Movement of Arsenic in undisturbed Soil Columns with Irrigated Rice Culture

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Introduction

Arsenic from irrigation water is accumulating in soils (Ullah, 1998; Panaullah *et al.*, 2003). The presence of high As in Bangladeshi soils and continuing use of As contaminated irrigation water may affect the movement of As in soil and accumulation of As in rice (Abedin *et al.*, 2002). Transport of As in soil, as well as uptake by plants is governed by mobility, yet mobility of As in soil is imperfectly understood. The objective of this study was to determine the mobility of As in soil columns, irrigated with As contaminated water, with and without rice cultivation.

Methodology

The experiment was conducted in a net house of Bangladesh Agricultural University (BAU) Mymensingh during January to November 2004. High arsenic containing soils were collected from Faridpur district (35, 10 ppm) and low As soils from BAU farm, Mymensingh (1.7, 1.6 ppm). Undisturbed soil cores were collected in PVC pipe. Three As treatments (irrigation water having 0, 1 and 2 ppm As as $NaHAsO_4.7H_2O$) were imposed during the Boro season. Boro rice (cv. BR 29) and T. Aman rice (cv. BR 33) were grown in the soil core units and As contaminated irrigation water treatments were applied to the soils during boro cropping only. Arsenic free irrigation water was used during T. Aman season. Continuous flooded conditon was maintained in the soil to avoiding soil cracking.

Leachate samples were collected periodically from soil cores and analyzed for pH, Eh, arsenate, arsenite, available P, Fe and Mn contents. Arsenic was determined by AAS-HG method (Unicam model 969 and MHS-10 hydride generator assembly using matrix-matching standard). After harvest of Boro and T.Aman rice, the yield and yield components were recorded. Rice grain, straw and husk were analysed for N, P, K, Fe, Mn, Zn and As levels.

Results and Discussion

The average As concentration of the leachate was very low in all soils irrespective of the level of As applied through irrigation water. However, the soils irrigated with higher As had higher As concentrations in the leachate. Although As free irrigation water was provided to the T. Aman rice, higher As levels were observed in the leachate from the aman season compared to Boro season, which can be attributed to the effects of residual As and maximum soil reduction. Concentration of As in the leachate increased with time continuously from the day after transplanting (DAT) of boro (Fig. 1). In T.Aman, the leachate As concentration increased from 10 DAT up to 55 days (Fig. 1) followed by a gradual decrease. As (III) was the dominant As species, which was an average of 76% and 63% of the total As in the leachate from the Boro and T. Aman season. In the paddy-soil environment, the applied arsenate was readily converted to arsenite. Agett and Kriegman (1988) observed that mobilized As is almost entirely As(III) in the soil column.

Variation in As concentration was observed in the leachate from the T. aman season. With the Faridpur-1 soil, the mean concentrations of As in the leachate were 76, 105 and 146 µg/L and the total As leached were 0.73, 0.97 and 1.4 mg, respectively (Fig.2 &Table 1). Similarly, with the BAU-1, BAU-2 and Faridpur-2 soils higher leachate-As concentrations was observed in the T.Aman season compared to the Boro season.

Table.1 Arsenic budget

Soil& Treatments	As added (mg)	As leached in Boro season (mg)	As leached in T. Aman season (mg)	Total As leached	% of As added
BAU-1(As-0 ppm)	-	0.17	0.33	0.50	-
BAU-1 (As-1 ppm)	43.5	0.28	0.76	1.04	2.4
BAU-1 (As-2 ppm)	86.0	0.33	1.18	1.51	1.8
BAU-2(As-0 ppm)	-	0.14	0.25	0.39	-
BAU-2 (As-1 ppm)	40.5	0.19	0.40	0.59	1.5
BAU-2 (As-2 ppm)	82	0.26	0.55	0.81	1.0
Faridpur-1 (As-0 ppm)	-	0.16	0.73	0.89	-
Faridpur-1(As-1 ppm)	40.5	0.23	0.97	1.20	2.9
Faridpur-1 (As-2 ppm)	82.0	0.33	1.40	1.73	2.1
Faridpur-2 (As-0 ppm)	-	0.08	0.37	0.45	0
Faridpur-2(As-1 ppm)	37.0	0.12	0.56	0.68	1.8
Faridpur-2 (As-2 ppm)	75.0	0.18	0.80	0.98	1.3

A significant positive correlation was observed between As and Fe and P concentrations, and a significant negative correlation were found between Mn and As concentrations in the leachate (Fig. 3). The leachate As concentration was lower at the higher redox value and increased with decreasing Eh value of the leachate. At lower soil redox levels, arsenic solubility was high and the major part of the arsenic in leachate was present as As (III) (Fig.4). Leachate pH was lower in the Boro season ranging from 5.5- 6.5 and higher in the T. Aman season with range from 6.0- 7.5 . The As(III)/As(V) ratio was found to be highly associated with the redox potential (Eh) and pH. Arsenic leaching in soil was positively correlated with the rate of As application and to the volume of water that percolated through the soil column.

Rice yield decreased with increasing As concentration in irrigation water. The As concentrations in rice straw, husk and grain increased with increasing As levels in irrigation water.

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References

Abedin. M. J., Feldmann J., and Meharg. A. 2002. Uptake kinetics of arsenic species in rice plants. Plant Physiol. 128: 1120- 1128.

Agett J. and Kriegman, M.R. 1988. The extent of formation of arsenic (III) in sediment interstitial waters and its release to hypopolimnetic waters in lake Ohakuri. Wat. Res. Vol. No. 4. pp. 407- 411.

Panaullah,G.M., Ahmed, Z.U., Rahman, G.K.M.M., Jahiruddin, M., Miah, M.A.M., Farid, T. M., Biswas, B.K., Lauren, J.G., Loeppert, R.H., Duxburry,J.M. and Meisner, C.A. 2003. The arsenic hazard in the irrigation water-soil-plant system in Bangladesh: A preliminary assessment. Proc. 7th International Conference on the Biogeochemistry of Trace Elements, Ed. Gobran, G.R and Lepp N., vol. 2,pp.104-105.

Ullah, S M. 1998. Arsenic contamination of groundwater and irrigated soils of Bangladesh. In Abstract: International conference on arsenic pollution of ground water in Bangladesh, causes, effects and

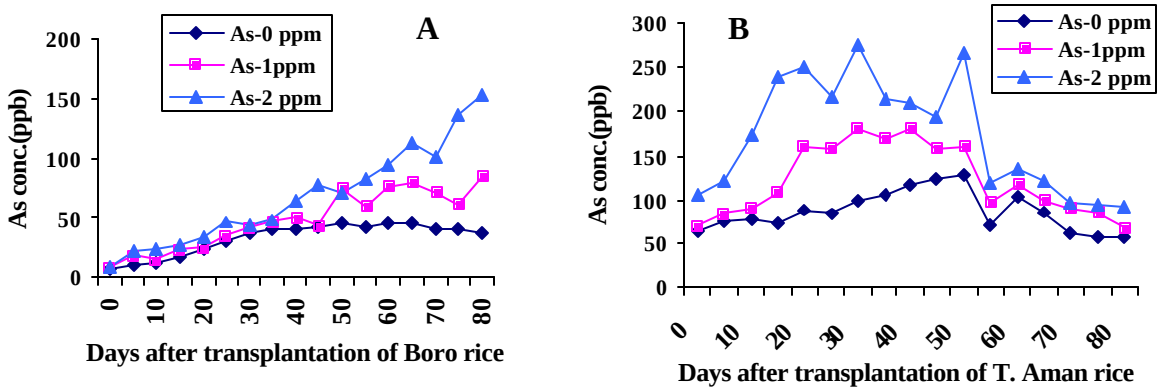

Fig. 1 Arsenic concentration in the leachate of Boro (A) and T. Aman (B) seasons with time in Faridpur-1 soil

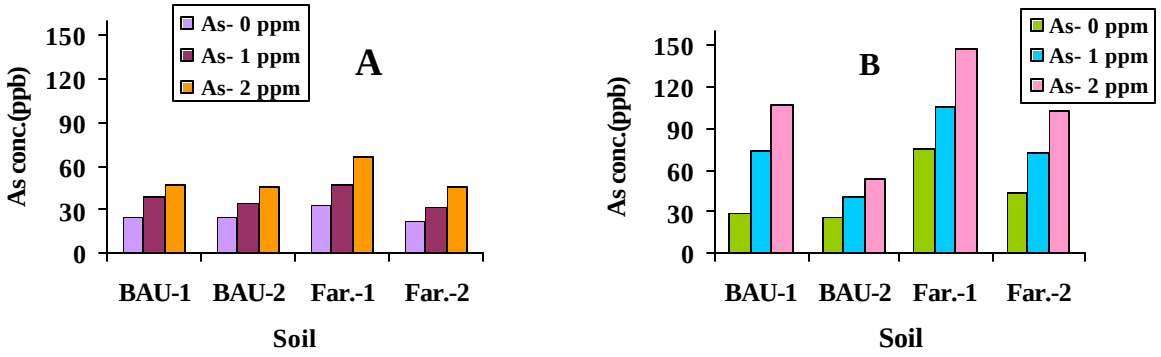

Fig. 2 Mean As conc. in the leachate of 4 soils x 3 irrigation As treatments during Boro (A) and T. Aman (B) seasons-2004

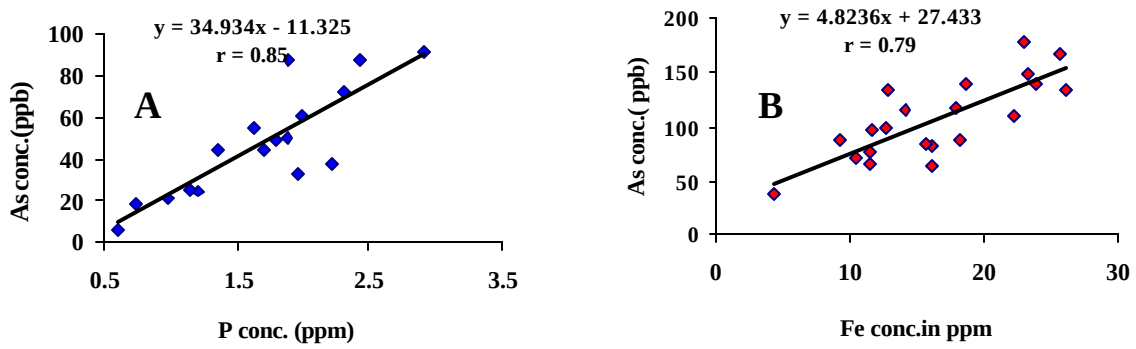

Fig. 3 Relationship of As with P and Fe in the leachate of BAU-1 soil during Boro (A) and T. Aman (B) seasons (Irrigation As 2 ppm applied in Boro season)

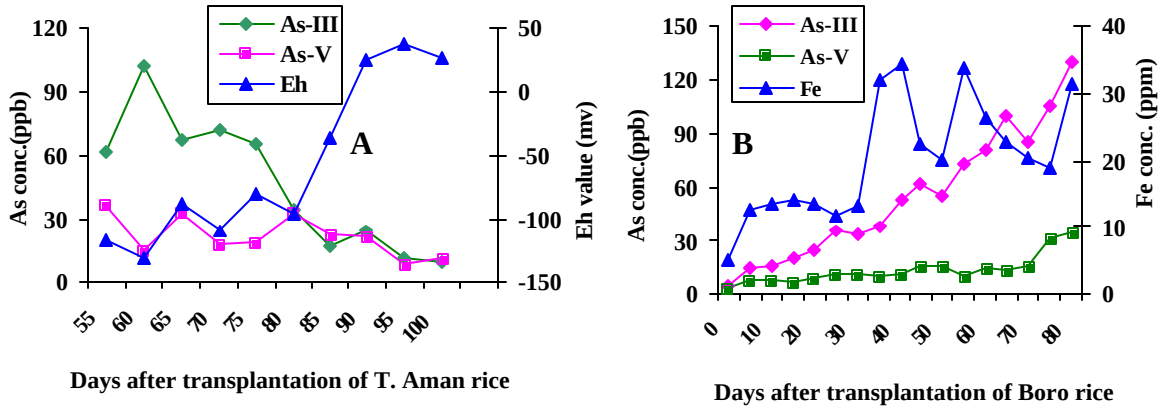

Fig. 4 A) Relationship between As (As-III & As-V) and Eh values of the leachate of T. Aman season in Faridpur-1 soil (Irrigation As-1 ppm applied in Boro season). B) As-III, As-V and Fe conc. in the leachate of Faridpur-1 soil during Boro season (Irrigation As 2 ppm)

remedies. 8-12 Feb. 1998, Dhaka Community Hospital, Dhaka, Bangladesh, p. 133.