Arsenic Distribution in Soil and Water of a STW Command Area

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Introduction

In Bangladesh, arsenic contamination in soil probably mainly occurs from the shallow tubewell (STW) irrigation water, particularly in the rice field. Arsenic distribution in the soil can vary depending on soil composition, depth and distance from the water source. It is also assumed that the concentration of arsenic in the irrigation channel will not be equal at every point of distribution. It may vary depending on the distance from the pump source due to arsenic immobilization and co-precipitation. The current study presents the spatial variability of As in soil and the water distribution channel of a particular STW command area in Faridpur.

Methodology

Water and soil samples were collected from a STW command area in Faridpur Sadar Upazila. The STW command area is a medium highland covering 10 acres of land, and Boro rice is being cultivated with irrigation water having 136 ppb As for the last 15 years. The soils were silt loam, silty clay loam, silty clay and clay loam. Fifty mL water samples were collected from the irrigation channel 30 minutes after starting the pump. Water samples were filtered (0.45µm) and acidified with 5 mL of 2 M HCl. Water samples were analyzed for pH and As, Fe and Mn concentrations. Two hundred and twelve soil samples were collected from 56 geo-referenced points at 4 depths (15 cm intervals up to 60 cm). Micro-land elevation of each geo-referenced point was determined using a theodolite. Soils were air-dried, and soil pH, texture, organic carbon, available P and clay content were determined. Three arsenic parameter were utilized (i) total by HNO_3/H_2O_2 digestion, (ii) extractable by pH 4.0, 0.1 M Na phosphate, and (iii) extractable by pH 3.0, 0.2 M ammonium oxalate (in the dark). Total free Fe oxide and poorly crystalline Fe oxide were determined by citrate dithionite and pH 3.0, 0.2 M NH_4-oxalate (in the dark) extraction, respectively. Arsenic, Fe and Mn concentration of soil extracts were determined by FI-HG-AAS and FAAS. Data were evaluated by linear regression statistical procedure. Semivariograms were calculated to determine the spatial dependency of As by GS+5.3.2.

Results and Discussion

The As concentration of channel water showed a wide variation from 68 to 136 ppb. Higher As concentration was recorded with the nearest point of STW channel and decreased gradually with distance (Fig.1). The Fe and Mn concentrations ranged from 0.3 to 2.3 and 1.0 to 1.1 mg L^{-1}, respectively. The total soil As in the surface soil varied widely from 11 to 61 mg kg^{-1} with an average of 24. mg kg^{-1} in the command area. Some 30 soil samples (geo-referenced points) out of 56 had an As content more than 20 mg kg^{-1} and the remaining 16 samples had values above 30 mg As kg^{-1} (Fig 2). The As concentration of surface soil in the command area decreased with distance from the STW, with a few exception (Fig.3). Micro-elevation data showed a downwards gradient from the the pump source and was significantly correlated with As concentration (Fig. 4). Vertical distribution of arsenic level in the command area decreased with soil depth. This result indicates a build-up of As in the command area due to long-term irrigation water use for Boro rice culture. The amount of arsenic extracted by the various arsenic assays decreased in the following order: total arsenic > oxalate-extractable arsenic >> phosphate- extractable arsenic. The oxalate-extractable arsenic represents an average of approximately 36 % of the total arsenic, which indicates the relative importance of poorly crystalline Fe oxides in the retention of arsenic in the soil. Arsenic extracted by three assays showed a positive correlation with. pH, available P, and citrate-dithionite and NH_4-oxalate extractable Fe and Mn, but negative correlation with soil clay and organic-carbon contents. The results indicate that the arsenic distribution in the command area depends on the distance from the pump source and soil mineralogical properties

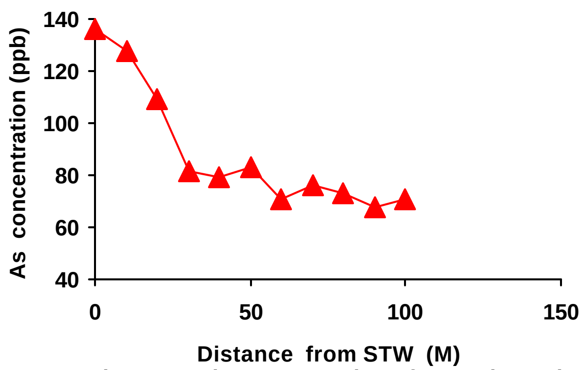


Fig.1 Arsenic concentration of STW channel water over

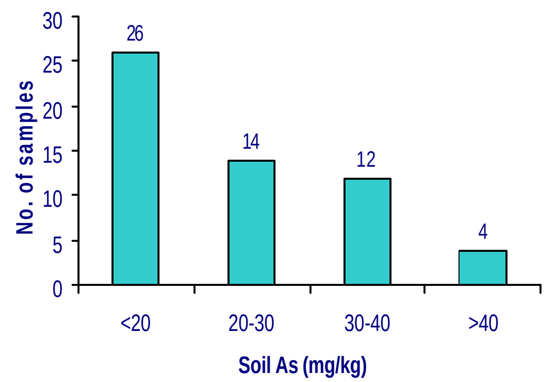
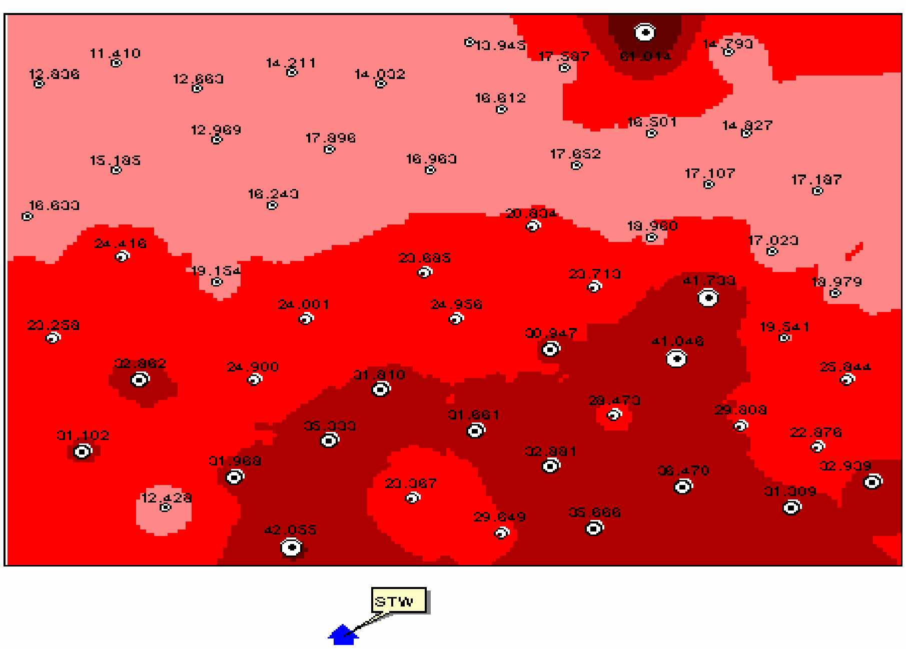


Fig. 2 Frequency distribution of arsenic in the STW command area (n=56)



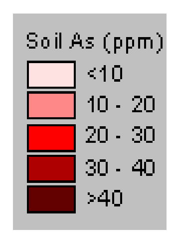


Fig. 3 Spatial variability maps of As in the STW command area

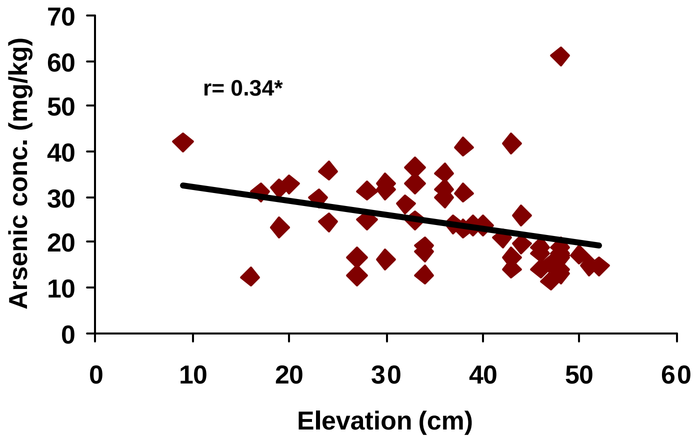


Fig. 4 Relationship between micro-land elevation with arsenic concentration

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