Nationwide Survey of Arsenic in Soils, Water and Crops in Bangladesh

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INTRODUCTION

Arsenic (As) poisoning has become a major public health problem and environmental issue in Bangladesh. It is well-reported that most of the ground water from shallow tube well, which is widely used for both drinking and irrigation is highly contaminated with As (BGS/DPHE, 2001). Consumption of As contaminated water and foods in the As affected areas of Bangladesh is a significant risk to public health. Contamination of ground water by As has been reported from many countries including Argentina, Australia, Chile, China, Hungary, Mexico, Peru, Thailand, Vietnam and USA (Smedley and Kinniburgh, 2002; WHO, 2004). But the most serious occurrences identified globally are clearly in Bangladesh and West Bengal (India). Shallow tube wells (STW) (<150 m) in 60 out of 64 districts are contaminated by As (BGS/DPHE, 2001). It is estimated that the number of people exposed to arsenic concentrations above 0.05 mg/L (the Bangladesh standard for acceptable limit of As) is 28-35 million and the number of those exposed to more than 0.01 mg/L (WHO guideline value) is 46-57 million (BGS/DPHE, 2001). More than 10,000 patients of As poisoning have so far been identified in the country (Hussain, 2001). Ground water is extensively used for irrigation of crops resulting in elevated levels of As in soils and As uptake to rice and other crops (Meharg and Rahman, 2003, Huq and Naidu, 2003). In order to implement As mitigation programs, detailed studies should be carried out to be aware of the real As hazard in the affected areas. A good number of studies have been made for assessing the status of As in ground water, soil and crops but most of them have been done in sporadic way and were concentrated in particular areas of the country. This paper discusses the findings of a concerted and widespreadsurvey throughout Bangladesh for assessing As status in irrigation water and corresponding soils and crops.

MATERIALS AND METHODS

Prior to the sampling Bangladesh was divided into seven hydrological sub-regions (HSR) on the basis of river network (WARPO, 2002). The composition of the sub-regions were northwest (NW), north centre (NC), north east (NE), south west (SW), south centre (SC), south east (SE) and eastern hill (EH) areas of the country (Fig. 1). From each of the HSR, every alternate thanas having ground water irrigation system were selected for sample collection. All thanas in the eastern hill areas and in the Sundarbans were excluded. From each of the selected thanas of the HSR, two unions were selected randomly using GIS sampling tool of Bangladesh Country Almanac. From each of the selected unions three shallow tube wells (STW) used for irrigating rice fields were selected for sampling. For convenience of the survey work, the seven HSR were again grouped into four regions. Region 1 consisted of the SW and SC sub-regions having 41 unions under 21 thanas. Region 2 comprised of the NC sub-regions having 38 unions of 19 thanas. Region 3 consisted of the

NW sub-regions having 26 unions under 13 thanas and Region 4 was composed of the NE and SE sub-regions having 30 unions under 14 thanas. A total of 270 STW from 135 unions under 67 thanas were selected for sampling. Water samples from each of the STW and nearby hand tube wells (HTW), ponds, canals and rivers were also collected. Soils and plant samples (rice straw and grains) were collected from within the command area of each of the STW. Soils were collected from 0-15 cm, 15-30 cm and 15-45 cm depths. Soil samples were also collected from nearby non-irrigated field. Acidified water samples were analyzed immediately after reaching the laboratory. Soils and plant samples were digested with tri-acid mixture (HNO_3 + $HClO_4$ + H_2SO_4) and As was determined using atomic absorption spectrophotometer equipped with hydride generation system (HG-AAS) (Alam et al., 2001).

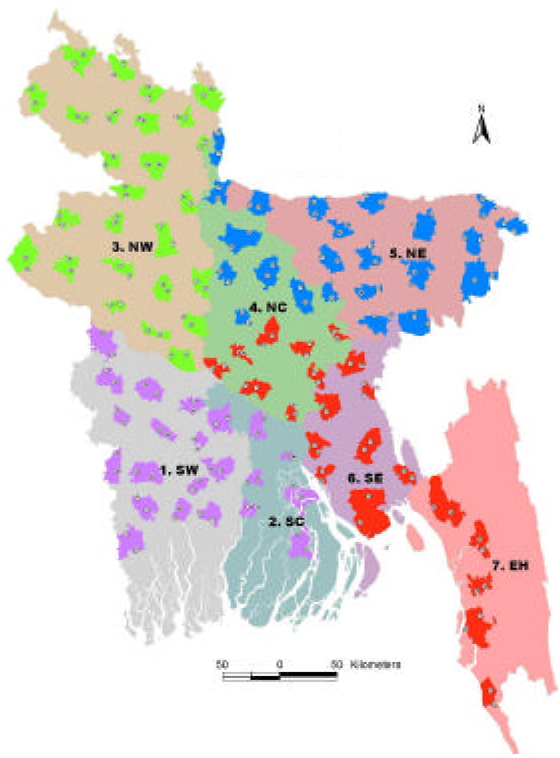

Fig. 1. Sampling sites located at different regions of Bangladesh.

RESULTS AND DISCUSSION

Arsenic in water sources:

The concentration of As in STW water ranged from < 1 µg/l to > 650 µg/l. The highest mean As concentration of STW was observed in the SE/NE region while the lowest was recorded in the NW region (Fig. 2).

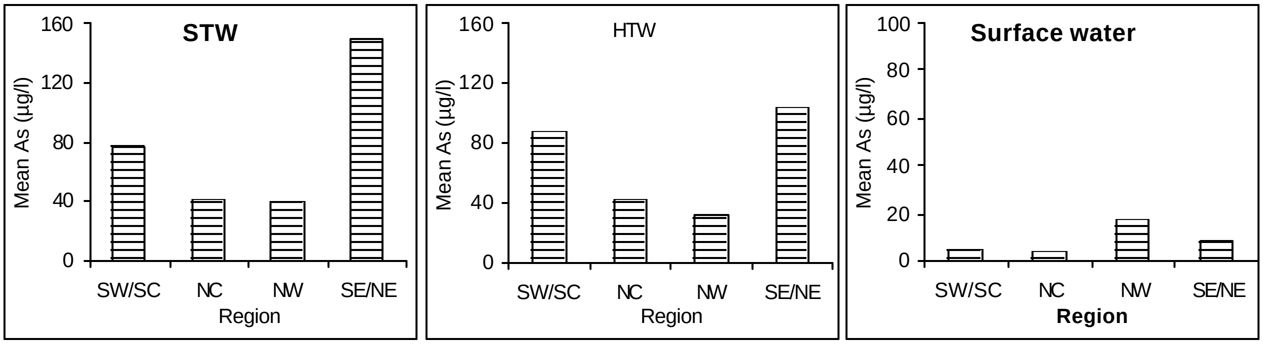

Fig. 2. Arsenic concentration in water of STW, HTW and surface water bodies collected from different regions.

The distribution pattern of As concentration in HTW was similar to that of STW, i.e., the highest in SE/NE regions and the lowest in NW region (Fig. 2). The range of As concentration in HTW water varied from <1 µg/l to >530 µg/l. The similarity in the distribution of As concentration in STW and HTW implies that both of this wells may withdraw water from the same aquifer. The level of As contamination in STW and HTW in the SW/SC and SE/NE regions of the country was much higher than those of the NC and NW regions (Figs. 1 & 2). This is in accordance with the findings of others (BGS/DPHE, 2001).

Among the three water sources the highest As concentration was observed in STW and the As concentration followed the trend: STW>HTW>surface water. The concentration of As in the surface water bodies (pond, river, canal etc.) ranged from 2 µg/l to as high as 63 µg/l. It is interesting to note that the surface water bodies, which were assumed to contain As-free water, exhibited high As values (>50 µg/l) particularly in the NW region (Fig.2). It was noticed during the survey period that the source of high As containing water in the ponds was the As-contaminated water from STW.

As in soils:

The range of As concentration in surface soil varied from 0.2 mg/kg in the NC region to 67.5 mg/kg in the SW/SC regions. Most of the surveyed soils contained below 20 mg/kg As, the maximum tolerable soil limit for the crops. The highest mean soil As was recorded in SW/SC region which is located in the Gangetic and Meghna floodplain and the lowest was observed in the NC region located mainly in the Pliestocene terraces (Figs. 1 & 3). Similar findings have been reported by others (BGS/DPHE 2001).

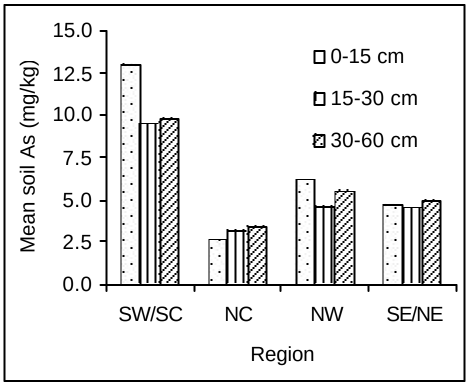

Fig. 3. Vertical distribution of As in irrigated soil of different regions of Bangladesh

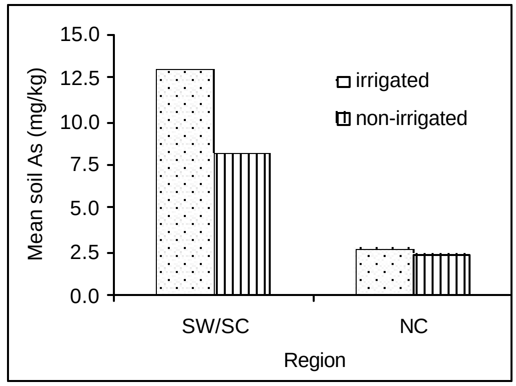

Fig 4. Arsenic concentration in irrigated and non-irrigated soils of two regions

The As concentration in the surface soil (0-15 cm) was higher than that of the subsurface soil (15-30 cm) in SW/SC, NW and SE/NE regions (Fig. 3). In these regions As concentration in the 30-60 cm soil layer was found higher than that of the immediate upper soil layer (15-30 cm) while reverse trend of the vertical distribution of As was observed in the NC region (Fig. 3), i.e., lowest in the surface soil and highest in the 30-60 cm soil. The average As concentration of non-irrigated soil was lower than that of the irrigated soil (Fig. 4) although the difference was negligible in NC region.

As in rice:

The concentration of As in rice grain ranged from 0.04 to 1.1 mg/kg. Except very few samples in the NW region, the rice grain As concentrations was much less than 1 mg As/kg. The mean As concentration of rice grain was found highest in the NW region (Fig. 5).

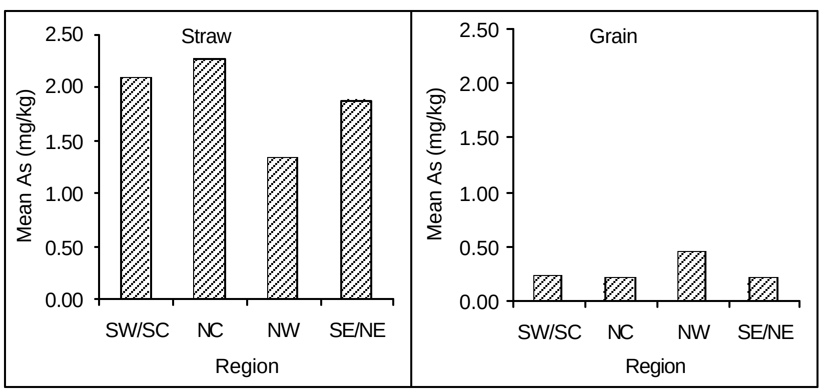

Fig. 5. Average As concentration in rice straw and rice grain of different regions.

On an average, the As content in rice straw was 7 times higher than that in grain. It is interesting to note that the distribution pattern of neither irrigation water As nor soil As was alike the grain or straw As (Figs. 2, 3 and 5). From the observed data it may not be assumed that the grain/straw As is directly influenced by the As concentration of irrigation water or soil.

CONCLUSION

The high concentration of As in irrigation and drinking water particularly in the southern areas of the country indicates an alarming situation. In these areas in terms of As-associated health risks, surface water may be a viable alternative source of drinking and irrigation water. The As concentration in most of the studied soils was less than 20 mg/kg, the maximum tolerable limit for crops. With very few exceptions, the As content in most of the rice grain samples was <1 mg/kg. No consistent relationship among the As concentration of irrigation water, soil and rice grain was observed. Further research is needed giving particular emphasis on these issues to alleviate the As problem successfully.

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