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Assessment of arsenic (As) contamination in soils of Kushtia and Rangpur Districts

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Abstract

The total arsenic (As) contents of collected sixteen soil series were determined using FI-HG-AAS (Flow Injection Hybrid Generation Atomic Absorption Spectrometry) method to find out whether the soils were contaminated or not in soil of different series in Kushtia and Rangpur districts, Bangladesh. Besides arsenic, other elements viz. soil properties like sand, silt, clay, pH, organic carbon, total nitrogen content and exchangeable cations like Ca, K and Na were also estimated in the Soil Science laboratory at Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. Results showed that the As level of Kushtia district ranged from 12.03 mg/kg - 20.06 mg/kg. The lowest As contaminated soil series in Kushtia district was Gopalpur 1 (12.03 mg/kg) and the highest contaminated soil series in Kushtia district was Ishurdi (20.06 mg/kg). In Rangpur district, the As level ranged from 1.81 mg/kg - 6.97 mg/kg, where all the soil series were non-contaminated. Kaunia 2 (6.97 mg/kg) and Belabo 1 (5.15 mg/kg) soil series were slightly contaminated with refers a level of 6 mg/kg and Belabo 2 (4.72 mg/kg) soil series were also slightly contaminated with refers a level of 5 mg/kg. The total As contents in the different surface soils were varied mainly due to local differences in the soil types, biogeochemical activities and farm management practices.

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Introduction

Arsenic is a toxic heavy metal. It is a steel-gray, brittle, crystalline metalloid with three allotropic forms that are yellow, black and gray. Chemically, arsenic is always present as compounds with oxygen, chlorine, sulphur, carbon and hydrogen on one hand with lead, gold and iron on the other hand, Arsenic is present in the earth's crust on an average of 2.5 mg/kg. The most common arsenic bearing minerals are arsenopyrite (FeAsS), enargite (Cu_3AsS_4) and orpiment (As_2S_3).

Bangladesh is facing the problem of arsenic poisoning in drinking water (Ali and Wakatsuki, 1998). The arsenic hazard will have an important impact on the health, social and economic status of the population. Humans are exposed to arsenic mainly through ingestion and inhalation. The World Health Organization (WHO) has recently revised its original guideline value for arsenic in drinking water of 0.05 mg/l (WHO, 1999) for Bangladesh and 0.01 mg/l for the developed countries. Arsenic problem was first detected in Bangladesh in 1993 by the Department of Public Health Engineering (DPHE). But the fact remained behind the screen till 1996. According to the latest surveys (BAMWSP, DPHE, 2006) conducted at both government and non-government agencies, at least 60 out of the total 64 districts of Bangladesh are affected with arsenic problem. The reasons for arsenic contamination of ground water in Bangladesh are yet to be identified. The source of arsenic contamination in the seven districts of West Bengal is noted to be geological. Bore-hole sediment analysis at several arsenic contaminated areas showed high arsenic concentration in soil layers where it was found to be associated with iron pyrites. The reason why arsenic is leaching out from the sources is not yet clear. Several studies have indicated that due to heavy extraction of groundwater, there is marked fluctuation of water level (Ali, 2009). As a result there is aeration of soil leading to decomposition of the pyrites that causes leaching of arsenic. Bangladesh is geographically adjacent to west Bengal having similar aquifers and socio-economic background.

In many regions of the Bangladesh there is enough surface water (river, pond and others) available to support the demands of drinking water. Although, surface water is not free from diseases producing microorganisms, may be used by boiling. At present in Bangladesh the PSF (Pond Sand Filter) and RWH (Rain Water Harvesting) projects have been started. Ground water is the source of drinking water for more than 97 percent of rural population who do not have access to public water supply system. These groups of people are at risk by exposed to arsenic pollution. So it is necessary to find out arsenic problem in the different soils of Bangladesh. Therefore, this study was initiated for the assessment of arsenic status of Kushtia and Rangpur districts whether the soils have undergone any contamination or not.

Materials and methods

Description of the Study Area

The study area was covered sixteen soil series in Bangladesh namely Garuri 1, Garuri 2, Gopalpur 1, Gopalpur 2, Sara, Ishurdi, Ghior from Ganges River Floodplain from Kushtia district and Pirgacha 1, Pirgacha 2, Kaunia 1, Kaunia 2 and Gangachara from Tista Meander Floodpalin and Chandra 1, Chandra 2 Belabo 1 and Belabo 2 soil series from North-Eastern Barind Tract from Rangpur district. Soil samples had been collected from Ganges River Floodplain area during January, 2010 and from Tista Meander Floodplain and North-Eastern Barind Tract area during June, 2009. The representative soil series are identified with the help of Soil Resources Development Institute (SRDI). For better understanding the sampling sites are described in Table 01 and Table 02. The soil samples were collected on a profile basis from each location and taken to the laboratory of BINA for their institutional research program. In this study, only different surface soils have been used for the assessment of As and selected data are also used in this study. Some physicochemical data have been used from a previous study (personnel communication with M. M. Ali, BINA).

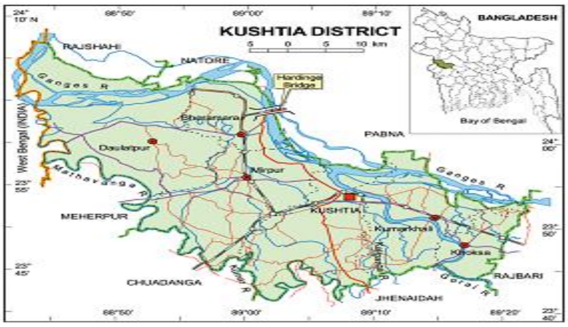

Fig. 1. Map showing the district of Kushtia.

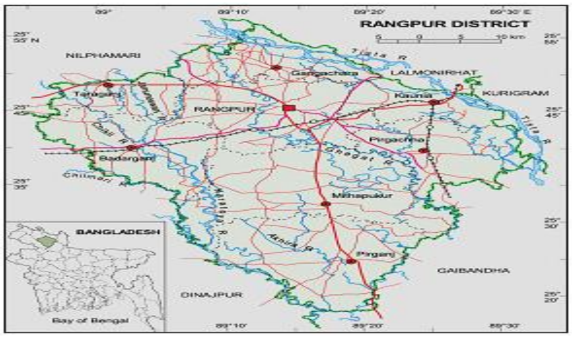

Fig. 2. Map showing the district of Rangpur.

Sample Preparation and Laboratory Analysis

Air-dried soil samples were ground and passed through 100 mesh sieve and stored in a plastic bottle for laboratory analysis. Approximately 0.5 grams of air-dried soil samples were taken in a glass bottle for oven drying. After oven drying at 50° C for 24 hours, all the samples were crushed and made into a fine homogenous powder within approximately 12 minutes using an agate morter and a pestle. The agate morter and pestle were cleaned with ethanol to ensure that the trace metal contamination did not originate from the grinding process.

Methods of Analysis

Soil texture

Sand, silt and clay contents were determined by hydrometer method (Bouyouscos, 1962). Fifty gram of air dry sample from each sampling depth was taken in a dispersion cup and 10 ml of 5% calgon solution was added to each sample and then left for 15 minutes for reaction. Distilled water was added into each cup up to 2/3rd of the cup.

The suspension was then stirred with an electrical stirrer for 10 minutes. The contents of each dispersion cup were then transferred to one litter sedimentation cylinders separately and distilled water added to make the volume up to 1 litter mark. An appropriate rubber cork was placed on the mouth of the cylinder and the cylinder was inverted several times until the whole soil mass appeared in the suspension. The cylinder was set right and the hydrometer readings were taken at 40 seconds and 2 hours of sedimentation. The correction of hydrometer readings were made as the hydrometer was calibrated at 68°F. The percentage of sand, silt and clay contents was calculated as follows:

$$\%(\text{silt} + \text{clay}) = \frac{\text{Corrected hydrometer reading at 40 seconds}}{\text{Oven dry weight of soil}} \times 100$$

$$\%(\text{clay}) = \frac{\text{Corrected hydrometer reading at 2 hours}}{\text{Oven dry weight of soil}} \times 100$$

% sand = 100 - (% silt + % clay)

% silt = (% silt + % clay) - % clay

The textural classes of soil at different depths of each location were determined by plotting the results on Marshall's triangular diagram following USDA system.

Soil p^H

Soil pH was determined by glass electrode pH meter as described by Jackson (1962). Twenty gram air-dry soil was taken in a beaker and 50 ml distilled water was added to it. The suspension was stirred well for several times during the next 30 minutes and allowed to stand for about an hour. Then the electrode was immersed into the partly settled soil suspension and pH was measured. The result was reported as "Soil pH measured in water" (Soil-water ratio being 1: 2.5).

Organic carbon

Organic carbon was determined titrimetrically by Walkely and Black's (1935) wet Oxidation method with oxidation of organic carbon with potassium dichromate ($K_2Cr_2O_7$). According to procedure 2 g soil along with 10 ml 1 N $K_2Cr_2O_7$ solution and 20 ml of conc. H_2SO_4 was taken in a 500 ml conical flask. After 30 minutes rest, about 200 ml distilled water and 10 ml conc. H_3PO_4 were added. Then 40 drops of diphenylamine indicator ($C_{12}H_{11}N$) was added and titrated against XN ferrous sulphate solution until purplish blue color was turned to fresh green color. The organic matter content of each sample was calculated by multiplying the content of organic carbon by Van Bemmelen factor, 1.73 (Page *et al.,* 1982).

Total nitrogen content

Total nitrogen content was determined by micro-Kjeldahl method. The soil was digested with H_2O_2 and conc. H_2SO_4 in presence of a catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 10: 1: 0.1) and the nitrogen in the digest was determined by distillation with 40% NaOH followed by filtration of distillate trapped in H_3BO_3 with 0.01 N H_2SO_4 (Bremmer and Mulvaney, 1982).

Exchangeable Ca, K and Na content

Exchangeable calcium, potassium and Sodium were determined by ammonium acetate extraction method. In this method, soil sample was saturated with NH_4Oac solution and the supernatant clear solution was separated and collected. The NH_4Oac solution was added again to make the final volume up to 100 ml for each sample. For the cation of Ca^{++}, K^+ and Na^+ the flame photometer was separately adjusted and different standard curves were prepared to find out the concentration of the cation but the extracting solution used for each sample was same. From each reading the concentration of each ion was obtained from their respective standard curves and was expressed as me%.

Analysis of Arsenic

Reagents

All reagents were of analytical reagent grade. Distilled de ionized water was used throughout. standard solutions were prepared by dissolving appropriate amounts of As_2O_3 (Merck, Germany), standard arsenic (V) Titrisol (Merck, Germany), $CH_3AsO_3Na_2.6H_2O$ (Carlo-Erba, Italy) and $(CH_3)_2AsO_2Na.3H_2O$ (Sigma, USA). Standard stock solutions were stored in glass bottles and kept refrigerated. Dilute arsenic solutions for analysis were prepared daily. Cation [Dowex X-50w (H^+ form)] and anion [Dowex-1 (Cl^- form)] exchange resins (Sigma, USA) were used. Sodium diethyldithiocarbamate (Merck, Germany) was used as a 0.5% (w/v) solution and purified shaking with chloroform. Ashing acid suspension was prepared by stirring 10% (w/v) $Mg(NO_3)_2.6H_2O$ and 1% (w/v) MgO in water until homogenous.

Table 1. Description of the soils in terms of morphology and land uses at Ganges River Floodplain area.

Soil series	Sampling location	Physiographic unit	Land type	Present land use
Garuri 1	B-2, Amla farm, Kushtia	Ganges River Floodplain	Medium lowland	Boro- T. aman
Garuri 2	B-9, Amla farm, Kushtia	"	"	Boro- T. aman
Gopalpur 1	B-7, Amla farm, Kushtia	"	"	Wheat/ Boro- T.aman
Gopalpur 2	Kaya, Kumarkhali, Kushtia	"	Medium lowland	Aus - T. aman- Boro
Sara	Kaya, Kumarkhali, Kushtia	"	Highland	Aus-vegetable
Ishurdi	Kaya, Kumarkhali, Kushtia	"	"	Boro - F - T.aman
Ghior	Kaya, Kumarkhali, Kushtia	"	Lowland	Boro - F - T.aman

Table 2. Description of the soils in terms of morphology and land uses at Tista Meander Floodplain Area.

Soil series	Sampling location	Physiographic unit	Land type	Present land use
Pirgacha 1	Hridevpur, Sadar, Rangpur	Tista Meander Floodplain	Highland	Tobacco- T.aman
Pirgacha 2	Chairmanpara, Hridevpur, Rangpur	"	"	Tobacco- T.aman
Gangachara	Dulapur, Mithapukur,Rangpur	"	"	Wheat- T.aus- T.aman
Kaunia 1	Manthana, Sadar, Rangpur	"	"	Tobacco-Boro- T.aman
Kaunia 2	Rathirampur, Sadar, Rangpur	"	"	Tobacco-Boro- T.aman
Chandra 1	Rajarampur, Pirganj, Rangpur	North-Eastern Barind Tract	"	T.aman- Boro
Chandra 2	Bara-Rajarampur, Pirganj, Rangpur	"	"	T.aman- wheat
Belabo 1	Khejmatpur, Pirganj, Rangpur	"	"	Sugercane- vegetables
Belabo 2	Kanchangari, Pirganj, Rangpur	"	"	T.aman- wheat

Table 3. Sand, silt and clay contents in different surface soil series in Kushtia and Rangpur districts.

Soil series	Physiographic unit	Sand (%)	Silt (%)	Clay (%)	Textural class
Garuri 1	Ganges River Floodplain	35.4	19.0	45.6	Clay
Garuri 2	"	31.3	14.0	20.7	Loam
Sara	"	38.4	26.0	22.6	"
Gopalpur 1	"	51.9	30.0	18.1	Sandy loam
Gopalpur 2	"	41.4	35.0	23.6	"
Ishurdi	"	33.3	37.0	29.7	Clay loam
Ghior	"	33.3	32.0	34.7	Clay loam
Pirgacha 1	Tista Meander Floodplain	64	28	8	Sandy loam
Pirgacha 2	"	75	15	10	"
Kaunia 1	"	57	30	13	"
Kaunia 2	"	43	42	15	Loam
Gangachara	"	60	30	10	Sandy loam
Chandra 1	North-Eastern Barind Tract	52	38	10	"
Chandra 2	"	52	38	10	"
Belabo 1	"	54	34	12	"
Belabo 2	"	52	36	12	"

The reducing solution was sodium tetrahydroborate (Merck, Germany) 1.25% (m/v) in 0.5% (m/v) sodium hydroxide. The HCl concentration was 5 M. Sodium acetate-acetic acid buffer at pH 5.5 was prepared by mixing acetic acid (0.2 M) until the pH was 5.5; citric acid-citrate buffer at pH 3.0 was prepared by using 40% (w/v) citric acid and adjusting the pH with NaOH solution. The buffers were purified by extraction with Na-DDTC and chloroform.

Speciation of arsenic content

A 250 ml aliquot of filtered preserved water sample adjusted to a pH of about 5.5 by adding dilute NaOH was transferred into a 500-ml separating funnel; 10 ml of sodium acetate-acetic acid buffer at pH 5.5 was added and the funnel was shaken; 5 ml of 0.5% Na-DDTC and 5 ml of chloroform were then added. The solution was shaken for 3 min. The procedure was repeated twice. All three chloroform extracts were combined and placed into a 50 ml round-bottom flask; chloroform was then removed by a rotary evaporator kept at 30°C on a water bath. The dry residue was decomposed by warming with nitric acid (0.1 ml), cooled and then transferred quantitatively into a known volume (5-10 ml) with water. Then FI-HG-AAS was used for the determination of arsenic against arsenate standard. After arsenite was removed from the water by chelate extraction, the remaining arsenic was determined directly by FI-HG-AAS against an Arsenate standard or total arsenic was measured directly by injecting the aliquot into FI-HG-AAS against arsenate standard and arsenate was determined by subtracting arsenite from total arsenic. Blanks were determined under identical conditions (Gautam *et al.,* 1992).

Results and discussion

The research results with regards to evaluate the soil physical and chemical characters e.g. particle size distribution (sand, silt and clay contents), soil pH, organic matter, total N and exchangeable cations (Ca^{++}, K^{+} and Na^{+}) contents for the assessment of arsenic status in Kushtia and Rangpur districts.

General Characteristics of Soil

Sand, silt and clay content in different surface soil series in Kushtia and Rangpur districts

The particle size distribution (sand, silt and clay contents) of the selected soil series are described in the study (Table 03). In Kushtia district, different textural classes were found according to the particle size distribution (sand, silt and clay contents). Most of the soil series were loam to clay loam. Among them, Garuri 2, Sara and Gopalpur 2 soil series were loamy soil and Ishurdi and Ghior soil series were clay loam soil. Garuri 1 soil series contained clay soil and sandy laom soil were found in the Gopalpur 1 soil series. However, most of the soil series of Rangpur district were sandy loam except Kaunia 2. Kaunia 2 was found loamy in texture.

Table 4. Soil pH, organic carbon and total N contents in different surface soil series in Kushtia and Rangpur districts.

Soil series	Physiographic unit	pH	Organic C (%)	Total N (%)
Garuri 1	Ganges River Floodplain	6.69	1.25	0.140
Garuri 2	"	7.28	1.20	0.105
Sara	"	7.38	0.58	0.084
Gopalpur 1	"	7.51	1.04	0.091
Gopalpur 2	"	7.40	0.81	0.119
Ishurdi	"	7.49	1.21	0.088
Ghior	"	7.47	1.76	0.125
Pirgacha 1	Tista Meander Floodplain	4.3	0.67	0.053
Pirgacha 2	"	4.8	0.59	0.04
Kaunia 1	"	5.4	0.92	0.098
Kaunia 2	"	5.0	1.05	0.10
Gangachara	"	5.0	0.78	0.08
Chandra 1	North-Eastern Barind Tract	4.0	1.07	0.089
Chandra 2	"	4.6	1.25	0.08
Belabo 1	"	4.6	0.77	0.085
Belabo 2	"	4.4	0.77	0.07

Table 5. Exchangeable cation (Ca, K and Na) contents in different surface soil series in Kushtia and Rangpur districts.

Soil series	Physiographic unit	Exch. Ca (me%)	Exch. K (me%)	Exch. Na (me %)
Garuri 1	Ganges River Floodplain	17.50	0.53	1.33
Garuri 2	"	16.25	0.44	1.43
Gopalpur	"	15.00	0.44	1.49
Ghior	"	20.00	0.41	1.49
Pirgacha 1	Tista Meander Floodplain	0.80	0.24	0.11
Pirgacha 2	"	1.4	0.09	0.11
Kaunia 1	"	1.98	0.11	0.20
Kaunia 2	"	2.0	0.11	0.14
Gangachara	"	1.6	0.08	0.15
Chandra 1	North-Eastern Barind Tract	0.48	0.07	0.08
Chandra 2	"	0.5	0.07	0.08
Belabo 1	"	0.79	0.10	0.12
Belabo 2	"	0.8	0.11	0.06

Table 6. Arsenic (As) contents of Kushtia and Rangpur districts.

Kushtia district		Rangpur district	
Soil series	As level (mg/kg)	Soil series	As level (mg/kg)
Garuri 1	16.50	Pirgacha 1	3.43
Garuri 2	13.27	Pirgacha 2	4.44
Sara	16.31	Kaunia 1	3.17
Gopalpur 1	12.03	Kaunia 2	6.97
Gopalpur 2	18.28	Gangachara	3.55
Ishurdi	20.06	Chandra 1	1.81
Ghior	16.25	Chandra 2	2.15
		Belabo 1	5.15
		Belabo 2	4.72

Table 7. Correlation coefficient (r) among the total As contents and the selected soil properties.

Soil properties	r values	
	Kushtia	Rangpur
Sand (%)	0.433^{NS}	0.226^{NS}
Silt (%)	0.566^{NS}	0.081^{NS}
Clay (%)	0.409^{NS}	0.674*
pH	0.007^{NS}	0.338^{NS}
Organic C (%)	0.030^{NS}	0.294^{NS}
Total N (%)	0.094^{NS}	0.076^{NS}
Exch. Ca (me %)	0.860*	0.513^{NS}
Exch. K (me %)	0.357^{NS}	0.121^{NS}
Exch. Na (me %)	0.476^{NS}	0.179^{NS}

* = Significant at 5% level of probability
NS = Not significant.

Particle size distribution (sand, silt and clay contents) showed variations in the soils of different soil series in Kushtia and Rangpur districts. The process that can contribute to these variations might be due to the redistributions of sand, silt and clay contents in the different sampling areas. The variations in the studied soils also might be due to the local differences in soil characteristics, changes in cropping systems (e.g. crop types, fertilization, irrigation, etc.) and other management practices in the farming communities.

Soil pH, organic carbon and total N contents in different surface soil series in Kushtia and Rangpur districts

The pH value, organic carbon and total N contents of the selected soil series are described in the study (Table 04). In Kushtia district, all the soil series were observed nearby in neutral condition and the range of pH values in Kushtia district are 6.69 to 7.49. Only Garuri 1 series were slightly acidic (pH value 6.69). In Rangpur district, all the soil series were observed in acidic in nature and the range of pH value in Rangpur district were 4.3 to 5.4. The organic carbon content in the soils of Kushtia district ranged from 0.58% to 1.76%. The highest value of organic carbon content in soil was found in Ghior soil series (1.76%). The organic carbon content in the soils of Rangpur district ranged from 0.59% to 1.25%. The highest value of organic carbon content was found in Chandra 2 soil series (1.25%). It was observed that the total nitrogen content in the soils of Kushtia district ranged from 0.084% to 0.140%. The highest value was found in Garuri 1 soil series (0.140%). In Rangpur district, the total nitrogen content ranged from 0.04% to 0.1%. The highest value was found in Kaunia 2 soil series (0.1%).

Soil pH, organic carbon and total N contents showed variations in the soils of different soil series in Kustia and Rangpur districts. The variations in pH values might be due to the differences of the farm management practices in the studied areas. The process that can contribute to these variations might be due to the redistributions of soil pH, organic carbon and total N contents in the different sampling areas. The variations in organic carbon and total N contents were mainly due to the use of organic manures during the farming activities (e.g. different farm manures and fertilizers, etc.). The variations in the studied soils also might be due to the local differences in soil characteristics, changes in cropping systems (e.g. crop types, fertilization, irrigation, etc.) and other management practices in the farming communities.

Exchangeable cation (Ca, K and Na) contents in different surface soil series in Kushtia and Rangpur districts

The exchangeable Ca, K and Na contents in the soils of Kushtia and Rangpur districts are described in the study (Table 5). The exchangeable Ca content in the soils of Kushtia district ranged from 15.00me% to 20.00me%. The highest value was found in Ghior soil series (20.00 me %). In Rangpur district, the exchangeable Ca content ranged from 0.48me% to 1.98me%. The highest value was found in Kaunia 1 soil series (1.98 me %).

The exchangeable K content in the soils of Kushtia district ranged from 0.41me% to 0.53me%. The highest value was found in Garuri 1 soil series (0.53 me %). In Rangpur district, the exchangeable K content ranged from 0.07me% to 0.24me%. The highest value was found in Pirgacha 1 soil series (0.24 me %). The exchangeable Na content in the soils of Kushtia district ranged from 1.33me% to 1.49me%. The highest value was found in Gopalpur and Ghior soil series (1.49 me %). In Rangpur district, the exchangeable Na content ranged from 0.06me% to 0.20 me%. The highest value was found in Kaunia 1 soil series (0.20 me %).

The exchangeable Ca, K and Na contents showed variations in the soils of different soil series in Kustia and Rangpur districts. The process that can contribute to these variations might be due to the redistributions of exchangeable Ca, K and Na contents in the different sampling areas. The variations in the exchangeable cation contents in different soils might be due to the differences in the farm management activities (e.g. fertilizations, etc.). The soils of Kushtia and Rangpur districts are represented the intensity of various actions of different processes under the tropical environment and the intensification of the overwhelming human activities. The variations in the studied soils also might be due to the local differences in soil characteristics, changes in cropping systems (e.g. crop types, fertilization, irrigation, etc.) and other management practices in the farming communities.

The findings of this study revealed that the natural biochemical activities played important roles in the soil texture (sand, silt and clay), soil pH, and contents of organic carbon, total N and exchangeable cations (Ca, K and Na). The study showed a wide variation in soil texture, organic carbon, total nitrogen and exchangeable cations (Ca, K and Na) within Kushtia and Rangpur districts. The soil characters might be due to the variations in the soil characteristics and management practices at the farm level.

Assessment of Arsenic Contents

General Arsenic contents in soil

The natural content of arsenic in soils is 5 mg/kg (Backer and Chesnin, 1975) or 6 mg/kg (Bowen 1979). Smith *et al.* (1998) reported a background arsenic level of 8 mg/kg for non-contaminated agricultural soils. The safe levels of arsenic in irrigation water, soils and foods are yet to be established for Bangladesh.

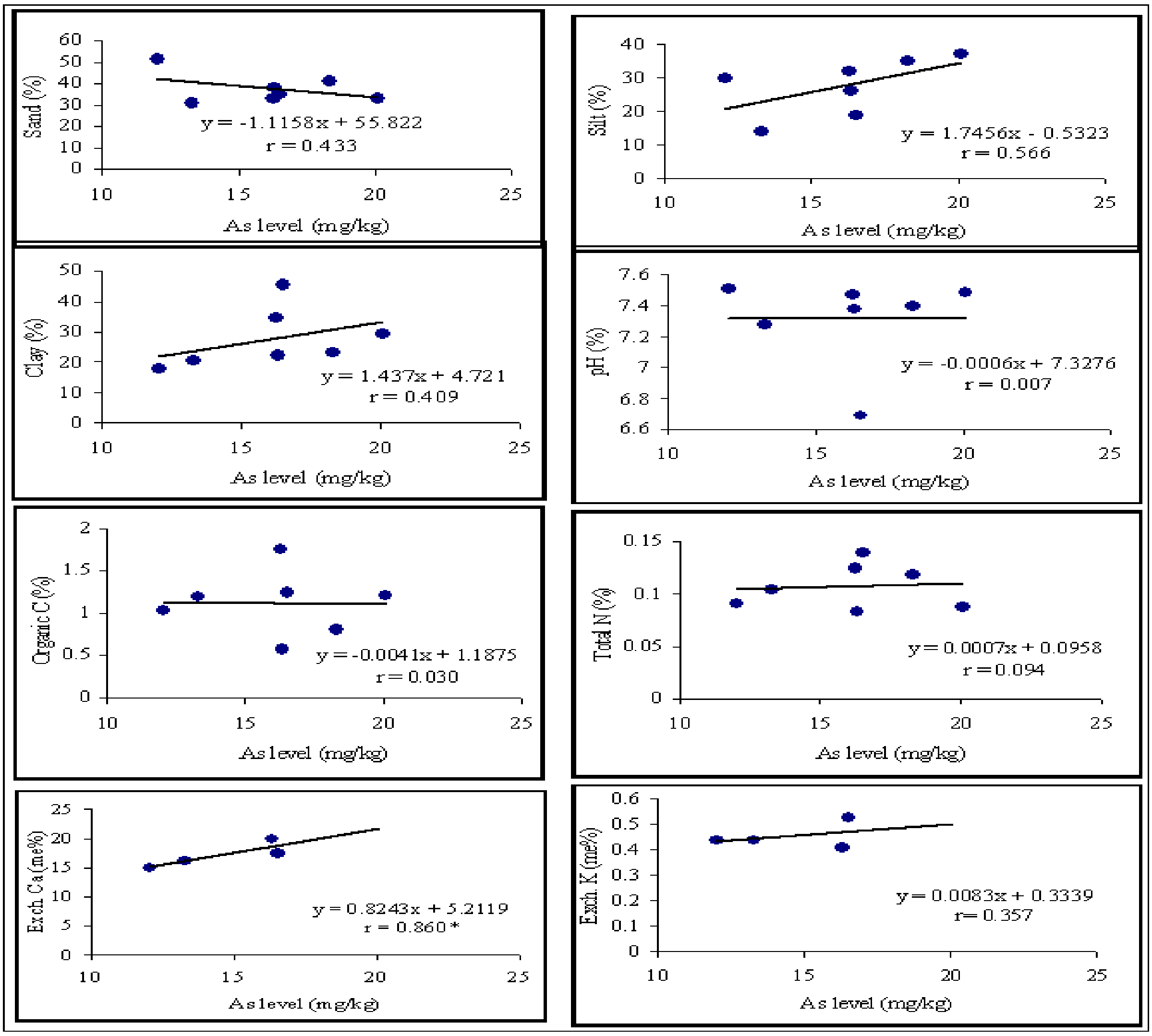

Fig. 3. Relationship between As distribution and selected soil properties in Kushtia district.

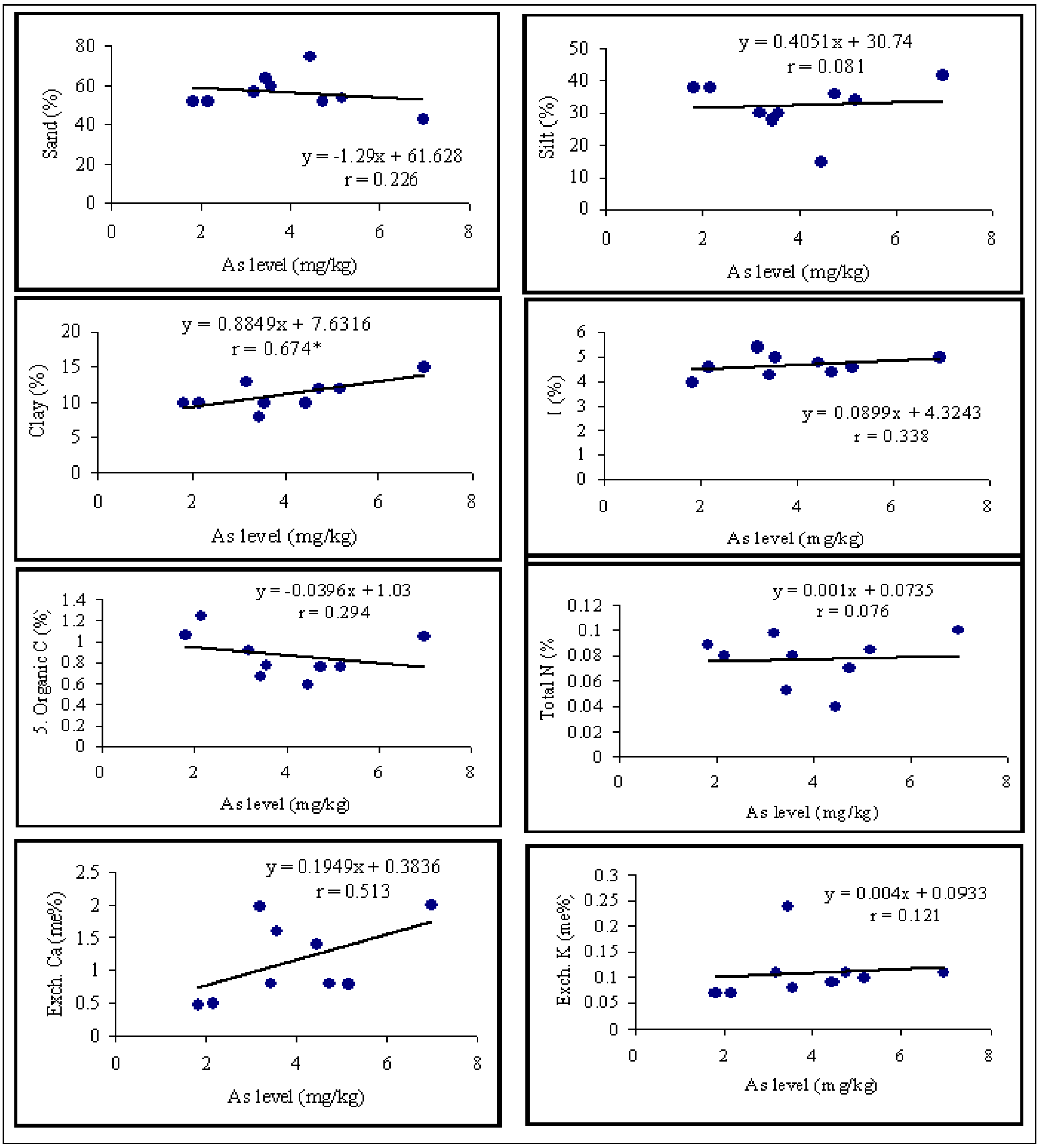

Fig. 4. Relationship between As distribution and selected soil properties in Rangpur district.

Arsenic contents of Kushtia and Rangpur districts

The arsenic contents of Kushtia district ranged from 12.03 mg/kg - 20.06 mg/kg, where all the soil series were highly contaminated (Table 06). The highest contaminated soil series in Kushtia district was Ishurdi (20.06 mg/kg). The lowest contaminated soil series in Kushtia district was Gopalpur 1 (12.03 mg/kg). In Rangpur district, the arsenic contents ranged from 1.81 mg/kg - 6.97 mg/kg, where all the soil series were non-contaminated. But according to Bowen (1979), Kaunia 2 (6.97 mg/kg) and Belabo 1 (5.15 mg/kg) soil series were slightly contaminated and Belabo 2 (4.72 mg/kg) soil series were also slightly contaminated according to Backer and Chesnin, 1975.

Comparison of total arsenic contents among the different soil series showed variations in Kushtia and Rangpur districts. The variations of the arsenic contents in the soils of different soil series might be associated with the local differences in parent materials (e.g. as-bearing minerals), farm management practices (e.g. use of arsenical pesticides), continental inputs (e.g. dry and wet deposition) and other biogeochemical activities.

Relationship between As distribution and soil properties

It has been reported that the soil composition such as sand, silt, clay contents, soil pH, organic carbon, total N and exchangeable cations (Ca, K, Na) are the major factors controlling trace elements in soils (Chen *et al.,* 1999). The variation in the As contents recorded in this study was, therefore, expected since the soils also varied considerably in the sand, silt, clay contents, soil pH, organic carbon, total N and exchangeable cations (Ca, K, Na) contents.

From the Table 07 it is found that, in Kushtia district, exchangeable Ca (r= 0.860*) was significant at 5% level of probability and other soil properties were not significant. It was observed that clay content (r= 0.674*) was significant at 5% level of probability in Rangpur district and other soil properties were not significant.

Conclusion

It can be concluded that in terms of the distribution of As in the soils of this study hold a clear benefit for the country. A clear difference in the As contents was observed in the soils of Kushtia and Rangpur districts probably due to the differences in the soil types, biogeochemical and farm management practices. The difference in the As contents of different soil series might be due to the variations in the landscape characteristics. In considering the present catastrophic ground water As contamination under the results of the soils of these two areas will play a significant role in Bangladesh. Routine research with wide public awareness, government participation and government regulations are essential for developing of safe and sound environment for the future.

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