption in Rice

[1]Tavehon J. McGarry, [2]Craig T. Connolly, [3]Eden Halpert, [2]Benjamin C. Bostick

[1]Columbia University, [2]Lamont-Doherty Earth Observatory of Columbia University, [3]Barnard College

Arsenic contamination, a known carcinogen, impacts the health of nearly 200 million people around the world. This is especially the case for people who live along the floodplains of South and Southeast Asia. Public exposure to Arsenic (As) is not restricted to the local water sources, but also accrues in the staple agricultural products, particularly rice, that accumulates As during the growing season, specifically when rice is irrigated with high As water (finding over 80% of samples exceed the 100 ppb safety guideline). Arsenic dissolves into pore water through the reduction of iron oxides that bind As. This mobilized Arsenic is absorbed by rice plants in flooded paddy soils as they grow and subsequently accumulated in the grain. The concentration of As within a harvested rice grain varies significantly both annually and geographically. This heterogeneity has made it difficult to identify the key environmental and geochemical variables that affect rice As levels. As a result, we currently lack the ability to either predict or minimize As levels in rice (or in water) through more effective management, critical to solving this public health crisis. We posit that As levels in rice vary in response to variable soil redox conditions (flooding), nutrient status (fertilization) and rice variety (impacting how those conditions impact the plant). In this study, we measure the chemical composition of more than 200 Cambodian rice samples grown by subsistence farmers in known paddy fields over three years (2018, 2019 and 2020) with widely variable flooding conditions. Flooding conditions and rice growth were estimated from remotely-sensed measurements of flooding frequency and normalized difference vegetation index (NDVI) of each site during each growing season. This analysis revealed that NDVI may be a more accurate proxy for water presence and also be an indicator of individual field growing conditions, as well as fertilizer use. Predictive models of grain As would require more environmental factors, including precipitation and temperature, to be incorporated, along with rice physiological factors affecting when As uptake occurs. A more dedicated and precise sample extraction technique may improve rice composition data; and further analysis of site-specific data should be filtered and viewed through lens of regional grouping, rice varieties, and individual variation. With these future steps, we anticipate that key drivers controlling rice As levels will become evident and our ability to predict these concentrations will subsequently improve.