OnLine Journal of Biological Sciences 1 (10): 989-992, 2001

Arsenic Contamination in Some Selected Soils of Bangladesh

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Abstract: The arsenic status of some selected soils was determined in ten thanas of four arsenic affected districts of Bangladesh. Thirty soil samples taking three from each of 10 thanas representing 4 districts viz. Gopalganj, Faridpur, Rajbari and Madaripur of Bangladesh were collected. The soils were collected from 3 depths viz. 0-15, 15-30 and 30-45 cm from each location. The arsenic content in soils of Gopalganj, Faridpur, Rajbari and Madaripur districts ranged from 3.96-25.09, 0-38.67, 1.32-36.99 and 1.32-38.19 ppm, respectively. Out of 30 samples, arsenic content was noticed for 21 samples at 0-15 cm depth (1.98-46.09 ppm), 26 samples at 15-30 cm depth (1.98-51.73 ppm) and 27 samples at 30-45 cm depth (1.98-54.05 ppm). Nine samples at 0-15 cm, 4 samples at 15-30 cm and 3 samples at 30-45 cm were free from arsenic contamination. On the other hand, 7 samples at 0-15 cm depth, 6 samples at 15-30 cm depth and 4 samples at 30-45 cm depth were found to be slightly arsenic contaminated. Correlation study of arsenic contents of soils was done with some soil properties viz. sand, silt and clay contents, soil pH, EC and organic matter status. Results showed that arsenic content correlated significantly with different soil properties.

Key words: Arsenic, contamination, soil, Bangladesh

Introduction

Arsenic contamination of groundwater is recognized as a major problem in Bangladesh. The full extent of this problem is not yet fully understood, but it has already posed a serious threat to the health of the people and ecology of the country. About 24 millions people are exposed to arsenic contamination and over 50 millions at some risk of exposure. Some 5,500 arsenic poisoned patients have already been registered, according to official statistics (Bakhtiar, 1999). Groundwater of 42 districts (out of 64) covering an area of 87,400 km^2 have arsenic contamination of above 0.01mg/L, the permissible limit as determined by WHO (Ullah, 1998). The maximum permissible level for human intake of arsenic in drinking water is 0.05 mg/l. But testing samples collected from tubewells in parts of the country revealed that the water spilled contaminated arsenic in the range between 0.1 to 0.3 mg/L (Bakhtiar, 1999).

Arsenic is an element with metalloid characteristics having sometimes organic and sometimes inorganic substances. It occurs in all environmental media. It is widely distributed throughout the earth's crust. High arsenic contamination is associated with the following: volcanic deposits, deposits of alluvial lacustrine in semi and zones geothermal system and mining areas of gold and uranium. In Bangladesh, it is believed to be the outcome of a natural process under the ground. Arsenic is widely distributed geologically as a component of hundred other minerals. One of the theories blames over drawing of ground water for the excessive presence of arsenic in water. Bangladesh has one of the world's highest concentration of wells to pump out ground water for drinking and irrigation. It has recently been reported in newspapers that over 1340 tons of toxic arsenic compound has entered Bangladesh soil through arsenic compound treated 25 lakh wooden electric poles imported from foreign countries for using in the rural electric supply system during the last two decades. Atomic Energy Commission expert said that the arsenic compounds on the poles may cause serious hazards by contamination of the under ground water sources as well the soil of Bangladesh, particularly the upper layer of soil. However, this should be tested for confirmation.

Bangladesh is an agricultural country having rice as the main crop. Thus, irrigation with As contaminated groundwater to rice and other crops may increase As level in soil and consequently, this toxic element may enter into food chain through crop uptake. Kabata-Pendius *et al.* (1992) viewed that As deposition might accumulate in soil within a short span of time. Hence, it is now an urgent necessity to understand the dynamics of As in the soil-plant system with a view to developing management strategies to restore the conditions required for a safe environment. During the last 6 years, hundreds of newspaper reports showed the arsenic contamination crisis in ground water in different areas of Bangladesh but very limited data are now available on soil environment of Bangladesh although soil is the mother reservoir of arsenic (Sattar, 2001). Thus, the experiment has been planned to determine the arsenic status at different soil depths of some selected soils of Bangladesh and to find out the relationship between soil properties and arsenic content.

Materials and Methods

The experiment was conducted with the soils of 10 thanas representing 4 districts of Bangladesh. The selected thanas are Gopalganj Sadar, Tungipara under Gopalganj district; Faridpur Sadar, Sadarpur, Bhanga, Nagarkanda under Faridpur district; Rajbari Sadar, Goalaundha under Rajbari district and Madaripur Sadar, and Rajair under Madaripur district. The soil sampling sites were selected with the help of the staffs of the Department of Soil Resources Development Institute (SRDI) of the respective area, the sites were selected on the basis of available records of high arsenic concentration in soils. Soil samples were collected from three locations of 10 thanas. Thus, a total of thirty composite soil samples were collected from 10 thanas. The samples were collected at three different depths viz. 0-15, 15-30 and 30-45 cm. Each composite samples was a combination of three individual soil sample collected from different spots of the same field. The area from where one composite sample was taken ranged from 0.5 to 5 ha of land and the plant roots, leaves, gravels etc. were picked up and discarded. Finally, about 1 kg of each soil was put into the plastic bag labeled properly and then carried to the laboratory, of the Department of Soil Science, Bangladesh Agricultural University, Mymensingh for subsequent physical and chemical analyses. The collected soil samples were

Table 1: General soil information of sampling sites

District	Thana	Location	AEZ	Land type	Soil series	General soil type
Gopalgonj	Gopalgonj Sadar	Charboira	Old Meghana Estuarine flood plain	Medium high land	Ishurdi	Celcareous Brown Floodplain Soil
		Ghonapara	"	"	"	"
		Gopalganj Govt. poultry farm	"	High land	"	"
	Tungipara	Tungipara	"	Medium low land	Sara	"
		Charkushli	"	"	Ishurdi	"
		Patghati	"	Medium low land	"	"
Faridpur	Faridpur Sadar	Deura	Low Ganges river plain	Medium high land	Ishurdi	"
		Mamudpur	"	"	"	"
		Bilmamudpur	"	"	"	"
	Sadarpur	Satrashi	"	"	Sara	"
		Atrashi	"	"	"	"
		Baishrashi	"	"	"	"
	Bhanga	Bhrammonkanda	"	"	"	"
		Sadardi	"	"	Ishurdi	"
		Moheshordi	"	Medium high land	Sara	"
	Nagarkanda	Banglakanda	"	"	"	
		Dunginagarkanda	"	"	"	
		Jadurida	"	Medium high land	Ghior	"
Rajbari	Rajbari Sadar	Chaidebpur	Low Ganges river flood plain	Medium high	Medium texture	"
		Khankhanpur	"	"	Ganges Alluvium	"
		Tipuragram	"	"	"	"
		Tipuragram	"			
	Goalaundha	Dewanpara	"	Medium low land	Medium texture	"
		Dhoulatida	"	"	Ganges Alluvium	"
		Kumrakandi	"	"	"	"
Madaripur	Madaripur Sadar	Shirkhara	Ganges river flood Plain	Medium high land	Gopalpur	"
		Srinadi	"	"	"	"
		Balabdi	"	"	"	"
	Rajair	Saramongal	Low Ganges river flood plain	Medium high land	Ghoir	
		Bowlgram	"	"	"	"
		Gosalkandi	"	Medium low land	"	"

dried at room temperature, ground and sieved through a 2-mm sieve. Then the entire amount of soil was thoroughly mixed. The prepared samples were preserved in polythene bags after proper labeling for laboratory analyses. The general soil information has been presented in Table 1.

The soil samples were analyzed for sand, silt and clay contents (Piper, 1950), Soil pH (Jackson, 1962) and organic carbon and electrical conductivity (EC) (Page *et al.*, 1982). Arsenic contents of the soils were determined by molybdenum heteropoly blue method as described by Allen (1974).

Results and Discussion

Arsenic content in soils

Arsenic content at Gopalganj district : The arsenic contents at six locatbns of Gopalganj district have been presented in Table 2. The arsenic content was detected in 14 samples out of 18 from 6 locations covering three soil depth viz. 0-15 cm (D_1), 15-30 cm (D_2) and 30-45 cm (D_3). The arsenic status varied from 1.98-29.72, 3.96-15.94 and 5.94-54.05 ppm in D_1, D_2, and D_3 samples, respectively. Maximum As content (54.05 ppm) was observed in the location of Patghati at depth of D_3 and the minimum (1.98 ppm) in Ghonapara at depth of D_1. The arsenic content was below the detection limit at D_2 and D_3 depths from Gopalganj Government Poultry Farm and at D_1 depth from two sites at Tungipara and Patghati. The average As contents at Charboira, Ghonapara, Gopalganj Govt. poultry farm, Tungipara, Charkushli and patghati were 25.09, 5.94, 3.96, 7.23, 19.15 and 23.33 ppm, respectively, irrespective of

Table 2: Arsenic content in selected soils of Gopalganj district

Locations	Arsenic status in soil (ppm)			
	0-15 cm depth (D_1)	15-30 cm depth (D_2)	30-45 cm depth (D_3)	Average value
Charboira	29.72	3.96	41.61	25.09
Ghonapara	1.98	5.94	9.91	5.94
Gopalganj Govt. Poultry farm	11.89	ND	ND	3.96
Tungipara	ND	15.76	5.94	7.23
Charkushli	19.81	11.89	25.76	19.15
Patghati	ND	15.94	54.05	23.33

ND = Not detected

Table 3: Standard values (guidelines) for arsenic contaminated soils (Thornoton, 1980)

Contamination status	Arsenic status (ppm)
Uncontaminated soil	0-30
Slight contaminated soil	30-50
Contaminated soil	50-100
Heavily contaminated soil	100-500
Usually heavy contamination	>500

Table 4: Arsenic content in selected soils of Faridpur district

Locations	Arsenic status in soil (ppm)			
	0-15 cm depth (D_1)	15-30 cm depth (D_2)	30-45 cm depth (D_3)	Average value
Deura	5.94	29.72	19.81	18.49
Mamudpur	1.98	5.38	3.96	3.77
Bilmamudpur	16.06	51.73	24.82	30.87
Satrashi	11.89	23.31	19.81	18.33
Atrashi	ND	ND	ND	ND
Baishrashi	1.98	5.94	5.94	4.62
Bhrammonkanda	41.61	29.72	27.74	33.02
Sadardi	39.63	27.74	15.85	27.74
Moheshordi	40.64	51.59	23.78	38.67
Bangalkanda	ND	ND	5.94	1.98
Dunginagarkanda	29.72	19.81	29.72	26.41
Jadurida	9.91	9.91	15.85	11.89

ND = Not detected

Table 5: Arsenic content in selected soils of Rajbari district

Locations	Arsenic status in soil (ppm)			
	0-15 cm depth (D_1)	15-30 cm depth (D_2)	30-45 cm depth (D_3)	Average value
Chaidebpur	1.98	1.98	ND	1.32
Khankhanpur	45.02	38.22	27.74	36.99
Tipuragram	ND	23.78	35.66	19.81
Dewanpara	11.89	17.83	19.81	16.51
Dhoulatdia	ND	3.96	1.98	1.98
Kumrakandi	15.85	17.83	25.76	19.81

ND = Not detected

Table 6: Arsenic content in selected soils of Rajbari district

Locations	Arsenic status in soil (ppm)			
	0-15 cm depth (D_1)	15-30 cm depth (D_2)	30-45 cm depth (D_3)	Average value
Shirkhara	41.61	29.72	25.76	32.36
Srinadi	ND	17.61	15.85	11.16
Balabdiu	ND	ND	3.96	1.32
Saramongal	46.09	42.2	26.96	38.19
Bowlgram	39.63	37.93	15.85	31.13
Gosalkandi	ND	39.63	38.23	25.95

ND = Not detected

soil depths. Now, the locations were set on the basis of average As content ranges in the following order: Charboira > Patghati > Charkushli > Tungipara > Ghonapara > Gopalganj Govt. poultry farm soils. The soil arsenic standards were classified by Thornton (1980) shown in Table 3. On the basis of this classification the soil of Charboira in D_3 depth was slightly contaminated and the soil of Patghati in D_3 depth was contaminated. In general, surface soil was not contaminated in Gopalganj district.

Table 7: Correlation of arsenic content in soils versus sand, silt, clay, pH, organic matter and EC content of selected districts

Districts	Correlation	No. of observations	r value
Gopalganj	As in soil x Sand	6	0.087
	As in soil x % Silt	6	0.551
	As in soil x % Clay	6	0.699
	As in soil x soil pH	6	0.089
	As in soil x Organic matter	6	0.552
	As in soil x Soil EC	6	0.085
Faridpur	As in soil x Sand	12	0.489
	As in soil x % Silt	12	0.326
	As in soil x % Clay	12	0.455
	As in soil x soil pH	12	0.002
	As in soil x Organic matter	12	0.089
	As in soil x Soil EC	12	0.542
Rajbari	As in soil x Sand	6	0.210
	As in soil x % Silt	6	0.197
	As in soil x % Clay	6	0.357
	As in soil x soil pH	6	0.389
	As in soil x Organic matter	6	0.097
	As in soil x Soil EC	6	0.714
Madaripur	As in soil x Sand	6	0.652
	As in soil x % Silt	6	0.776
	As in soil x % Clay	6	0.394
	As in soil x soil pH	6	0.861
	As in soil x Organic matter	6	0.035
	As in soil x Soil EC	6	0.439

ND = Not detected

Arsenic content at Faridpur district: At Faridpur district, arsenic was found in 31 samples out of 36 samples from 12 locations (Table 4). Atrashi site was entirely free from arsenic and was not detectable in D_1 and D_2 of Bangalkanda. The arsenic status in depths of D_1, D_2 and D_3 samples varied from 1.98-41.61 ppm, 5.38-51.73 ppm and 3.96-29.72 ppm respectively. The average values of arsenic concentrations at 11 locations were 18.49 ppm at Deura, 3.77 ppm at Mamudpur, 30.87 ppm at Bilmamudpur, 18.33 ppm at Satrashi, 4.62 ppm at Baishrashi, 33.02 ppm at Bhrammonkanda, 27.74 ppm at Sadardi, 38.67 ppm at Moheshordi, 1.98 ppm at Bangalkanda, 26.41 ppm at Dunginagarkanda and 11.89 ppm at Jadurdia . The average highest arsenic content was found in Moheshordi which was followed by Bhrammonkanda, Bilmamudpur, Sadardi, Dunginagarkanda, Deura, Satrshi, Jadurdia, Baishrashi, Mamudpur and Bangalkanda. However, in most of the soils the arsenic level did not exceed the maximum limit of 20 ppm. The results are in agreement with Kabata-Pendius and Pendius (1992).

On the basis of arsenic standards in soils, the D_3 of Bhrammonkanda, Sadardi and Moheshordi were slightly contaminated and D_2 of Bilmamudpur and Moheshordi is contaminated area.

Arsenic content at Rajbari district: Arsenic contents were not detectable from 3 samples and detectable from 15 samples out of 18 from 6 locations of Rajbari district (Table

5). The arsenic concentration ranged were from 1.98-45.02 ppm at D_1, 1.98-38.22 ppm at D_2 and 1.98-35.66 ppm at D_3. Arsenic content was maximum in Khankhanpur at D_1 and minimum in Chaidebpur at D_1 and D_2 and in Doulatdia at D_3 depth. The average lowest arsenic content was found in Chaidebpur which was followed by Doulatdia, Dewanpara, Kumrakandi-Tipuragram and Khankh anpur . In Rajbari district the samples of Khankhanpur (D_1 and D_2) and Tipuragram (D_3) were slightly contaminated.

Arsenic content at Madaripur district: The levels of arsenic at 6 locations of Madaripur district have been reported in Table 6. The arsenic content was detectable in 14 samples out of 18 from 6 locations covering 3 soil depths viz. 0-15 cm (D_1), 15-30 cm (D_2) and 30-45 cm (D_3). The highest arsenic content (46.09 ppm) was found in Saramongal at D_1 depth and the lowest amount of arsenic (3.96 ppm) was observed in Balabdi at D_3 depth. The average highest arsenic was found in Saramongal which was followed by Shirkhara, Bowlg ram, Gosalkandi, Srinadi and Balabdi. The averag e arsenic value of most of the soils was higher than the maximum limit of 20 ppm. The soils of Madaripur district were calcareous in nature. Jahiruddin *et al.* (2000) also found higher arsenic content in calcareous soils.
On the basis of arsenic standard in soils (Thornton, 1980), the D_1 of Shirkhara, D_1 and D_2 of Saramongal and Bowlgram and D_2 and D_3 Gosalkandi were slightly arsenic contaminated. In general, surface soil of Madaripur district was not contaminated.

Correlation of arsenic contents of soils with some soil properties: The correlation between arsenic content and soil properties like sand, silt, clay, pH, organic matter and EC status has been shown in Table 7. In Gopalganj district positively significant correlation existed among the arsenic content and organic matter ($r = 0.552$), clay content ($r = 0.699$) and pH of the soils and negative significant correlation existed among the arsenic content and EC, sand and silt particle. These results are in agreement with Diddapa and Khan, (1985) who found similar correlations. The arsenic status of Faridpur district were correlated with the sand, silt, clay, pH, organic matter and EC content, the parameters showed a positive or negative correlation (Table 7). All parameters showed negative correlation except clay particle. Clay particle showed a positive significant correlation ($r = 0.455$). The arsenic levels of Rajbari district were correlated with soil properties like sand, silt, clay, pH, organic matter and EC status. In Rajbari district, a positive significant correlation was observed with the pH ($r = 0.389$), EC and arsenic content in soil. Arsenic status of Madaripur district were correlated with sand, silt, clay, pH, organic matter and EC status (Table 7). It was observed that soil pH, EC and sand particles showed positive significant correlation with arsenic.
From the above discussion and findings, it can be concluded that arsenic status in most of the selected soils were low except in few cases. In general, most of the surface soil, arsenic status was normal that is not harmful although a very few soils showed minor arsenic contamination. Further studies should be done to identify the arsenic contaminated soils all over Bangladesh. Most sensitive method (s) and precision of the methods should be done. Public awareness and the involvement of government and non-government organizations are necessary to minimize the arsenic disaster in Bangladesh.

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