

Accumulation of Arsenic in Rice Plant from Arsenic Contaminated Irrigation Water and Effect on Nutrient Content

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Abstract

For Bangladesh, the requirement for food is very high due to its huge population. To achieve self-sufficiency in food grain production, the HYV rice varieties are widely produced in Bangladesh, particularly in the dry season, and this requires a large volume of groundwater irrigation. Groundwater of many areas of our country is severely contaminated with arsenic. So, there is a possibility of arsenic accumulation in rice and rice plants from arsenic contaminated irrigation water. Generally, consumption of protein is not adequate for our people due to insufficient production of major protein sources like fish, meat, milk, eggs etc. and also due to economic constraints. Any adverse effect on protein content in rice due to use of arsenic contaminated irrigation water may, therefore, enhance the malnutrition problem of our people. This study aims at assessing the accumulation of arsenic in rice plants and its possible effect on nutrient (protein) content of rice grains. Results from this study show that arsenic accumulates in different parts of rice plants, though the accumulation rate varies from variety to variety. Presence of arsenic in rice plants (leaf, stem) poses risks for cattle and human health. Test results for protein content show protein deficiencies in rice grains. More studies are needed to better understand these phenomena.

BACKGROUND

Bangladesh and the adjacent areas of West Bengal, India are currently facing the challenge of high arsenic concentration in groundwater. A large number of tube wells in at least 61 districts out of 64 have been identified to have arsenic concentration above the national recommended limit of 0.05 mg/L. Conservative estimates indicate that about 29-33 million people are exposed to the risk of being affected by arsenic contaminated water.

The country is heavily dependent on its agricultural sector for its gross domestic product. National growth relies heavily on the growth of agricultural output. More than 80% of the population depends on agriculture for its livelihood. The agricultural sector employs about 90% of rural males as well as 80% of rural females (World Development Indicators, 1998) of the country. The population growth rate is still quite high and therefore the demand of food grain production, especially rice production has always been a challenging issue for our country. To ensure food security Bangladesh Government has emphasized on increasing rice production. To become self-sufficient in food grain, Bangladesh Government has encouraged production of HYV rice which require a large volume of irrigation water. The use of groundwater for irrigation has increased abruptly over the last couple of decades. About 86% of total groundwater withdrawn is utilized in agricultural sector (WRI, 2000). The use of arsenic contaminated irrigation waters in Bangladesh may cause accumulation of arsenic in rice and rice plants and this issue needs to be examined.

As a poverty stricken country, many people are living under the absolute poverty level measured on the basis of calorie intake, which is 2122 Kcal/capita/day. Recommended allowances for protein requirements for the people of Bangladesh are 1.85 g/day per kg of body weight for infant, 23-41 g/day for children, 53-79 g/day for adolescents, 60 g/day for adult male, 50 g/day for adult female, with additional 15 g/day for pregnant mother and 25 g/day for lactating mother (Kabir, 2002). The major sources of protein are meat, fish, eggs and milk. However, due to lack of availability and economic reasons, peoples' access to these protein sources is inadequate. Many people especially children suffer from malnutrition in Bangladesh. Since rice is the staple food in this country, any adverse effects on nutrient content of rice due to arsenic contaminated irrigation water would only enhance the malnutrition problem. Arsenic uptake and accumulation in rice plant from irrigation water may differ depending on cultivars used (Xie and Huang, 1998).

Abedin (2002) found considerable differences in uptake of arsenic among different varieties of rice grains.

Protein accumulation in paddy and brown rice vary with time. Protein content in Hbj IV brown rice decreases from 12.3% at 4 days after flowering (DAF) to 9.6% at 20 DAF and in BR3 brown rice from 16.5% at 4 DAF to 7.6% at 20 DAF. Though the percentage of protein in brown rice decreases, the total quantity of protein per brown rice increases between 4 DAF to 20 DAF from 0.47 mg to 1.79 mg/brown rice of Hbj IV and from 0.19 to 1.75 mg/brown rice of BR3 (BRRI, 1999).

The present study was aimed at examining whether or not rice and rice plants accumulate arsenic from arsenic contaminated irrigation water and to see if there is any adverse effect on the nutritional (protein) level of rice. The specific objectives of the study are: (i) to find out the level of arsenic accumulated by rice grain and rice plant produced with irrigation water contaminated with arsenic; (ii) to determine the relationship between the amounts of arsenic accumulated by rice and rice plant and arsenic concentration in irrigation water; and (iii) to examine the possible changes in nutrient content (protein) in rice.

METHODOLOGY

In order to achieve the above objectives, the following programs and activities were undertaken in the study:

- (1) Selection of 21 field sites in Comilla district for analyzing arsenic content of groundwater.
- (2) Collection of water samples from selected fields and testing of water samples for arsenic, selection of 13 field sites for additional study.
- (3) Collection of rice plants and soil during harvesting from the selected fields and conducting tests for arsenic in rice, different part of rice plants and soil samples, and
- (4) Testing for protein content in rice.

Tests for arsenic were done by the atomic absorption spectrophotometer (Shimadzu, AA6800). In this method soil samples were oven dried, digested with aqua-regia, filtered and tested with the GF-AAS. Different parts of rice plant and rice samples were oven-dried, digested with HNO₃, HCl and perchloric acid, filtered and tested with GF-AAS. For measuring protein content in rice, samples were digested with digestion mixture and concentrated H₂SO₄, distilled adding NaOH, boric acid and mixed indicator and finally titration of distilled solution done with standard HCl.

RESULTS AND DISCUSSION

Concentration of arsenic in soil samples and in different parts of rice plants such as rice grain, rice husk, leaf and stem and the level of protein content found in rice are presented in the Table 1. From the test result it is clear that arsenic accumulation of rice varies from variety to variety. Arsenic accumulation in rice *purbachi* variety of rice is more than other varieties such as BR28, BR29, BR14 and IR 50 varieties. Arsenic was detected in all the grain samples of *purbachi* variety of rice tested and in few samples of BR-28 and BR-29 varieties. But no arsenic accumulation was found in the grain samples of BR-14 and IR-50 varieties of rice. Root samples were found to have the highest accumulation of arsenic. The BR28 and BR14 varieties were found to have the highest accumulation in husk, leaf and stem than other varieties tested. Arsenic content of soil samples varied from about 2.0 to 12.0 mg/kg.

From the test results presented here, it is clear that rice plants accumulate arsenic from soil/water and the accumulation of arsenic varies among the different parts of plants. The quantity of accumulated arsenic decreases from root to shoot gradually. It is interesting to note that while arsenic accumulation is observed in different parts of rice plant, no arsenic accumulation was found in the rice grain in some cases. In some cases, arsenic is found in rice husk but not in rice grain and vice versa. Such variations could depend on many factors such as rice variety, composition of irrigation water, soil quality, fertilizer applied, etc. It is however, obvious that arsenic from contaminated irrigation water accumulates in root, stem and leaf of rice plant that may cause risks for cattle and human health. The tendency of rice plant to accumulate arsenic varies from variety to variety and the test results of the present study suggest that *purbachi* variety is more susceptible to arsenic accumulation.

Test results of protein content show that the protein content in rice samples tested are lower than the level shown in BRRRI's standard. However, the test results are only indicative of possible adverse effects of arsenic contaminated irrigation water on protein content. Further extensive research is necessary before such a conclusion could be established.

Table 1: Arsenic content of irrigation water, soil, different parts of rice plants and protein content of rice grain

As in Water (ppb)	As in Soil (mg/kg)	Rice Variety	As in Different Parts of Rice Plants (mg/kg)				Protein Content (%)	
			Rice Grain	Husk	Leaf	Stem	Measured	Standard
156	7.52	BR-14	0.00	0.066	0.63	0.35	7.3	7.5
364	2.07	BR-14	0.00	0.114	3.32	3.35	7.0	
277	12.0	BR-14	0.00	0.052	0.29	15.8	6.8	
199	3.76	BR-28	0.00	0.150	2.45	3.10	6.2	8.6
131	3.98	BR-28	0.032	0.060	0.19	1.25	7.0	
188	3.30	BR-28	0.00	0.099	3.10	1.85	7.8	
255	2.42	BR-28	0.063	0.00	2.28	2.19	6.7	
62	2.01	BR-29	0.016	0.067	0.68	0.00	7.0	7.0
208	3.63	BR-29	0.00	0.015	0.62	1.40	6.6	-
278	9.93	IR-50	0.00	0.00	0.52	0.85	7.0	
105	3.37	Purbachi	0.022	0.035	0.53	2.65	8.9	9.0
222	2.24	Purbachi	0.026	0.00	0.78	2.45	7.6	
177	3.02	Purbachi	0.094	0.00	0.89	0.25	8.7	

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