Management of Arsenic for Rice Production in Bangladesh

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INTRODUCTION

Shallow groundwater aquifers in Bangladesh are widely used for human consumption as drinking water. Toxic levels of inorganic arsenic in much of the groundwater have created a major health crisis in the country. The shallow groundwater is also used in large quantities for irrigation of agricultural crops, especially for winter season, or *boro*, rice. Large-scale addition of As-contaminated water to soils poses threats to agricultural productivity and to human and environmental health as As is transferred through the food chain.

METHODS

Plant digests ($HClO_4$) and water samples were analyzed for As by hydride generation AAS. Spatial extrapolation of the BGS database for As concentration in shallow groundwater using block kriging gave mean irrigation water As contents at the *upazila* level. Country-wide databases on *boro* rice production and irrigation at the *upazila* level were obtained from the Food Policy and Monitoring Unit of the Ministry of Food and the Directorate of Agricultural Extension, respectively. Data sets were combined to identify areas of the country with both high arsenic in groundwater and high production of groundwater irrigated rice. The resolution of the analysis was limited to the *upazila*-level by the production and irrigation databases.

RESULTS AND DISCUSSION

The major concern is with winter season rice as roughly 1m depth of irrigation water is

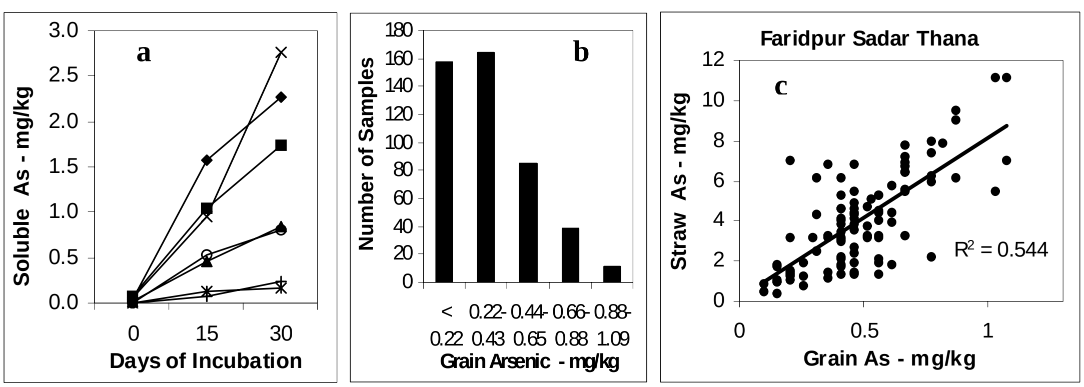

Figure 1. a) Effect of flooding soil on arsenic dissolution in soils from Tala Upazila; b) Distribution of arsenic concentrations in rice grain collected from five Upazila; and c) Relationship between arsenic concentrations in rice grain and straw

applied per crop and because arsenic availability is substantially increased when soils are in the reduced (flooded) condition (Fig. 1a). Concentrations of arsenic in rice grain can reach 1 ppm (Fig.1b) and levels in straw are approximately 10x higher (Fig. 1c). Practical approaches for management of arsenic in rice culture include avoidance and use of practices and varieties that reduce uptake of As by rice. Water treatment, the main strategy for drinking water, is not a feasible approach for large volumes of irrigation water. A countrywide, Upazila based GIS analysis of groundwater irrigated *boro* rice showed that 76% of the production is in areas where groundwater As is < 50 ppb and can be considered at low risk for contamination. Thus, the distributions of *boro* rice production and groundwater As are such that potential As contamination from groundwater is largely avoided. Of the remaining Upazila, 15, 7 and 2 % of the *boro* rice production is associated with mean concentrations for groundwater arsenic between 50-100, 100-200, and >200 ppb, respectively. Upazila with the highest risk for contamination are in the south central zone of the country where groundwater arsenic levels are the highest (Fig. 2a). Use of surface water for irrigation in this area limits the exposure of *boro* rice to arsenic and could be extended as an avoidance strategy. Another area of concern is Satkhira district in SW Bangladesh (Fib 2b) where surface water irrigation is not feasible. Here, the best strategy would be replacing rice with crops that use less water. Using water-conserving technologies such as raised beds and furrow irrigation instead of

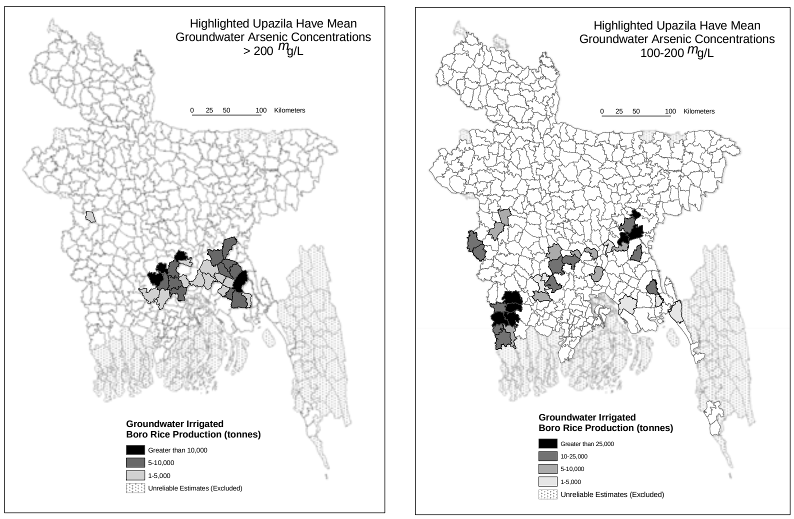

Figure 2. *Boro* rice production with groundwater irrigation at different groundwater arsenic concentrations

flood irrigation would further reduce As loading to soil. Expansion of *boro* rice production should be encouraged in northern Bangladesh where risk of contamination from groundwater As is low. This requires substantial investment in infrastructure, supporting policies, and knowledge transfer to farmers. Soil As concentrations should also be included in the analysis. Strategies to reduce As uptake by rice, (growing more aerobically or competition with phosphate), should be viewed with caution as they may allow continued contamination of soil with As and adverse long-term consequences.

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REFERENCES

Ross, Z, J.M. Duxbury, D.N.R. Paul and S.D. DeGloria. 2005. Potential for arsenic contamination in Bangladesh: Spatial analyis and mapping of high risk areas. Int. J. Risk Assessment and Management, in press.