Status of the Arsenic Concentrations of Water, Soil and Crops in South-western Bangladesh

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INTRODUCTION

The massive contamination of groundwater by arsenic (As) in Bangladesh is a serious environmental issue. Ground water is used extensively in the irrigation of rice resulting in elevated levels of As in paddy soils and As uptake to rice grain (Meharg and Rahman, 2003). Consumption of As contaminated water and foods in the affected areas of Bangladesh is a significant risk to public health. In this context, a survey was conducted in the south-western part of Bangladesh with a view to evaluating the status of As in groundwater and its impact on soil and crops.

METHODS

In March 2004 a survey was conducted in 44 randomly selected unions (smallest administrative unit) within 16 districts in the south-western part of Bangladesh. Three shallow tube wells (STW) used for irrigating rice fields were sampled from each union. Water samples were also collected from hand tube wells (HTW), ponds and river near the selected sampling locations. Soil samples from 0-15 cm, 15-30 cm and 30-60 cm depths and plant samples (rice straw and grain) were collected from the command area of the selected STW. Acidified water samples were analysed immediately after reaching the laboratory. Soil and plant samples were digested in tri-acid mixture ($HClO_4$+HNO_3+H_2SO_4) and As was determined using an atomic absorption spectrophotometer equipped with a hydride generation system (HG-AAS).

RESULTS AND DISCUSSION

Mean As content of STW was the highest among the three water sources (Table 1). High As concentrations (>50 µg l^{-1}) were found in 59% and 36% of samples from the STW and HTW respectively. 84% and 65% of the STW and HTW samples contained >10 µg As l^{-1}, the WHO guideline value for drinking water. In contrast, >90% of the surface water samples contained <10 µg As l^{-1}.

Table 1. Descriptive statistics of the water, soil and plant As.

	Water As (µg l^{-1})			Soil As (mg kg^{-1})			Rice plant As (mg kg^{-1})	
	Surface water	STW[a]	HTW[b]	0-15 cm	15-30 cm	30-60 cm	Straw	Grain
N	70	99	124	113	113	113	94	95
Mean	5.1	87.3	77.4	13	9.5	9.8	2.1	0.23
Minimum	0.8	0.3	0.2	4.5	3.5	4.2	0.2	0.04
Maximum	45.9	530.3	551.9	67.5	51.3	32.9	9.05	0.65
CV[c](%)	132	100	150	65	54	41	88	53

[a] STW=shallow tube well, [b]HTW=hand tube well; [c]CV=coefficient of variation (i.e., standard deviation/mean)

High coefficient of variation (CV) values imply a large variability of the As content in the water sources as compared with As concentrations in the soil and plant samples evaluated (Table 1). Mean As concentrations in the surface soil (0-15 cm) were significantly higher than the sub-surface soil layers (Table 1). Specifically, the number of samples containing >20 mg As kg^{-1} were 13 for 0-15 cm, 3 for 15-30 and 2 for 30-60 cm layers, respectively.

On average, the As content in rice straw were 9 times higher than in grain. In addition, all rice grain samples collected contained As at concentrations <1 mg As kg^{-1}.

Table 2. Correlation coefficient among the As contents of water, soil and plant samples.

		HTW	STW	0-15 cm	15-30 cm	30-60 cm	Rice straw
	STW	0.57**					
	0-15 cm	0.30**	0.40**				
Soil	15-30 cm	0.44**	0.32**	0.82**			
	30-60 cm	0.20*	0.17	0.46**	0.55**		
	Rice straw	0.31*	0.35**	0.18	0.15	0.09	
	Rice grain	0.09	0.13	0.01	-0.01	-0.13	0.72**

*, ** correlation coefficient is significant at 0.05 and 0.01 levels respectively

The correlation between the As content in STW and HTW (Table 2) implies a significant relationship between the two water sources. A strong significant correlation was also found between As content in soil 0-30 cm and As concentration in the water from the STW and HTWs samples. Similar findings were reported by Meharg and Rahman (2003). The strong relationship between STW water As and rice straw As indicates that irrigation water As may influence the uptake of As by rice. This is in accordance with the findings of Alam and Rahman (2003). However, no significant relationship was observed between As content in STW and HTW and grain As. Similarly, no significant relationship was observed between As content in soil and straw or grain As. Reasons for this will be discussed.

CONCLUSION

As concentrations in water samples derived from STW and HTW used for irrigation and drinking water purposes in the south western districts of Bangladesh evaluated in this study exceeded both national and international standards. In these areas in terms of As-associated health risks, surface water may be a viable alternative source of drinking and irrigation water. In addition, As concentrations in most of the soils surveyed were below 20 mg kg^{-1}. Further, the arsenic contents in rice grain were also below 1 mg/kg. However, the strong significant relationships between the As contents of STW and HTW water samples and soil and STW and HTW water samples and rice straw needs to be considered seriously.

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