

Contamination of Arsenic In Relation to Soil Properties of Mymensingh and Chuadanga Districts

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Abstract- An experiment was conducted during January 2015 to assess the present status of arsenic contamination and find out the relationship with soil properties and arsenic at Alamdanga upazila of Chuadanga district and Trishal upazila of Mymensingh district. Arsenic contamination and its relationship with soil properties (e.g. soil pH, total organic matter, total N, available P, available S, Exch. Ca, Exch. K and Exch. Na) of Alamdanga upazila and Trishal upazila were studied in the Soil Science laboratory at Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. Arsenic contents of Alamdanga upazila ranged from 8.81 – 16.26 mg/kg and at Trishal upazila ranged from 6.58 – 9.16 mg/kg. Neutral acidic condition was observed at Alamdanga upazila (6.45 to 7.62) range where at Trishal upazila soil samples were slightly acidic in nature (6.38 to 6.69) range. Organic matter content in the soils of Alamdanga upazila ranged from 0.83 to 1.10%; Trishal upazila organic matter ranged from 1.23 to 2.06%. Total nitrogen content at the soils of Alamdanga upazila ranged from 0.07 to 0.09% where at Trishal upazila total nitrogen content ranged from 0.076 to 0.104%. Negative significant relationship was found with organic matter content and total nitrogen with As at Trishla upazila soil. At Alamdanga upazila available P content (12.1 to 17.3) range, available S (11.3 to 17.6 ppm) range; Trishal upazila available P content (5.76 to 8.5 ppm) range, available S contents (11.3 to 17.6 ppm) range. Positive significant relationship with As and available P were observed at Alamdanga upazila soil. Exchangeable Ca content (9.80 to 14.20me %) range, exchangeable K (0.20 to 0.42me %) range and exchangeable Na content (1.10 to 1.43me %) range were found at Alamdanga upazila where exchangeable Ca content (6.57 to 15.66me %) range, exchangeable K contents (0.06 to 0.08me %) range and exchangeable Na contents (0.23 to 0.25me %) range were found at Trishal upazila. Positive significant relationship was found among exchangeable Ca and exchangeable K with arsenic contents of Trishal upazila soil sample.

I. INTRODUCTION

Arsenic in groundwater was recognized as a potential threat to human life, much effort has been directed to ensure the safe drinking water either through mitigation techniques or through finding another water sources but the continuation of cropping of long-term irrigated soils subjected to As contaminated ground water will pose significant risk to animal and human health through soil-crop transfer of As. The As

concentration in soil varies widely because it depends on the initial concentration (background) in parent material, natural geochemical cycles and soil types (Díez et al. 2007); therefore, the mean values of As in natural soils, according to the literature, range between 0.1 and 80 mg kg⁻¹ worldwide (Alloway 1995; Adriano 2001; Bohn et al. 2001; Kabata-Pendias and Mukherjee 2007). The main soil properties affecting As availability are as follows: Fe oxides, pH, calcium carbonate, clay content, cation-exchange capacity and organic matter content (Lock and Janssen 2001; Smolders et al. 2003, 2004; Rooney et al. 2006; Song et al. 2006).

Arsenic in irrigation water can result in land degradation, adversely affecting incomes and agro-ecosystem services in terms of their ability to provide a sustainable source of sufficient and safe foods. Rice can contribute significantly to the total daily intake of inorganic As through water and foods in Bangladesh because of the high rice consumption and relatively high levels of inorganic As in rice. The present work evaluates the influence of different soil properties and constituents on As solubility in soils, with the aim of assessing the toxicity of this element for studies of environmental risk assessment in soil contamination.

MATERIALS AND METHODS

The methods and procedures are following and conducting this study has been presented in this chapter with a conceptual frame work. Study was initiated for the assessment of arsenic and other soil properties eg. (soil pH, organic matter, total N, exchangeable cations (Ca⁺⁺, K⁺ and Na⁺), available P and available S contents status of Alamdanga upazilla og Chuadanga districts and Trishal upazilla of Mymensingh districts whether the soils have undergone any contamination.

3.1 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. 0.5 gram of air-dried soil samples were taken in a glass bottle for oven drying. After oven drying at 50⁰ C for 24 hours, all the samples were crushed and made into a fine homogenous powder within approximately 12 minutes using an agate mortar and a pestle. The agate mortar and pestle were cleaned with ethanol to ensure that the trace metal contamination did not originate from the grinding process.

3.2 Methods of analysis:

3.3.1 Soil pH:

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)

3.3.2 Organic carbon:

Organic carbon was determined titrimetrically by Walkley 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).

3.3.3 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 : $CuSO_4 \cdot 5H_2O$: 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).

3.3.4 Available P:

Available P was extracted from the soil by shaking it with 0.5 M $NaHCO_3$ solution at pH 8.5 following Olsen method (Olsen *et al.*, 1954). The extracted P was determined by $SnCl_2$ reduction of phosphomolybdate complex and measuring the intensity of color spectrophotometrically at 660 nano meter.

3.3.5 Available S:

Available S content of soil was determined by extracting the soil sample with $CaCl_2$ solution (0.15%). The S content in the soil extract was estimated turbidimetrically with spectrometer at 420 nano meter wavelength.

3.3.6 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%.

3.4 Analysis of arsenic:

3.4.1 Reagents:

All reagents were of analytical reagent grade. Distilled deionized water was used throughout. Standard solutions were prepared by dissolving appropriate amounts of As_2O_3 (Merck, Germany), standard arsenic (V) Titrisol (Merck, Germany), $CH_3AsO_3Na_2 \cdot 6H_2O$ (Carlo-Erba, Italy) and $(CH_3)_2AsO_2Na \cdot 3H_2O$ (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) $Mg(NO_3)_2 \cdot 6H_2O$ and 1% (w/v) MgO in water until homogenous. 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.

3.4.2 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 $30^{\circ}C$ 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.*, 1999).

II. RESULTS AND DISCUSSION

Research results with regards to evaluate the soil properties (soil pH, organic matter, total N available P available S contents and exchangeable cations Ca^{++} , K^+ and Na^+), for the assessment of arsenic contamination and find out the relationship between soil properties with arsenic contamination at Alamdanga and Trishal Upazila.

4.1 General characteristics of soil

4.1.1 Soil pH, organic matter and total N contents at surface soils (0-10cm) of Alamdanga and Trishal Upazila

Soil pH value, organic carbon and total N contents of the selected soil series were illustrated at Table 3 for Alamdanga and Table 4 for Trishal Upazila.

Neutral acidic conditions were observed at Alamdanga Upazila which ranged from 6.45 to 7.62 except Hardi soil samples were slightly acidic (pH value 6.45). Trishal Upazila soil samples were slightly acidic in nature and ranged from 6.38 to 6.69.

Organic matter content in the soils of Alamdanga Upazila ranged from 0.83 to 1.10%. Hardi soil sample 1.10% has highest

value of organic matter content. At Trishal Upazila Organic matter ranged from 1.23 to 2.06% and highest value organic matter content were found at Kazirshimla soil sample 2.06%.

It was synthesized that the total nitrogen content in the soils of Alamdanga Upazila ranged from 0.07 to 0.09% and highest value were found at Gangni soil sample 0.09%. Total nitrogen content ranged from 0.076% to 0.104% at Trishal Upazila has highest value were found at Dulalbari soil sample 0.104%.

Table 1 Soil pH, total N and Organic matter contents at surface soil (0-10 cm) of Alamdanga Upazila.

SL. No.	Location	pH	Total N (%)	OM (%)
1	Khadimpur	7.26	0.07	0.97
2	Gangni	6.45	0.09	1.14
3	Bardi	7.39	0.07	1
4	Belgachi	7.05	0.07	0.83
5	Dauki	7.57	0.07	1.03
6	Bhangabaria	7.57	0.08	1.07
7	Hardi	7.62	0.08	1.1

Table 2 Soil pH, total N and Organic matter contents in surface soil (0-10 cm) of Trishal Upazila.

SL. No.	Location	pH	Total N(%)	OM (%)
1	Kanhor	6.67	0.076	1.23
2	Kzirshimla	6.62	0.087	2.06
3	Voradoba	6.69	0.095	1.89
4	Boilor	6.61	0.08	1.66
5	Mathbaria	6.66	0.098	1.89
6	Bashkuri	6.69	0.091	1.49
7	Dulalbari	6.38	0.104	2.04

4.1.2 Available P and Available S content at surface soils (0-10cm) of Alamdanga and Trishal Upazila

Available P and available S contents at the soils of Alamdanga Upazila were visualized respectively at the Figure 3 and Figure 4 and that of Trishal Upazila were at the Figure 5 and Figure 6

Available P content at Alamdanga Upazila ranged from 12.1 to 17.3 ppm where highest values were found at Bardi soil

sample 17.3 ppm. Trishal Upazila available P content were ranged from 5.76 to 8.51 ppm and Boilor soil sample 8.51 ppm has highest value of available P.

Available S contents at the soils of Alamdanga Upazila ranged from 11.3 to 17.6 ppm where Hardi 17.6 ppm soil sample has highest value of available S. Trishal Upazila Available S ranged from 3.1 ppm to 15.28 ppm and highest value of available P was found at Boilor soil sample 15.28 ppm.

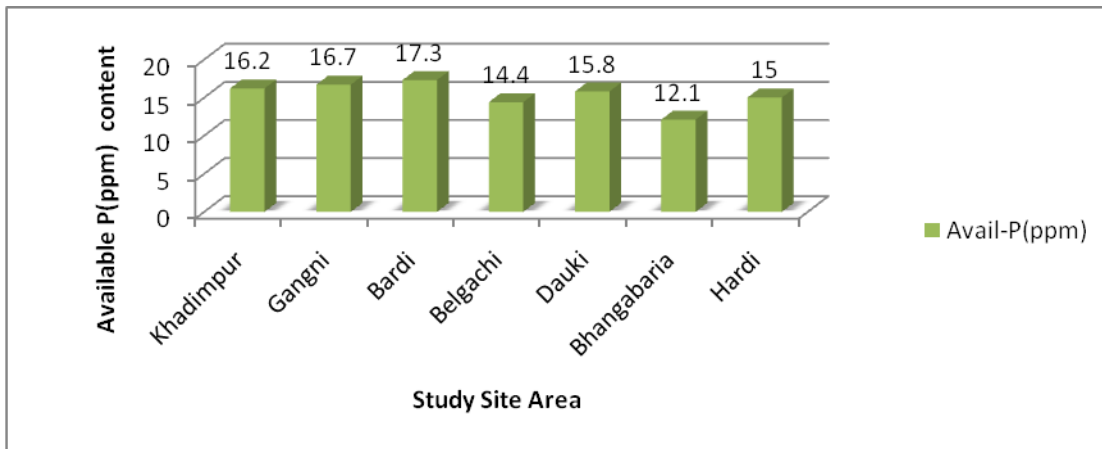


Figure 1 Available P content at surface soil (0-10 cm) of Alamdanga Upazila.

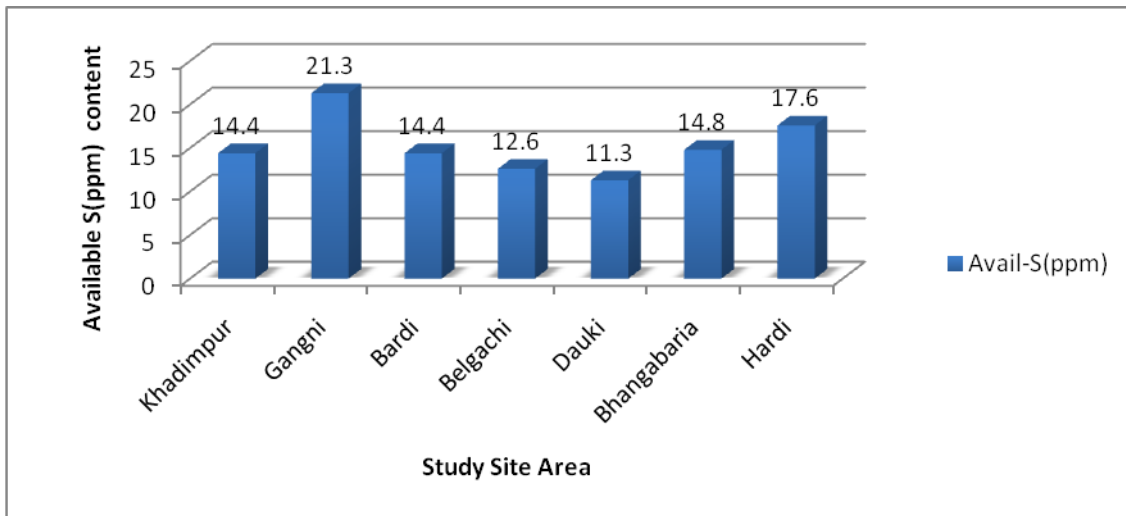


Figure 2 Available S content at surface soil (0-10 cm) of Alamdanga Upazila.

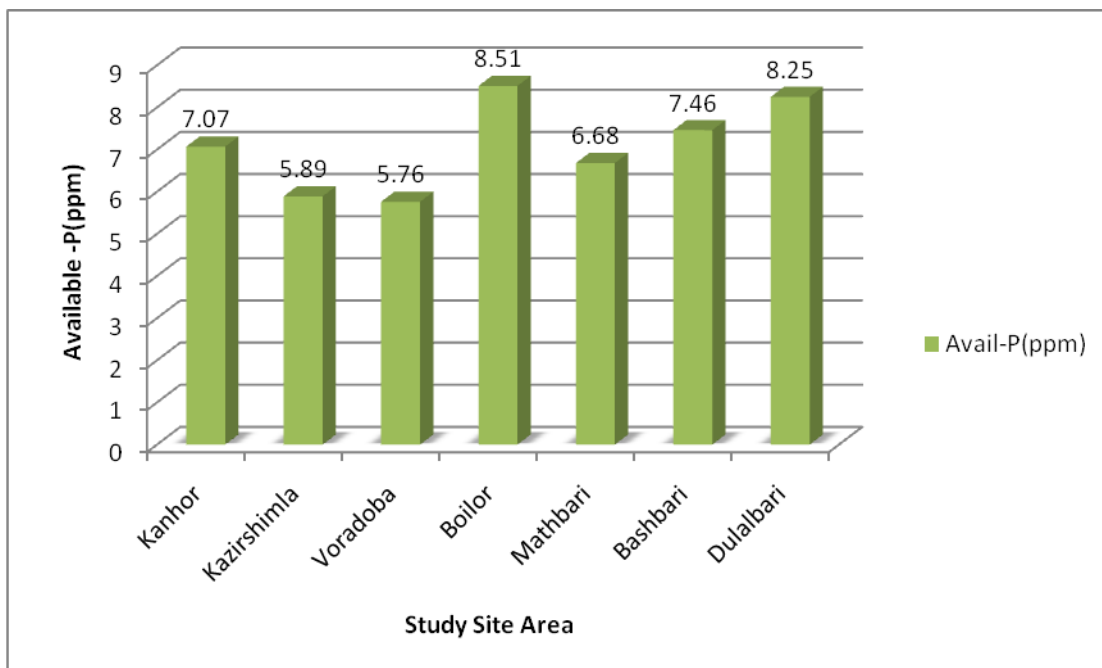


Figure 3 Available P content at surface soil (0-10 cm) of Trishal Upazila.

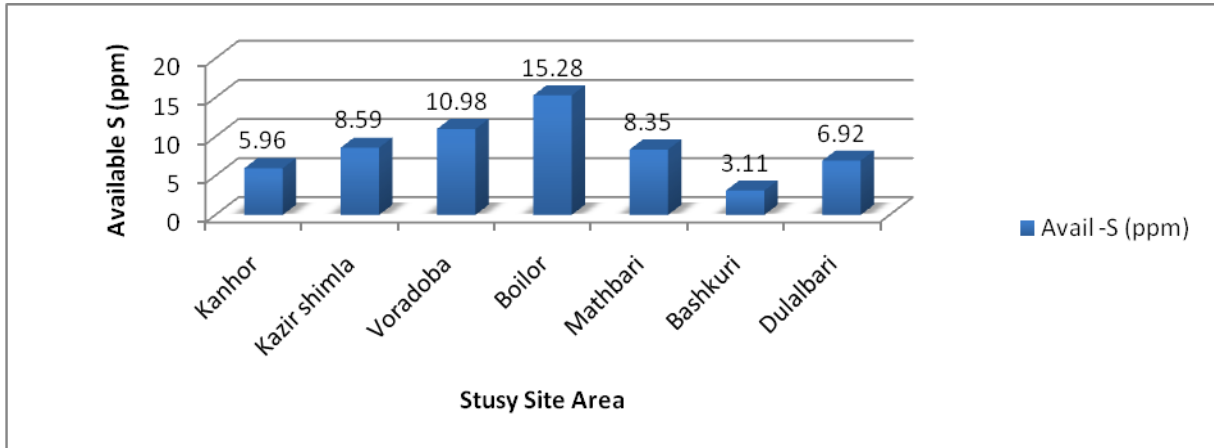


Figure 4 Available S content at surface soil (0-10 cm) of Trishal Upazila.

4.1.3 Exchangeable cation (Ca, K and Na) contents at surface soils (0-10cm) of Alamdanga and Trishal Upazila

Exchangeable Ca, K and Na contents in the soils of Alamdanga Upazila and Trishal Upazila were represented respectively at the study Table 5 and Table 6 Exchangeable Ca content at the soils of Alamdanga Upazila ranged from 9.80 to 14.20me % and highest value were measured at Gangni soil sample 14.2me %. Trishal Upazila exchangeable Ca content ranged from 6.57 to 15.66me% and Boilor soil sample 15.66me

% has highest value. Exchangeable K content at Alamdanga Upazila ranged from 0.20 to 0.42me % and highest values were identified at Gangni soil sample 0.42me %. At Trishal Upazila the exchangeable K content ranged from 0.06 to 0.08me %. Exchangeable Na content at Alamdanga Upazila ranged from 1.10 to 1.43me% where highest value was measured at Gangni soil sample 1.43me%. Trishal Upazila exchangeable Na content ranged from 0.23 to 0.25me %.

Table 3 Exchangeable cation (Ca, K and Na) contents at surface soil (0-10 cm) of Alamdanga Upazila.

SL. No.	Location	Exch. Ca (me%)	Exch. K(me%)	Exch. Na(me%)
1	Khadimpur	13.1	0.25	1.33
2	Gangni	14.2	0.42	1.43
3	Bardi	10.5	0.35	1.2
4	Belgachi	9.8	0.4	1.25
5	Dauki	11.5	0.2	1.1
6	Bhangabaria	13.4	0.36	1.4
7	Hardi	11.2	0.3	1.39

Table 4 Exchangeable cation (Ca, K and Na) contents at surface soil (0-10 cm) of Trishal Upazila.

SL. No.	Location	Exch. Ca(me%)	Exch. K(me%)	Exch. Na(me%)
1	Kanhor	8.23	0.08	0.25
2	Kzirshimla	6.68	0.07	0.23
3	Voradoba	7.05	0.06	0.25
4	Boilor	15.66	0.08	0.24
5	Mathbaria	7.35	0.08	0.24
6	Bashkuri	6.75	0.06	0.25
7	Dulalbari	6.57	0.06	0.25

4.2 Assessment of Arsenic contents

4.2.1 General Arsenic contents in soil

There are no federal regulations limiting soil As levels in the USA. However, the US Environmental Protection Agencies (EPA) superfund risk model gives a value of 0.43 ppm total soil As for a cancer risk of 1 in 106 for exposure by soil ingestion. This has created an interesting situation for regulation of soil As by individual States as the average background As level in USA soils is ~ 5 ppm. State standards for remedial action vary tremendously, but many require this when soil As is above the natural background, which is often less than 10 ppm. Background soil As levels have been shown to vary with soil type (Chen et al., 2002), which is sometimes considered in evaluations of soil contamination. Soil As standards in other countries (Canada, UK, Netherlands, Australia) are generally in the 10-20 ppm range for agricultural use of soils. Total soil As in the top 15 cm of Bangladesh soils was above 10 ppm for 48% and 65% of the 456 sites in the 2002 US-AID study and 161 sites in Shah et al. (2004), but it is clear that there is cause for concern from both agricultural sustainability and human health perspectives. The safe levels of arsenic in irrigation water, soils and foods are yet to be established for Bangladesh.

4.2.2 Arsenic contents at surface soils (0-10) of Alamdanga and Trishal Upazila

Arsenic contents of Alamdanga Upazila ranged from 8.81 – 16.26 mg/kg, where all soil samples were contaminated and the details data were showed in Figure 7. Highest As contents value was found at Hardi soil sample 16.26 mg/kg where lowest arsenic contents were found at Bhangabaria soil sample 8.81 ppm at Alamdanga Upazila. At Trishal Upazila arsenic contents ranged from 6.58–9.16 mg/kg, where all the soil sample were slightly contaminated and details data were showed in Figure 8 where the highest value of As contamination were found at Boilor 9.16 mg/kg lowest contaminated soil sample was observed in Mathbari 8.81 mg/kg.

Comparison of total arsenic contents among the different soil location showed variations at Alamdanga Upazila and Trishal Upazila. 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.

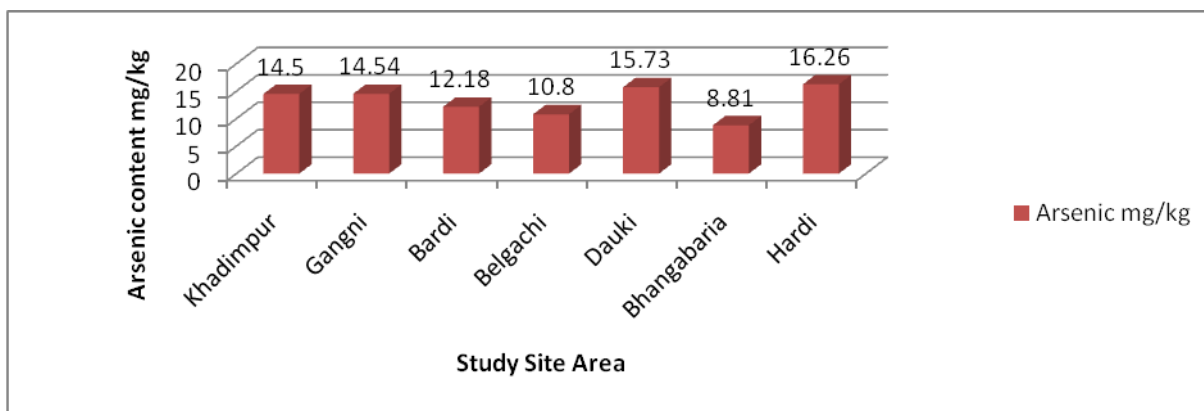


Figure 5 As content at surface soil (0-10 cm) of Alamdanga Upazila.

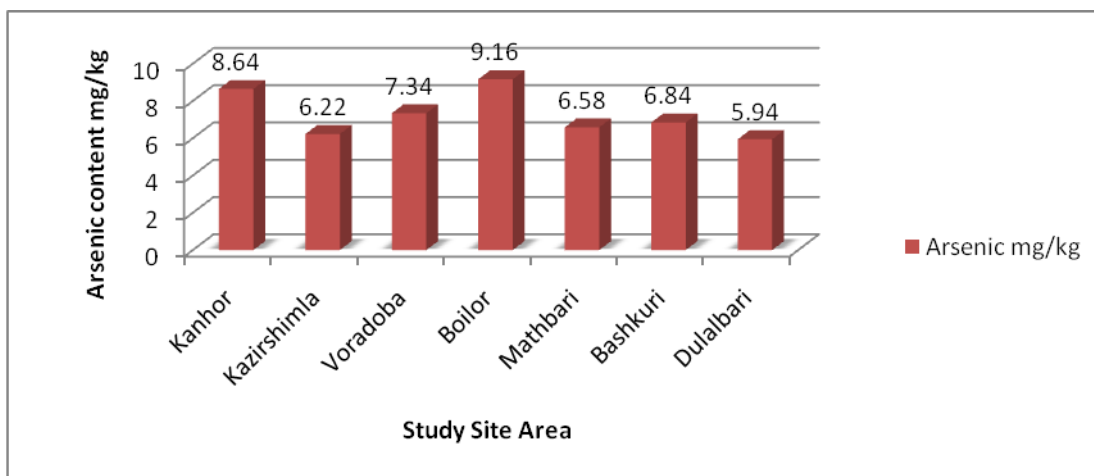


Figure 6 As contents at surface soil (0-10 cm) of Trishal Upazila.

4.2.3 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, available S, available P and exchangeable cations (Ca, K, Na) are the major factors controlling trace elements in soils (Chen et al., 2008). 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, available S, available P and exchangeable cations (Ca, K, Na) contents.

Table 5 Correlation coefficient (r) among the total As contents and the selected soil properties.

Soil properties	r values	
	Alamdanga	Trishal
pH	-0.02835 ^{NS}	0.393591 ^{NS}
Organic OM (%)	0.370442 ^{NS}	-0.69594*
Total N (%)	0.085575 ^{NS}	-0.8116*
Avail -P (ppm)	0.611835*	0.305898 ^{NS}
Avail -S (ppm)	0.24479 ^{NS}	0.486246 ^{NS}
Exch. Ca (me %)	0.05007 ^{NS}	0.790737 *
Exch. K (me %)	-0.54795 ^{NS}	0.580288*
Exch. Na (me %)	-0.11714 ^{NS}	0.138998 ^{NS}

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

4.3 Comparison of the soil properties in relation to As contamination in Alamdanga and Trishal Upazila

4.3.1 Soil pH, organic carbon and total N contents

Between pH value and arsenic contamination no significant relationship were found. Reza et al. (2010) identify that organic matter are the major leachable solids carrying As. Organic matter content in the soils of Alamdanga Upazila ranged from 0.83 to 1.10% and Trishal Upazila ranged from 1.23 to 2.06%. Result suggested that Trishal Upazila soils were enriched with Organic Matter. Natural organic matter is a prevalent constituent of natural waters, is highly reactive toward both metals and surfaces and is thus a clear candidate to influence arsenic mobility (McArthur et al., 2004). Arsenic contents in sediments positively correlated organic matter (Han et al., 2013) but in the surface soil a negative significant relationship were found between As contamination and the organic matter contents at Trishal Upazila soil sample (Figure 9)

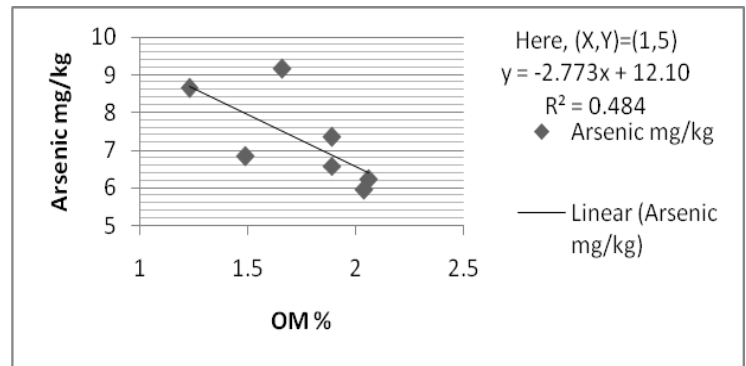


Figure 7 Relationship between As contamination and OM % at Trishal Upazila.

Total nitrogen content at Alamdanga Upazila ranged from 0.07 to 0.09% and Trishal Upazila 0.076 to 0.104%. Total N content at Trishal Upazila are higher than the Alamdanga Upazila. Microbial biomass C and N were significantly ($P < 0.05$) lower in contaminated than uncontaminated soils (Bardgett et al., 1994). As contamination and the total N (%) contents of Trishal Upazila soil samples showed negative significant relationship with arsenic contamination (Figure 10)

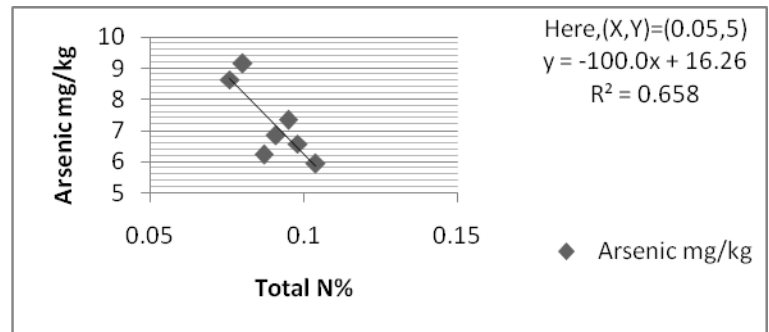


Figure 8 Relationship between As contamination and Total N (%) at Trishal Upazila.

4.3.2 Available P and Available S content

Concentration of silica and phosphate compete with arsenite and arsenate respectively during uptake by plants (Sahoo and Mukherjee, 2014). Available P content at Alamdanga Upazila ranged from 12.1 to 17.3ppm and at Trishal Upazila ranged from 5.76 to 8.51 ppm. Result showed that the amount of Available P at Alamdanga Upazila was higher than the Trishal Upazila. Arsenic concentrations in the roots of *U. dioica* were negatively correlated with concentrations of arsenic in the soil and positively correlated with phosphorus in the soil. Effects of arsenic on plants will therefore depend on the amount of phosphorus available in the soil (Otte et al., 1990). Positive significant relationship were observed between As contamination and the available P content of Alamdanga Upazila soil sample (Figure 11)

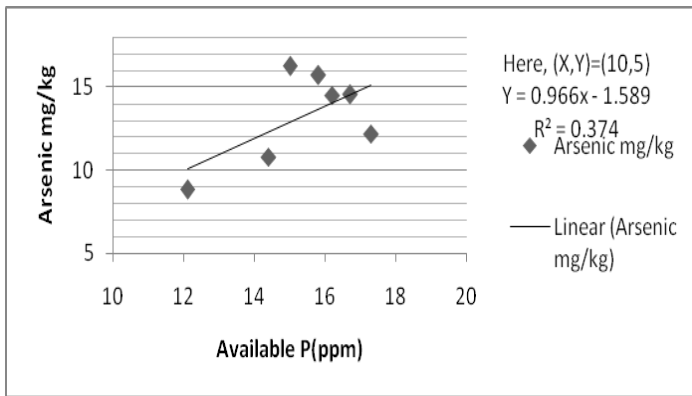


Figure 9 Relationship between As contamination and available P at Alamdanga Upazila.

Available S contents at Alamdanga Upazila ranged from 11.3 to 17.6 ppm and Trishal Upazila ranged from 3.11 to 15.28 ppm. Between available S and As contamination no significant relationships were found at Alamdanga and Trishal Upazila soil sample. The combined increase of P and S in the nutrient solution did not lead to higher accumulation of As, but enhanced As translocation from the root to the shoot (Grifoni et al., 2014).

4.3.3 Exchangeable cation (Ca, K and Na) contents in different surface soil series in Alamdanga and Trishal Upazila

Exchangeable Ca content in Alamdanga Upazila ranged from 9.80 to 14.20 me% and at Trishal Upazila 6.57 to 15.66 me%. Positive significant relationships were identified between As contamination and the Exchangeable Ca content of Trishal Upazila soil sample (Figure 12)

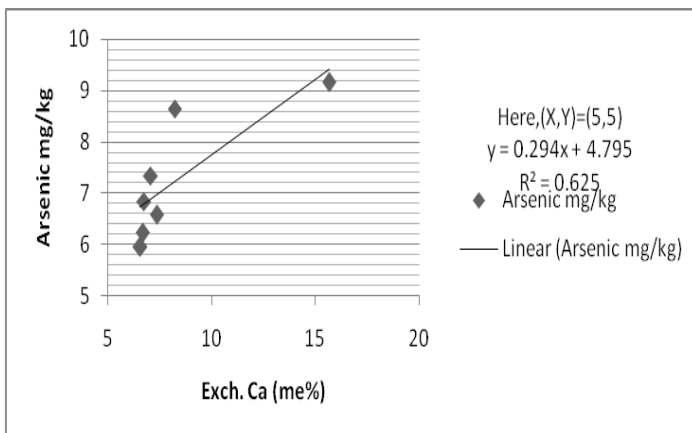


Figure 10 Relationship between As contamination and Exch. Ca in Trishal Upazila.

Exchangeable K content in the soils of Alamdanga Upazila ranged from 0.20 to 0.42 me% and at Trishal Upazila ranged from 0.06 to 0.08me%. Positive significant relationships were found between As contamination and the Exchangeable K content of Trishal Upazila soil samples (Figure 13).

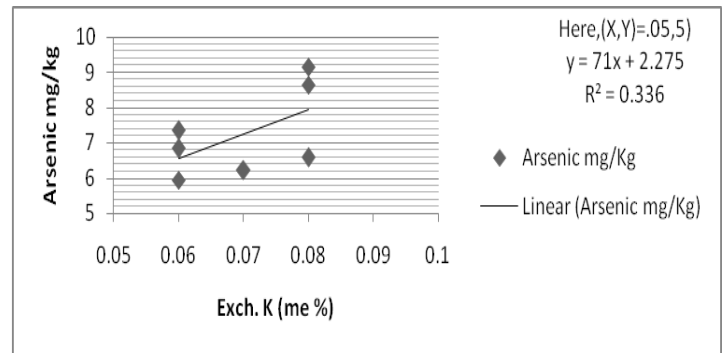


Figure 11 Relationship between As contamination and Exch. K at Trishal Upazila.

Exchangeable Na content in the soils of Alamdanga Upazila ranged from 1.10 to 1.43 me% at the Trishal Upazila exchangeable Na content ranged from 0.23 to 0.25 me%. No significant relationships were found between As contamination and Exchangeable Na at both Upazila.

Soil pH, organic matter, total N available P, available S and exchangeable Ca, K and Na contents showed variations in the soils of different soils of Alamdanga Upazila and Trishal Upazila. The process that can contribute to these variations might be due to the redistributions of particle size distribution (sand, silt and clay), soil pH, organic matter, total N, available P, available S and exchangeable Ca, K and Na contents in the different sampling areas. Variations in the e different soils might be due to the differences in the farm management activities (e.g. fertilizations, etc.). The soils of Alamdanga Upazila and Trishal Upazila 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 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) with Alamdanga Upazila and Trishal Upazila. The soil characters might be due to the variations in the soil characteristics and management practices at the farm level.

III. SUMMARY AND CONCLUSION

With this study and others findings it is apparent that arsenic contamination are present at surface soils (0-10 cm), which are dependent on geological and anthropogenic factors, more research is needed on how arsenic moves through ground water systems and contaminated the soil within different areas of Bangladesh. Whether the variation in the soil properties are influences the differences in arsenic concentration in surface soil (0-10 cm) is still an open question. If answered, it can likely assist government, NGOs and communities in addressing the arsenic problem at a much greater scale than at present.

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