

Investigation of Vertical Distribution of Soil Elements at Central Part of Bangladesh Using Neutron Activation Analysis

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Abstract-Soil is a mixture of minerals, plant and animal materials formed during a long process that may take thousands of years. The trace elements in soil are very important in aspects of both soil and environmental quality as well as the geological purposes. The soil and sediments have been extracted in the undisturbed state from Singair Upazila, Manikgonj district, Bangladesh; each of them extending from 1.5 feet (0.46m) up to about 27 feet (8.23m) of depth. The drilling cores were executed by wash borings method which were mainly composed of silty clay, very fine silty sand, fine to very fine sand, fine to medium sand and fine sand with mica layers at different depths. Nuclear reactor based Instrumental Neutron Activation Analysis (INAA) method has been used for analysis of concentrations of various trace elements in subsurface soil and sediments at various depths. Although the mean, median and standard deviation of trace elements concentration from the two study sites soil samples demonstrate same distribution characteristics of soil, but the analytical results of selected borehole sediment samples of contaminated areas shows that the vertical distributions of arsenic and iron do not follow any regular or particular pattern. They are randomly distributed over all layers and the correlations coefficients [$R^2 = 0.6568$ (n=16), $R^2 = 0.4668$ (n=18)] between total arsenic and iron in the core sediments are significant. Furthermore, a highly significant correlation was observed between Fe-Mn, Cr-Fe, Cr-Sc and Sc-Fe which indicates that they are closely associated with each other and variation in concentrations of one can influence the concentration of others.

Keywords- Investigation; Trace Elements; Neutron Activation Analysis, Correlation Analysis

I. INTRODUCTION

Bangladesh, the world's biggest delta landscape, is very small compared to the large population. Although the country does not have much forest, it is still lush green and is noted for its unique landscape. It is not surprising that the land and soil suffer numerous threats in sustaining their fertility and quality. Due to catering for the exploiting population agricultural production is intensified to radical frontier. In this struggle for food self-sufficiency, nutrient mining is a major concern. At the same time, diverse land usage is removing land from agriculture to other uses like industrial and social infrastructures. In addition, production of waste products from different sources and their careless

disposal into agricultural land and water bodies are becoming another major burning question.

In many countries researches on the base line concentrations of trace elements in soils have been conducted from the earlier periods. For instance, in USA, researches have been conducted to provide a reliable data base on concentrations of trace metals in soils. This is necessary for the regulators to specify the maximum metal concentration in wastes for land application. Similarity, Norway, France, Poland, China, Japan, India and many other developed countries have their own data base. Unfortunately, existing data on baseline concentrations of trace elements in soils of Bangladesh are inadequate for determining the issue of cleaning up the polluted soils.

Trace elements find their way into humans and animals either by direct absorption via air and drinking water or the food chain. Plants absorb trace elements either via the root system or foliar absorption. Whenever the trace elements have abnormally low or high-level of concentration in soil, have an adverse effect on environment.

Realizing the importance, an attempt has been made to perform the following studies: i) to determine the amount of arsenic and other trace elements in the soils and sediments collected from the surface to various depths of Singair Upazila (Manikganj district, Bangladesh) using INAA technique; ii) to find a correlation of arsenic with other trace elements. Correlation analysis has been used to identify the source and the relations of common geogenic origin among the measured elements, to examine the possible relationships, to measure the variation in concentration of each other, etc. Throughout the study, the baseline data of the elemental status of the study area will be created that will help to find out the geological origin of arsenic contamination of our ground water. The application of INAA technique ensures the production of quality baseline data as the method is treated a 'referee method' to check the accuracy of other analytical methods worldwide especially for solid sample analysis. The INAA is treated as a referee method due to the simplicity of sample preparation,

capability of analysis solid sample (no chemical treatment or decomposition of sample is required like AAS, ICP-MS, etc.) simultaneous multielement determination capability, nearly matrix independent characteristics. However, as NAA involved radioactive decay turn around time is comparatively higher than other chemical methods for long-lived elements.

II. STUDY VICINITY

Singair Upazila (Manikganj district, Bangladesh) with an area of 217.38 sq km, is bounded by Dhamrai and Manikganj Sadar Upazilas on the north, Nawabganj (Dhaka) Upazila on the south, Savar and Keraniganj Upazilas on the east, Manikganj Sadar Upazila on the west. Main rivers are the Dhaleshwari, Ghazikhali and Kaliganga in Fig. 1 [3]. The study areas of Bakchor and Panishain villages of Singair Upazila under Manikgonj district are chosen as they seem to be arsenic affected. The INAA is a good choice to analyze soils and sediments. So to realize the necessity of the point, this work has been done using the 3 MW TRIGA Mark-II research reactor in the Institute of Nuclear Science and Technology (INST), Atomic Energy Research Establishment (AERE), Savar, Dhaka.

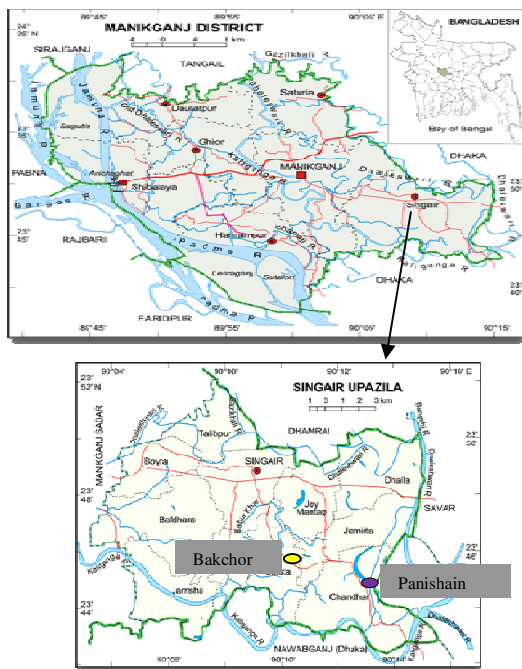


Fig. 1 Study area in Bakchor and Panishain villages of Singair Upazila under Manikgonj district of Bangladesh (Source: Ref [3])

III. EXPERIMENT

A. Boring Execution and Sample Collection

In the study area, two borings (one is up to 24 feet or 7.32 m and another is up to 27 feet or 8.23 m, distance between these two is about 1 Km) were executed in the field by the technical assistance of the consulting firm. The method of wash borings was followed in drilling the boreholes after driving the casing pipe in Fig. 2



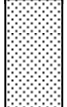
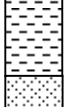
Fig. 2 Sample collection by wash borings drilling method

The soil samples in the undisturbed state have usually been extracted from each of the 1.5 feet (0.46 m) depth up to the depth of the investigation, along with the performance of the Standard Penetration Test (SPT). The SPT includes dropping of a hammer weighting 63.5 kg (140 lb) and falling freely over a constant height of 30 inch along the drill pipe in order to drive the sampler attached at the end of the same. The SPT blow count value and bore logs descriptions are shown in Tables I and II, against the respective interval of depth.

TABLE I BORE LOG DESCRIPTION IN SOIL OF BH-1

Bore hole Log-1 D: 23/03/08, Time: 1pm Vill : Bakchor Thana : Singair Dist : Manikgonj			
Boring Depth (ft)	Litho Symbol	Color	Lithology
0-1.5		Brown	Silty Clay
1.5-3		Brown	Silty Clay
3-4.5		Gray	Silty Clay
4.5-6		Gray	Silty Clay
6-7.5		Gray	Silty Clay
7.5-9		Gray	Silty Clay
9-10.5		Gray	Silty Clay
10.5-12		Gray	Silty Clay
12-13.5		Gray	Silty Clay
13.5-15		Gray	Silty Clay
15-16.5		Gray	Silty Clay
16.5-18		Gray	Silty Clay
18-19.5		Gray	Very fine silty sand
19.5-21		Gray	Fine to very fine sand
21-22.5		Gray	Fine to medium sand
22.5-24		Gray	Fine to medium sand

TABLE II BORE LOG DESCRIPTION IN SOIL OF BH-2

Bore hole Log-2 D: 24/03/08, T: 11.55 am. Vill : Panishain Thana : Singair Dist : Manikgonj Chandonpur Govt. Primary School			
Boring Depth (ft)	Litho Symbol	Color	Lithology
0-1.5		Brown	Silty clay
1.5-3		Gray	Silty clay
3-4.5		Gray	Silty clay
4.5-6		Gray	Silty clay
6-7.5		Gray	Silty clay
7.5-9		Gray	Silty clay
9-10.5		Gray	Silty clay
10.5-12		Gray	Silty clay
12-13.5		Gray	Silty clay
13.5-15		Gray	Very fine silty sand
15-16.5		Gray	Very fine silty sand
16.5-18		Gray	Very fine silty sand
18-19.5		Gray	Fine to very fine sand
19.5-21		Gray	Fine to very fine sand
21-22.5		Gray	Fine to medium sand
22.5-24		Gray	Fine to medium sand
24-25.5		Gray	Fine sand with mica
25.5-27		Gray	Fine sand with mica

B. Sample Preparation

Soil samples were weighted, cleaned and dried in an oven at 70°C until having constant weight. The dried soil samples were gently ground and homogenized in an agate mortar and stored as stock sample. From the stock sample about 100 mg was packed into ultra clean irradiation type small polyethylene envelopes and then heat shield in Fig. 3.



Fig. 3 Samples were packed and prepared to transfer in a vial before irradiation

The standard reference material (SRM) IAEA-SL-1, IAEA Soil-7 and NIST coal fly ash (1633b) were taken into the same kind of ultra clean polyethylene irradiation envelopes of same size and their weight were determined. Two sets of samples and standards were prepared. For the

first set, soil samples of 16 numbers together with the standard references were packed into four layers inside the high density polyethylene irradiation tube in such a way that the first layer consisted of four samples, second layer consisted of one sample and three standards; each of third and four layers consisted of four samples. In order to monitor the neutron flux gradient within the sample stack, foils of IRMM Al-0.1%Au were placed at the top, bottom and in the middle position of the stack in Fig. 4 (A set). For the second set, 24 soil samples together with the standard references were packed into four layers in such a way that each of the first, second and fourth layer was consisted of six samples, third layer consisted of three samples and three standards in Fig. 4 (B set).

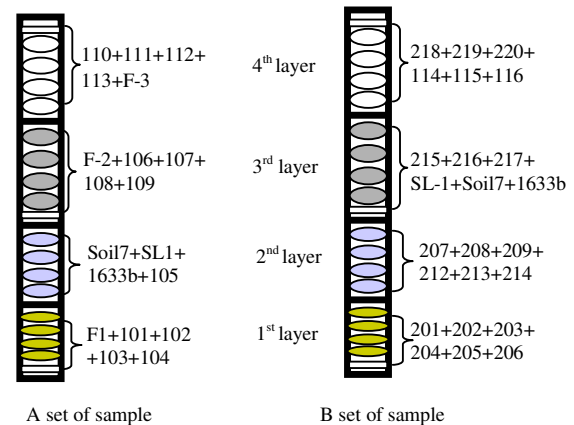


Fig. 4 Sample, standard and flux monitor foils arrangements inside the high density polyethylene tube for irradiation

C. Irradiation of Samples

Two independent irradiations were performed for irradiations of two sets of sample at the irradiation position of G19 of the TRIGA reactor core. For loading and unloading the rabbit tube, the pneumatic transfer system was used. In both cases the irradiation was performed for 8 minutes at 2 MW reactor power with thermal neutron flux $\sim 1.5 \times 10^{13}$ n/ cm²/sec.

After the end of irradiation, the tube was unloaded and all the irradiated samples were kept in a lead castle for one day as a waiting time to decay the short lived nuclides. Afterwards the emitted γ -rays from the studied, reference and the monitor samples were counted by means of a high resolution HPGe detector (resolution at FWHM is 1.92 keV at 1,332.5 keV of ⁶⁰Co) associated with other electronic accessories.

D. Gamma Ray Spectra Acquisition and Analysis

The acquisition of γ -spectra for all irradiated samples was done by the High Purity Germanium (HPGe) detector. For the case of first irradiated samples, three independent measurements were performed by allowing various decay intervals in order to identify different nuclides: (1) after the decay time of 24 hours for the determination of Mn with a measuring time of 5 minutes; (2) after the decay time of 3–6 days, with a measuring time of 1.39 h to 2.23 h for the determination of U, La, As, Sb, Na, and K; (3) after a decay

time of 3 weeks for the determination of Th, Eu, Cr, Cs, Sc, Fe and Co with a measuring time of 1.1 h. The Al – 0.1% Au monitor foils were measured after 1 week of irradiation. The measurements of short lived elements in the samples and standards were carried out on the 2 cm of the detector and long lived elements in the samples and standards were

carried out on the surface of the detector due to the low activity of the product nuclides. The γ -spectra for all kind of samples and standards were achieved by Canberra HPGe detector coupled with Genie 2000 VDM acquisition software in Fig. 5.

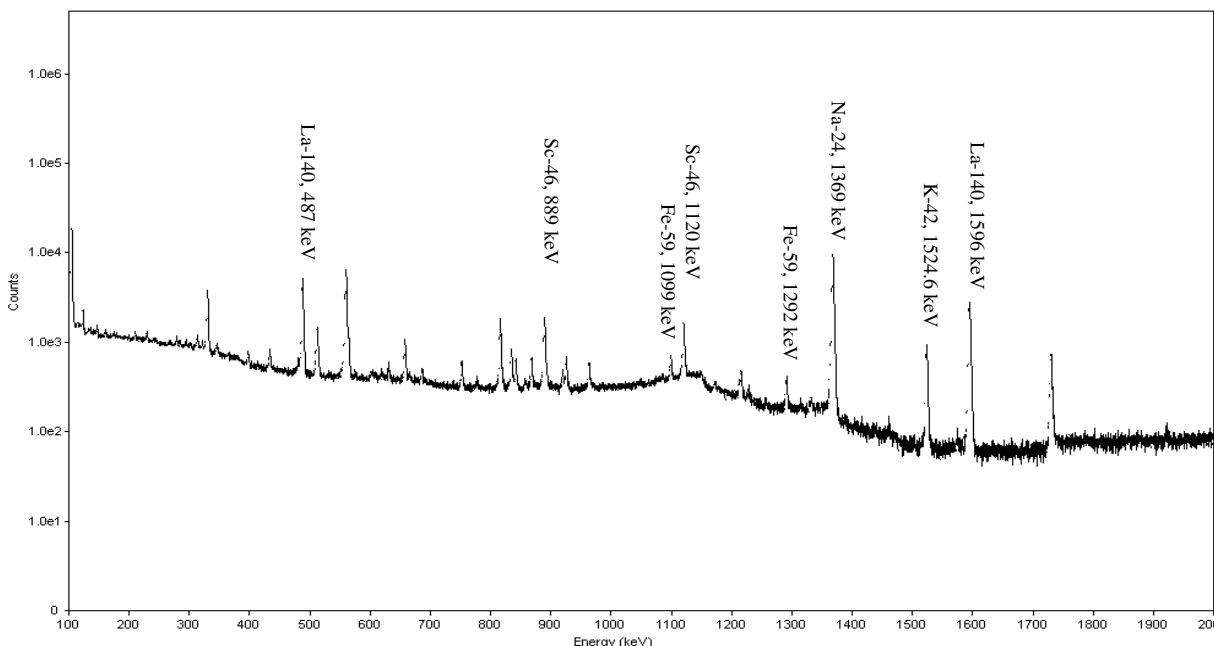


Fig. 5 The gamma ray spectrum of a soil sample achieved by Canberra HPGe detection coupled with Genie 2000 acquisition software

E. Concentration Calculation

The relative standardization approach is applied to calculate the concentration of elements in the investigated sample using the following relation:

$$(W)_{\text{sample}} = \frac{\frac{\text{Decaycorrectedcps in the sample}}{\text{Decaycorrectedcps in the standard}} \times \text{content of element in standard}}$$

F. Background Problem

Interfering background in gamma spectra originates either from within the sample being counted (Compton-produced) or from the environment. The background effect is very important for the present work, in detecting gamma rays by High Purity Germanium (HPGe) detector. For extremely weak samples, the environmental background becomes more significant as the magnitude of the background ultimately determines the minimum detectable radiation level, it becomes most significant in those applications involving weak radiation sources having activity. As the HPGe detector used in the present experiment is well surrounded with a very good and effective shielding, the background effect is negligible. There was no gamma line found in the background spectrum at our investigated energy.

G. Neutron Flux Gradient Measurement

Neutron flux gradient within the irradiation tube was determined by irradiating 3 IRMM Al – 0.1% Au foils placed at the bottom, middle and top of the tube. All these 3 samples were counted at the sample geometry of HPGe detector for the determination of their specific activity at the end of irradiation. By comparing their decay corrected specific activity, the neutron flux gradient was determined and implemented to calculate the concentration using relative method. In extreme case the neutron flux gradient varied only 5% with the irradiation tube.

IV. RESULTS AND DISCUSSION

A. Trace Elements Concentration in Soil

Trace elements act as metalloenzymes and perform important metabolic functions. These elements may be integral parts of the enzyme-protein molecule and they are involved in vitamins and hormones. Any functions, i.e., deficiency or excess in their normal level in living cells may cause the physiological disorders and may lead to various diseases. The contamination of water supply and food with trace metals arising from various sources may have, in long run, deleterious effects on health and welfare of human population of a country. This concern has stimulated increasing interest in the study of trace elements related to soil and their movement in the environment.

Table III represents the concentration of trace metals in the sub surface soil of the Bakchor bore log samples. The average concentrations of U, La, Sb, As, K, Na, Th, Cr, Sc, Fe, Co are 3.70, 43.29, 0.22, 4.73, 24314.30, 2972.32, 23.28, 71.88, 12.22, 39390.09, 20.26 mg/kg, respectively. Table IV represents the concentration of trace metals in the sub surface soil of the Panishain bore log samples. The average concentrations of U, La, Br, Sb, As, Mn, Na, K, Th, Cr, Sc, Fe, Co are 2.92, 44.04, 6.07, 0.09, 3.84, 601.48, 14643.86, 21750.94, 22.36, 104.53, 1.97, 7622.67, 10886.65 mg/kg, respectively. The average concentrations of U, La, As, k and Th are almost same of the two villages but the median concentration of Na in Panishain soil sample is higher than Bakchor soil sample.

TABLE III COMPOSITIONS OF SOME TRACE ELEMENTS (IN MG/KG) OF SOILS AND SEDIMENTS OF BAKCHOR STUDY AREA

Trace Elements	Min	Max	Mean	Median	SD
U	0.00	5.11	3.70	4.17	1.59
La	27.06	61.07	43.29	43.69	8.09
Sb	0.00	0.57	0.22	0.24	0.22
As	0.00	12.48	4.73	4.71	2.96
K	16847.10	32718.30	24314.30	23760.91	5262.99
Na	10.38	19515.38	2972.32	13.21	6470.14
Th	14.42	35.89	23.28	23.00	5.46
Cr	0.00	101.65	71.88	85.38	31.79
Sc	7.87	16.41	12.22	12.00	2.78
Fe	22458.16	55181.06	39390.09	39594.83	11336.55
Co	0.00	87.09	20.26	17.48	19.17

TABLE IV COMPOSITIONS OF SOME TRACE ELEMENTS (IN MG/KG) OF SOILS AND SEDIMENTS OF THE PANISHAIN STUDY AREA

Trace Elements	Min	Max	Mean	Median	SD
U	0.00	6.23	2.92	3.66	2.13
La	30.03	55.80	44.04	45.00	7.20
Br	0.00	28.16	6.07	2.27	7.79
Sb	0.00	0.73	0.09	0.00	0.22
As	1.67	9.90	3.84	3.51	2.00
Mn	348.36	947.67	601.48	612.62	126.32
Na	11215.03	16319.17	14643.86	15097.09	1403.87
K	16845.11	26148.91	21750.94	21824.72	2745.09
Th	16.41	30.35	22.36	22.60	3.27
Cr	0.00	149.22	104.53	100.14	35.42
Sc	0.83	5.32	1.97	1.76	1.10
Fe	6081.35	8373.30	7622.67	7805.48	654.13
Co	8437.73	13084.62	10886.65	10923.42	1371.68

The mean, median and standard deviation of trace metals concentration from the two study sites soil samples in Tables III and IV demonstrates same distribution characteristics of soil and the Pearson correlation coefficients in Tables V and VI among most trace elements are almost same. Thus, the trace metals concentrations mainly inherited from parent materials because the soils are young with relatively little weathering impacts^[14].

B. Correlation Analysis and Vertical Distributions of As, Fe and Mn

If an aquifer has a porosity of 25% and the sediment contains say 1 mg As kg⁻¹ of labile As, the complete dissolution of that As would lead to a groundwater As concentration of 7950 µg As L⁻¹, far in excess any drinking water standard^[7]. The loss of only 0.1 µg/g of As from the solid phase can enrich the groundwater by 200 µg/l^[5]. The

concentrations of arsenic are also plotted as a function of different selected parameters. The correlations coefficients [$R^2 = 0.6568$ (n=16), $R^2 = 0.4668$ (n=18)] between total arsenic and iron in the core sediments are significant in Fig. 6. Besides this, the As/Mn and Fe/Mn containing minerals in the same layers in Fig. 7 (Panishain village) is controlled the distribution of arsenic. There also show strong correlations [$R^2 = 0.821$, $R^2 = 0.542$ (n=18)] between total arsenic-manganese and iron-manganese respectively in the core sediments.

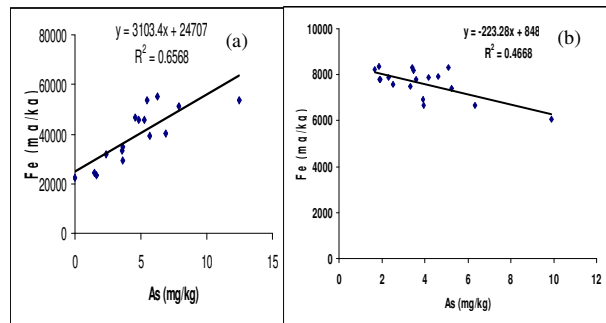


Fig. 6 Profile showing the relationship between the concentrations of As with Fe of (a) Bakchor and (b) Panishain bore logs

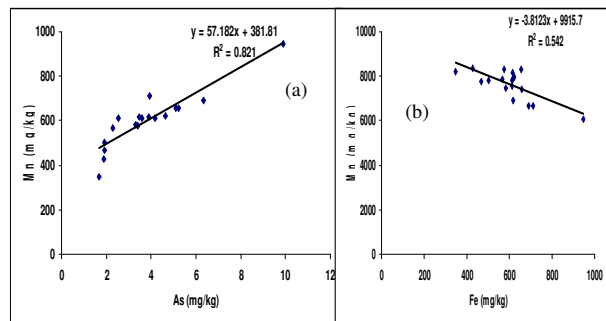


Fig. 7 Profile showing the relationship between the concentrations of (a) As with Mn and (b) Fe with Mn of Panishain bore logs

Correlation analysis of arsenic and other elements of soil samples from the sub soil were carried out using the Pearson's correlation method from SPSS statistical software. Correlation coefficients ranged in value from -1 (a perfect negative relationship) to +1 (a perfect positive relationship). The most significant linear correlation is counted at the correlation coefficient $>\pm 0.7$ shown in Table V and VI.

TABLE V PEARSON CORRELATION OF BOREHOLE-1

	U	La	Sb	As	K	Na	Th	Cr	Sc	Fe	Co
U	1										
La	0.45	1									
Sb	0.39	0.25	1								
As	0.68	0.28	0.71	1							
K	0.21	0.19	0.38	0.27	1						
Na	-0.89	-0.28	-0.44	-0.63	-0.24	1					
Th	0.74	0.73	0.20	0.48	0.20	-0.65	1				
Cr	0.68	0.51	0.57	0.63	0.72	-0.69	0.58	1			
Sc	0.68	0.24	0.41	0.55	0.77	-0.70	0.54	0.79	1		
Fe	0.72	0.23	0.55	0.81	0.62	-0.69	0.53	0.81	0.90	1	
Co	-0.40	-0.27	-0.07	-0.01	-0.13	0.21	-0.31	-0.32	-0.06	-0.03	1

TABLE VI PEARSON CORRELATION OF BOREHOLE-2

	<i>U</i>	<i>La</i>	<i>Br</i>	<i>As</i>	<i>Sb</i>	<i>Mn</i>	<i>Na</i>	<i>K</i>	<i>Th</i>	<i>Cr</i>	<i>Sc</i>	<i>Fe</i>	<i>Co</i>
U	1												
La	-0.16	1											
Br	-0.55	-0.05	1										
As	0.57	-0.42	-0.36	1									
Sb	0.42	-0.03	-0.24	0.85	1								
Mn	0.53	-0.49	-0.23	0.91	0.69	1							
Na	-0.14	0.31	-0.06	-0.72	-0.73	-0.78	1						
K	0.65	-0.41	-0.49	0.79	0.55	0.81	-0.52	1					
Th	0.20	0.38	0.07	-0.30	-0.10	-0.37	0.45	-0.53	1				
Cr	0.33	-0.18	-0.12	0.50	0.47	0.43	-0.30	0.30	0.19	1			
Sc	0.56	-0.38	-0.35	1.00	0.87	0.90	-0.73	0.78	-0.29	0.50	1		
Fe	-0.10	0.29	-0.09	-0.68	-0.71	-0.74	1.00	-0.48	0.45	-0.28	-0.70	1	
Co	0.65	-0.41	-0.49	0.80	0.55	0.81	-0.52	1.00	-0.53	0.30	0.78	-0.48	1

Presence of organic matter in the aquifer sediments of the Bengal Basin has been reported in several studies ^[1, 9, 10]. Degradation of this organic matter could drive the sequence of redox reactions in the aquifer and may, thereby enhance arsenic mobilization ^[2, 8, 11]. Analytical results of selected boreholes sediment samples of contaminated areas (Bakchor and Panishain villages) show in Fig. 8 that the vertical distribution of arsenic and iron has not followed any regular or particular pattern but is rather randomly distributed over

all layers. The drilling cores are mainly composed of silty clay, very fine silty sand, fine to very fine sand, fine to medium sand and fine sand with mica layers at different depths in Fig. 8. Arsenic concentrations in medium sand are relatively lower than those of clay, fine sand and silt but they contain considerable amount (1.6–3.5mg/kg) of arsenic in Fig. 8 depending on the amount of reddish iron-oxide fine particles found on the sand grains.

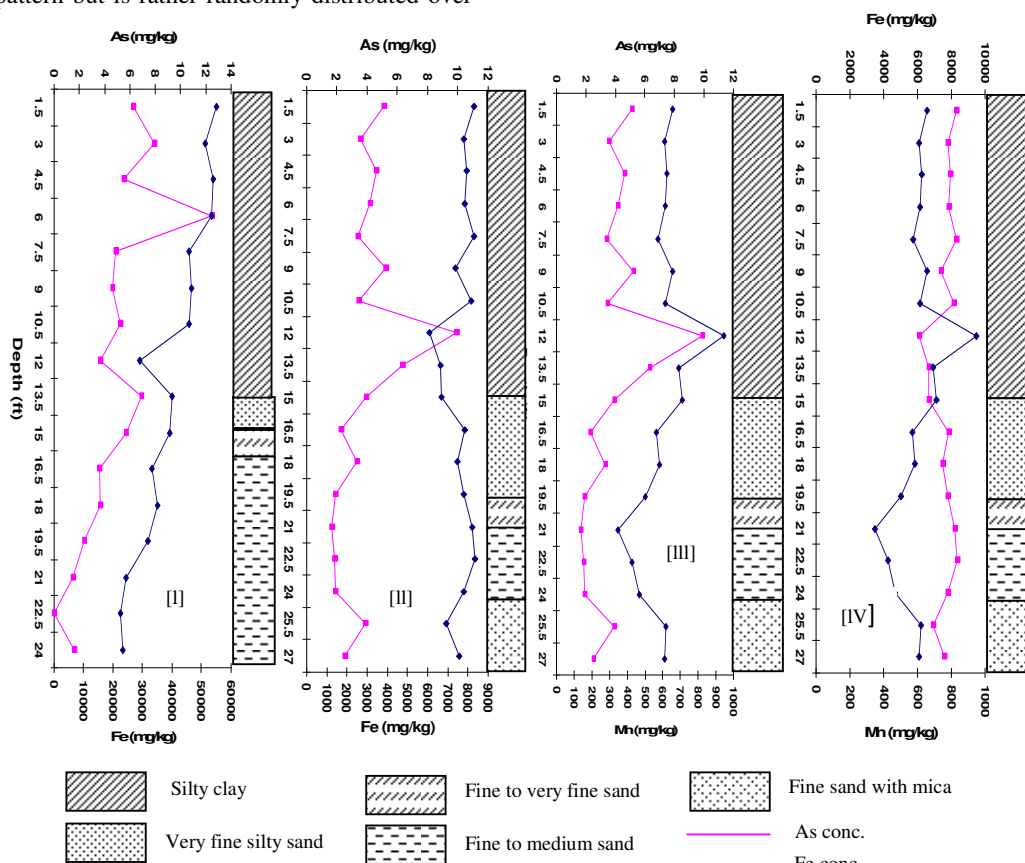


Fig. 8 Vertical profile used for analysis of As with Fe in [I] Bakchor and [II] Panishain village; [III] As with Mn and [IV] Fe with Mn in Panishain village along with the stratigraphic column of the sequence sampled by the bore logs soil sample

The overall variation of arsenic concentration (Bakchor: 0.00–12.48 mg/kg; Panishain: 1.67– 9.90 mg/kg) with depth (27ft) can be attributed to the different flood cycles sedimentation pattern and fluvio-deltaic sedimentary profiles of the major rivers in these areas in the recent past and also to the post-depositional as well as early diagenetic nature of organic matter. The strong relationship between total arsenic and iron contents may be a result of the presence Fe-(hydr)oxides and the homogeneous distribution of arsenic on metal (hydr)oxides^[13].

C. Spatial Distribution of Arsenic with Ferrous

Profiles of the As and Fe distribution at different depths with important parameters related to release it into soil are shown in Fig. 9. Considerable variability is noted in the levels of Fe (22458.16 to 55181.06 mg/kg and 6081.35 to 8373.30) with As in the soil samples as a function of depth. In Bakchor bore log, high concentration of arsenic is observed at 6ft depth (12.48 mg/kg), similarly, the highest concentration of Fe is observed at 1.5ft depth (55181.06 mg/kg) in Fig. 9 (a). On the other hand, the lowest concentration of As and Fe is found at 22.5 ft depth in Fig. 9 (a). In Panishain bore log, the highest concentration of As is observed at 12 ft depth and Fe is observed at 22.5 ft depth in Fig. 9 (b).

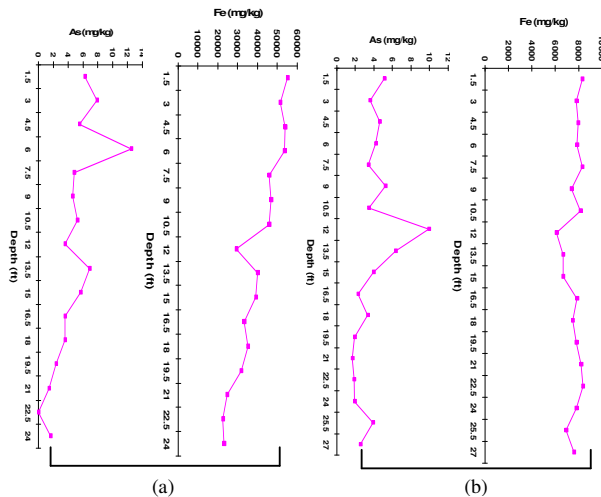


Fig. 9 Profile showing the distribution of As with Fe of (a) Bakchor and (b) Panishain according to depth of bore logs

D. Spatial Distribution of Other Trace Elements

It is therefore apparent that the As distribution in soil is not only controlled by depth but also depend on subsurface geology^[1]. This means that one should expect the soil and sediments with fine silt and clay contents to be relatively high in arsenic concentration. The variations of the concentrations of As and Fe in the soil are probably the result of biodegrading of organic matter in subsurface sediments^[4, 6, 9, 12].

Among the other parameters, concentrations of U(0.00 to 5.11 mg/kg), La(27.06 to 61.07 mg/kg), Sb(0.00 to 0.57 mg/kg), K (16847.10 to 32718.30 mg/kg), Na(10.38 to 19515.38 mg/kg), Th(14.42 to 35.89 mg/kg), Cr(0.00 to 101.65 mg/kg), Sc(7.87 to 16.41 mg/kg), Fe(22458.16 to

55181.06 mg/kg), Co(0.00 to 87.09 mg/kg), are observed in the Bakchor soil sample in Fig. 10 (a – j).

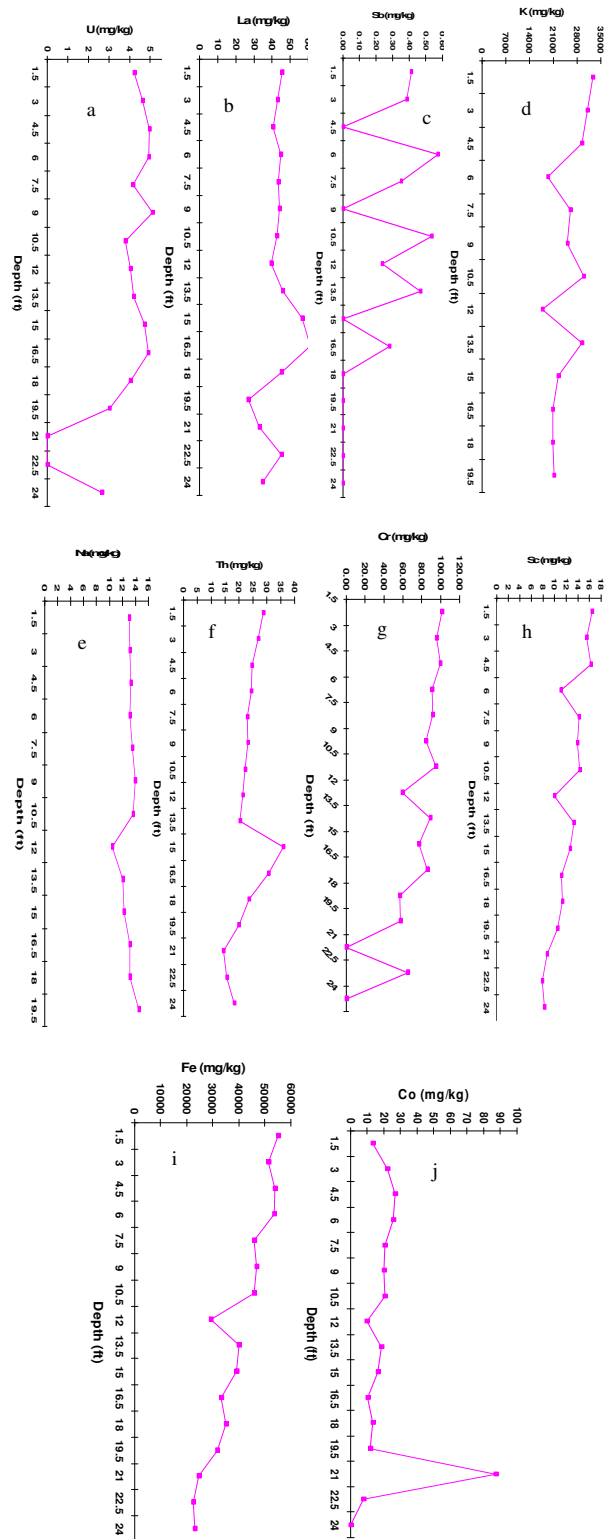


Fig. 10 Profile showing the distribution of (a) U, (b) La, (c) Sb, (d) K, (e) Na, (f) Th, (g) Cr, (h) Sc, (i) Fe and (j) Co with depth of Bakchor bore log

In Panishain soil sample, the concentrations of U(0.00 to 6.23 mg/kg), La(30.03 to 55.80 mg/kg), Br(0.00 to 28.16

mg/kg), Sb(0.00 to 0.73 mg/kg), Mn(348.36 to 947.67 mg/kg), Na(11215.03 to 16319.17 mg/kg), K(16845.11 to 26148.91 mg/kg), Th(16.41 to 30.35 mg/kg), Cr(0.00 to 149.22 mg/kg), Sc(0.83 to 5.32 mg/kg), Fe(6081.35 to 8373.30 mg/kg) and Cr(8437.73 to 13084.62 mg/kg) are observed in Fig. 11 (a – l).

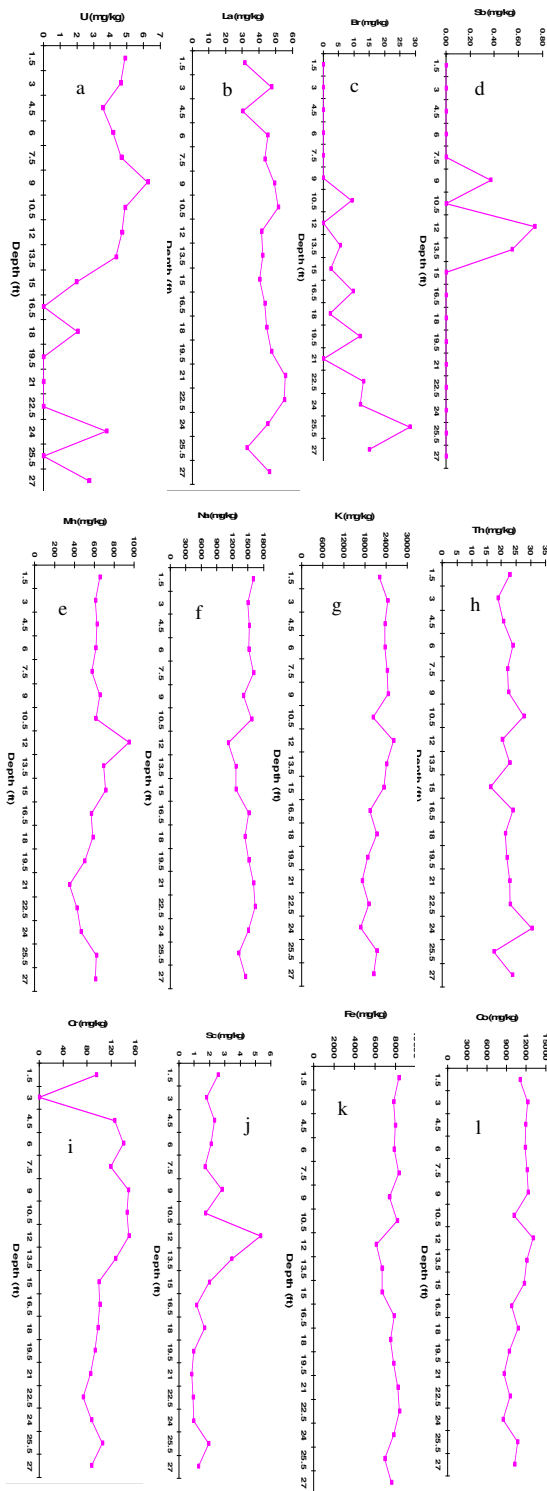


Fig. 11 Profile showing the distribution of (a) U, (b) La, (c) Br, (d) Sb, (e) Mn, (f) Na, (g) K, (h) Th, (i) Cr, (j) Sc, (k) Fe and (l) Co with depth of Panisham bore log

E. Correlation Analysis of Other Investigated Elements

It was observed that trace elements are most closely associated with each other. Strong positive correlation was observed for Cr-Fe, Cr-Sc and Sc-Fe having correlation coefficients of 0.652, 0.6164 and 0.8063 in Fig. 12 indicate that they are closely associated with each other and variation in concentration of one can influence the concentration of others.

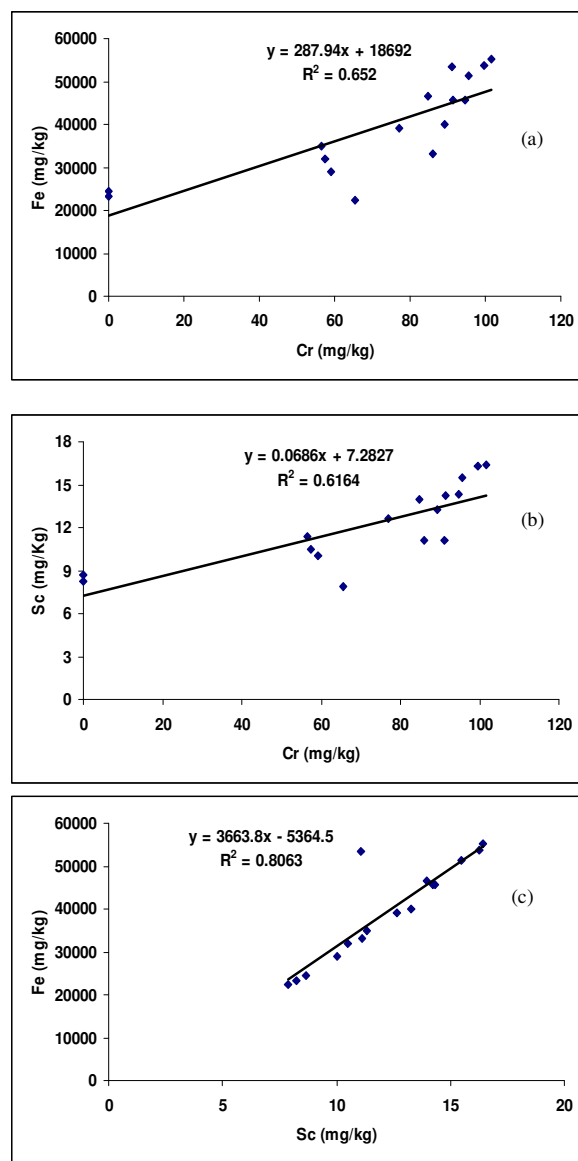


Fig. 12 Showing the relationship of (a) Cr with Fe; (b) Cr with Sc; (c) Sc with Fe of Bakchor bore log

V. CONCLUSIONS

In the present study, concentrations of various trace elements were assessed in subsurface soil and sediment in various depth of Singair Upazila. The drilling cores are mainly composed of silty clay, very fine silty sand, fine to very fine sand, fine to medium sand and fine sand with mica layers at different depths. Instrumental Neutron Activation

Analysis method has been used for analysis wherein the average concentrations of U, La, Br, As, Sb, Mn, k, Th, Cr, Sc, Fe and Co are almost same for the soil samples from two villages except (mean concentration of Na is 2972.32 mg/kg but the median concentration is 13.21 mg/kg) of Bakchor soil samples which is higher than Panishain soil samples. The mean, median and standard deviation of trace metals concentration from the two study sites soil samples demonstrate same distribution characteristics of soil. Pearson correlation coefficients among most trace elements are almost same. This phenomenon is a result of almost same parent materials between two study soils.

However, distribution of arsenic in soil and sediments depend not only on the texture but also on the concentration of metal (Fe, Mn) oxides and some other factors. The concentrations of arsenic are also plotted as a function of different selected parameters. Arsenic exhibited significant correlation with iron and manganese. Analytical results of selected borehole sediment samples of contaminated areas (Bakchor and Panishain villages) show that the vertical distribution of arsenic and iron has not followed any regular or particular pattern but is rather randomly distributed over all layers and the correlation coefficient [$R^2=0.6568$ ($n=16$), $R^2=0.4668$ ($n=18$)] between total arsenic and iron in the core sediment are significant. Furthermore a highly significant correlation was observed between Fe-Mn, Cr-Fe, Cr-Sc and Sc-Fe which indicate that they are closely associated with each other and variation in concentration of one can influence the concentration of others.

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