Soil Degradation Due to use of Arsenic Contaminated Ground Water and its Effect on the Quality of Rice Grain and Straw

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Soil degradation takes place in two ways: displacement of soil material (e.g., soil erosion by water forces or by wind forces) and *in situ* soil deterioration covering chemical or physical soil degradation (Ballyan, 2000) In Bangladesh, among others, arsenic loading in soils through ground water irrigation practice has been coming up as a component of soil deterioration. Arsenic is getting into rice, Bangladesh's staple crop, through irrigation water pumped from contaminated soils (Meharg and Rahman, 2002). Rice alone comprises about 73% of a Bangladeshi's caloric intake. Pumping water for irrigation can raise its arsenic levels and, therefore, in some regions, rice may appear as the dominant source of arsenic. This study aims to explain soil degradation associated with arsenic loading in the upper layers of the soils due to use of arsenic contaminated ground water for irrigation. Shallow Tube Wells (STW) is the main source of irrigation water for rice cultivation in Bangladesh and rice uses about 70% of the available irrigation water.

METHODS

The study was conducted in Tala *thana* of Satkhirara district, the smallest administrative unit in Bangladesh and is located in one of the highly ground water Arsenic contaminated region. Classical statistical techniques were used to identify the physiochemical properties of soil and irrigation water related to degradation of the topsoils, the root zone of most irrigated rices. GIS and geostatistical tools were used to derive the spatial variability of ground water As degraded soils due to arsenic contamination.

RESULTS AND DISCUSSION

The arsenic concentrations in the STW waters varied widely within the *thana*, the maximum is about 462 ppb, the minimum <5 ppb with an average value 150 ppb. Soil arsenic content, too, varied widely, the soil arsenic ranged from 4- 52 ppm with an average of 18ppm. Using step-wise regression, As concentration in ground was found to be influenced positively by the water parameters namely, Phosphorous, Boron, Iron and Potassium and, negatively by Sulphur. Besides its background level, soil As was contributed significantly by As in irrigation water and its extent was dependent the time span (age of tube well) of using ground water irrigation. About 72 % of the soils in Tala *thana* had arsenic concentration >15 ppm. Classification of ground water As surface showed that 30% of total *thana* area fell in zone-4 with As level >20 ppb (Fig. 1). Summarizing soil As over the ground water As zones showed that average soil As was higher for ground water As zones representing higher As levels. Both grain and straw As increased with As concentration in soils (Table 1). Of the total rice samples, As concentration of about 8% was above 50 ppb, the allowable critical level of As in drinking water. The results of pot experiments demonstrate that there was a significant yield reduction above 10 ppm soil-applied As or above 1 ppm irrigation-water added As (Zahiruddin et al., 2005). The results seems to give clear indication that the wet land rice

soils of Bangladesh using As contaminated ground water irrigation is being degraded over time in terms of soil As threatening the yield of rice and quality of rice grain and straw.

Table 1. Mean Arsenic (As) level of rice straw and grain at different soil As zones.

Soil As Zones	Mean As level (ppm)		
	Top soil (0-15 cm)	Rice straw	Rice grain
Zone 1 (<10 ppm)	7.2781 a	3.7299 a	0.2684 a
Zone 2 (10-15 ppm)	12.7521 b	3.5585 a	0.2872 ab
Zone 3 (15-20ppm)	17.7267 c	6.2913 b	0.3350 ab
Zone 4 (>20 ppm)	26.3891 c	6.6960 b	0.3546 b

Note: Analysis was performed on natural log scale of original data. Means in a column followed by same letter are not significantly different at 0.05 probability level by lsd.

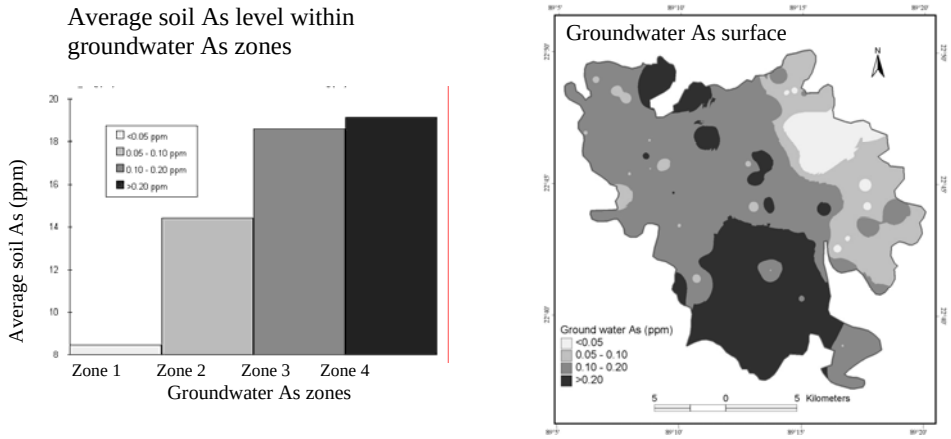

Fig. 1. Ground water As surface and average soil As level within groundwater As zones.

CONCLUSIONS

The wetland rice soils of Bangladesh are being degraded gradually over time in terms of soil arsenic affecting yield and quality of rice. The extent of arsenic loading in the surface soils of wetland rice from ground water depends primarily on the water arsenic level and on the time span of using contaminated water. There is indication that soil and water arsenic above some critical level reduces rice yield and arsenic concentration both in rice grain and straw happens to be higher for soils having elevated arsenic level.

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