Canadian Journal of Pure and Applied Sciences
Vol. 9, No. 1, pp. 3177-3184, February 2015
Online ISSN: 1920-3853; Print ISSN: 1715-9997
Available online at www.cjpas.net

STATUS OF ARSENIC AND SELENIUM IN SOME ARSENIC HOT SPOTS OF BANGLADESH AND ITS RELEVANCE TO ARSENICOSIS IN HUMAN BEINGS

Badhan Saha[1], Mohammad Moniruzzaman[1] and *SM Imamul Huq[2]
[1]Soil and Environment Section, Biological Research Division,
Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhanmondi, Dhaka-1205, Bangladesh
[2]Bangladesh-Australia Centre for Environmental Research (BACER-DU),
Department of Soil, Water and Environment, University of Dhaka, Dhaka-1000, Bangladesh

ABSTRACT

The present work was conducted to find any relevance to the selenium (Se) content in soil, water and in an edible plant to the incidence of arsenicosis in some arsenic hotspots of the country where arsenicosis patients have been identified and where no arsenicosis patients have yet been reported. Soil, plant and water samples were collected from arsenic hot spots of five localities *viz.* Sonargaon, Manikgonj, Munshigonj, Jessore and Ishwardi. The collected plant was Arum (*Colocasia esculenta*) – a hyper accumulator of As and a very common edible vegetable all over the country. Soil, plant and water samples were analyzed to determine the content of arsenic and selenium in them. Analyses of soil, plant and water samples reveal that the average concentrations of As in the three niches at the locations where arsenicosis is prevalent are higher (3.56, 3.0 and 0.062 mg/kg respectively) than where the incidence of arsenicosis has not been reported (2.83, 2.66 and 0.053 mg/kg respectively). On the other hand, the Se contents showed a reverse phenomena – lower in the locations where patients are prevalent (0.082, 0.027 mg/kg and bdl respectively in three niches) than where no patients have been reported (0.156, 0.053 mg/kg and bdl respectively). The findings are suggestive of the implication of Se in alleviating As toxicity in human beings.

Keywords: Arsenic, Selenium, Arsenicosis patients.

INTRODUCTION

Contamination of groundwater by arsenic (As) in the deltaic region, particularly in the Gangetic alluvium of Bangladesh is considered as one of the world's most important natural calamities (Imamul Huq and Naidu, 2003). More than 35 million people are supposed to be exposed to high arsenic contents in drinking water exceeding the national standard of 50µg/L while the number is estimated to be 49 million for exceeding the World Health Organization (WHO) guideline value of 10µg/L (BGS/DPHE, 2001). It has been reported that 38,000 persons were diagnosed with arsenicosis with an additional 30 million people at risk of As exposure (APSU, 2005). The exposure to arsenic of the human being is also effected through food chain besides the principal ingestion pathway through drinking water (Correll *et al*., 2006; Chakravarty *et. al*., 2003). It is estimated that about 50% of the existing tube wells in Bangladesh discharge water with sufficient amounts of As to produce arsenicosis. Access to As free water is the priority of the local administration. An improved diet and/or dietary supplements could be an ameliorative measure for As toxicity in situations where As-free potable water is difficult to be provided. Presence of high concentration of arsenic in the dietary system might adversely affect the status of an essential human trace element, selenium (Spallholz *et al*., 2004) as arsenic can replace the Se-biochemical pathways. Selenium (Se) is a dietary essential nutrient element for human with a minimum adult requirement of approximately 20.0µg/day (Raymond, 2000). Se is primarily associated with animal and plant protein consisting mostly of selenomethionine and lesser amounts of selenocysteine (Combs, 2001). A number of proteins in human cells contain selenium where it is largely associated with oxidative metabolism like glutathione peroxidase, selenoprotein P, selenoprotein W, thioredoxin reductase, selenophosphate synthetase and prostate epithelial selenoprotein (Frausto da Silva and Williams, 2001). Soil Se contents regulate the presence of this element in fruits, vegetables and in cereal grains (Spallholz *et al*., 2004). In soil the prime source of Se is sulfide rocks. Sedimentary rocks (Shale) generally have the highest concentration of selenium (Lakin, 1961; Lakin and Davidson, 1967; Rosenfeld and Beath, 1964).

*Corresponding author e-mail: imamhuq@hotmail.com

In Bangladesh there are many areas which are affected by arsenic and a number of arsenicosis patients have been identified. But in some arsenic affected areas no arsenicosis patients could be identified (Imamul Huq and Naidu, 2003). A number of possibilities could be linked to the observed phenomenon: (1) the nutritional levels of the non-affected persons could be better than those affected; (2) the food habit is different; (3) difference in genetic make- up etc. Another possibility could be related to the soil characteristic: that the soils in those areas contain higher Se content which ultimately enters into the crops and the consumed crops are providing a Se supplement. Taking this idea in view, this research was undertaken to make a comparison of the As and Se status of the soils, plants and water samples from localities in As hot spots where situation of incidence of arsenicosis patients are not prevalent to the situations in the localities where arsenicosis patients are prevalent.

MATERIALS AND METHODS

Selection of sampling sites

For this study, information about As contamination was obtained from secondary sources (BGS/DPHE, 1999). For sample collection arsenic contaminated areas were divided into: As contaminated areas where arsenicosis patients are prevalent and the areas where no arsenicosis patients are prevalent yet. The information about arsenicosis patient was obtained from The Dhaka Community Medical College and Hospitals as well as from local health complexes, from the different NGO's and local community in the sampling areas. So far, 435 sub-districts (upazilla) have been identified as arsenic hotspots (Imamul Huq, 2008). Out of these, some arsenic hot spots areas in Sonargaon, Manikgonj, Munshigonj, Jessore and Ishwardi were selected for the present study. Geographic Locations of the sampling sites are presented in table 1.

Collection of soil sample

Replicate surface (0-15 cm) and sub-surface (15-30 cm) soil samples from the above mentioned areas were collected by composite soil sampling method as suggested by the USDA (1951). The soil samples were collected from the same sites wherefrom water and plant samples were collected. The soil samples were processed following the procedures mentioned in Imamul Huq and Didar (2005).

Collection of plant sample

Samples of Arum (*Colocasia esculenta*) were collected adjacent to the place of soil sample collection. This plant was collected considering its hyper accumulative nature for As and its widespread use as an edible vegetables. Plants were uprooted very carefully. Once collected the plant samples were processed and preserved as described in Imamul Huq and Didar (2005).

Collection of water sample

Water samples (100 mL) from hand-tube wells were collected by initially pumping water for five minutes. Immediately after sampling, one mL of concentrated HCl was added to the 100 mL vials containing water and transported to the laboratory on ice within 24 hours for further analysis. Vials were filled to the top. Once transported to the laboratory, the water samples were centrifuged at high speed, filtered through 0.45 µ Millipore filters and the filtrate was conserved till analysis.

Laboratory analyses

Soil, plant and water sample were analyzed for total As and Se by atomic absorption spectrophotometer (AA-7000, Shimadzu, Japan) with HVG unit. The arsenic form the plant samples was extracted with HNO_3 and from the soil with aqua regia solution (Portman and Riley, 1964). The analyses followed all protocols to ensure QA/QC. All results for soil and plant expressed in the text are based on dry-weight basis. The data were statistically analyzed by using the common statistical software MINITAB 13.0.

RESULTS

As conc. in soil samples collected from different arsenic affected areas

Concentration of As in soil samples collected from different hot spots of As affected locations in situations where arsenicosis patients are prevalent and also from the locations in situations where no arsenicosis patients are prevalent yet is shown in figure 1.

The concentration of As in soils collected from different arsenic affected areas where arsenicosis patients are present ranged from 1.573 mg/kg to 7.974 mg/kg with an average of 3.56 mg/kg and in soils from those arsenic affected locations where no arsenicosis patient are present ranged from 1.004 mg/kg to 5.539 mg/kg with an average of 2.832 mg/kg.

Se conc. in soil samples collected from different arsenic affected areas

Concentration of Se in soil samples collected from the various hot spots for the two different locations is shown in figure 2.

The concentration of Se in soils collected from different arsenic affected locations where arsenicosis patient are present ranged from 0.038 mg/kg to 0.105 mg/kg with an average of 0.082 mg/kg and in soils from those arsenic affected locations where no arsenicosis patients are reported ranged from 0.059 mg/kg to 0.332 mg/kg with an average of 0.156 mg/kg.

Table 1. Geographical Location from where the samples were collected.

Sampling Sites	Sampling Point	Remarks	Sample Type	Geographical location
Manikganj (Village: Der Gram, Purbo Dhashora & Harirampur)	1	NP	Soil, Plant & Water	23º39.141´ N, 90º35.932´ E
	2	P	Soil, Plant & Water	23º52.308´ N, 90º01.621´ E
	3	NP	Soil, Plant & Water	23º52.309´ N, 90º01.623´ E
	4	NP	Soil, Plant & Water	23º52.310´ N, 90º01.620´ E
	5	P	Soil, Plant & Water	23º52.308´ N, 90º01.623´ E
	6	P	Soil, Plant & Water	23º52.360´ N, 90º01.772´ E
	7	P	Soil, Plant & Water	23º52.359´ N, 90º01.769´ E
	8	NP	Soil, Plant & Water	23º52.359´ N , 90º01.769´ E
	9	NP	Soil, Plant & Water	23º52.360´ N, 90º01.770´ E
	10	P	Soil, Plant & Water	23º52.320´ N , 90º01.725´ E
Sonargaon (village: Adampur & Chaper Bon)	11	P	Soil, Plant & Water	23º39.206´ N , 90º36.045´ E
	12	P	Soil, Plant & Water	23º39.206´ N , 90º36.039´ E
	13	NP	Soil, Plant & Water	23º39.264´ N , 90º36.038´ E
	14	P	Soil, Plant & Water	23º39.365´ N, 90º36.039´ E
	15	NP	Soil, Plant & Water	23º39.272´ N, 90º36.067´ E
	16	P	Soil, Plant & Water	23º39.265´ N, 90º36.061´ E
	17	P	Soil, Plant & Water	23º39.202´ N, 90º36.037´ E
	18	P	Soil, Plant & Water	23º39.205´ N, 90º36.038´ E
	19	P	Soil, Plant & Water	23º52.320´ N, 90º01.725´ E
	20	P	Soil, Plant & Water	23º39.370´ N, 90º36.043´ E
	21	NP	Soil, Plant & Water	23º39.281´ N, 90º36.049´ E
Munshiganj (Village: Aatorpara, Sirajdikhan)	22	P	Soil, Plant & Water	23º32.362´ N, 90º20.167´ E
	23	P	Soil, Plant & Water	23º33.973´ N, 90º20.156´ E
	24	NP	Soil, Plant & Water	23º34.012´ N, 90º20.131´ E
	25	NP	Soil, Plant & Water	23º34.016´ N, 90º20.152´ E
	26	P	Soil, Plant & Water	23º34.112´ N, 90º20.155´ E
	27	P	Soil, Plant & Water	23º34.025´ N, 90º20.105´ E
	28	NP	Soil, Plant & Water	23º33.212´ N, 90º20.170´ E
	29	P	Soil, Plant & Water	23º33.175´ N, 90º20.235´ E
	30	NP	Soil, Plant & Water	23º33.853´ N, 90º20.120´ E
	31	P	Soil, Plant & Water	23º32.302´ N, 90º20.237´ E
Jessore (Village: Purandarpur, Jhikorgacha)	32	P	Soil, Plant & Water	23º05.705´ N, 89º05.790´ E
	33	NP	Soil, Plant & Water	23º05.627´ N, 89º05.732´ E
	34	NP	Soil, Plant & Water	23º05.772´ N, 89º05.608´ E
	35	P	Soil, Plant & Water	23º05.778´ N, 89º05.624´ E
	36	P	Soil, Plant & Water	23º05.783´ N, 89º05.524´ E
	37	NP	Soil, Plant & Water	23º05.583´ N, 89º05.506´ E
	38	P	Soil, Plant & Water	23º05.603´ N, 89º05.425´ E
	39	NP	Soil, Plant & Water	23º05.613´ N, 89º05.753´ E
Ishwardi (village: Charruppur)	40	P	Soil, Plant & Water	24º03.145´ N, 89º03.145´ E
	41	P	Soil, Plant & Water	24º03.147´ N, 89º03.341´ E
	42	P	Soil, Plant & Water	24º03.093´ N, 89º03.355´ E
	43	NP	Soil, Plant & Water	24º03.084´ N, 89º03.338´ E
	44	NP	Soil, Plant & Water	24º04.014´ N, 89º03.313´ E
	45	NP	Soil, Plant & Water	24º04.124´ N, 89º03.235´ E
	46	P	Soil, Plant & Water	24º04.208´ N, 89º03.350´ E
	47	NP	Soil, Plant & Water	24º03.862´ N, 89º03.183´ E
	48	NP	Soil, Plant & Water	24º04.106´ N, 89º03.252 E
	49	NP	Soil, Plant & Water	24º04.106´ N, 89º03.252 E

*NP= No Patient was found *P= Patient was found

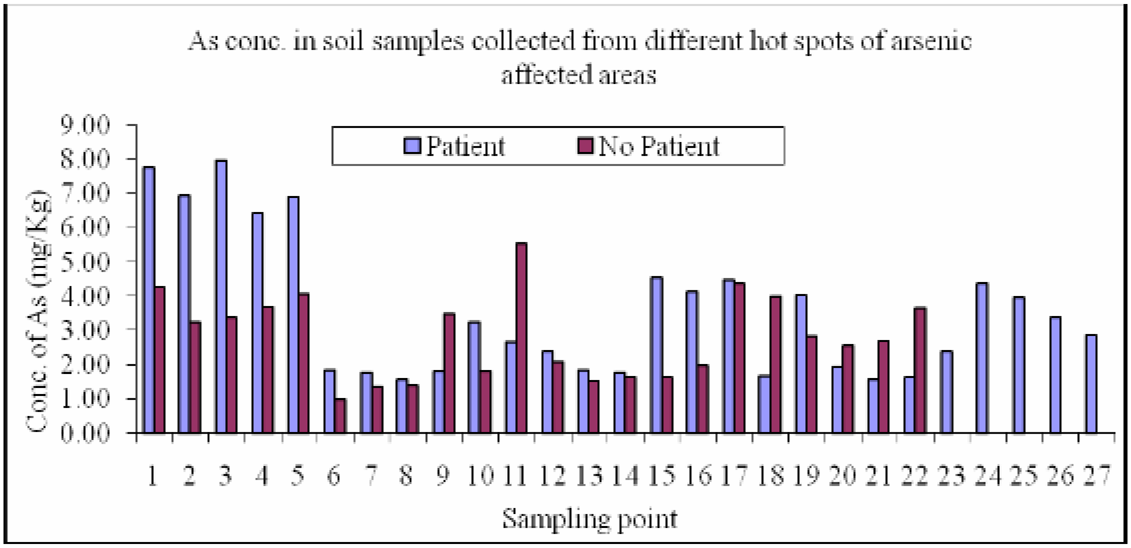

Fig. 1. As conc. in soil samples collected from different arsenic affected areas.

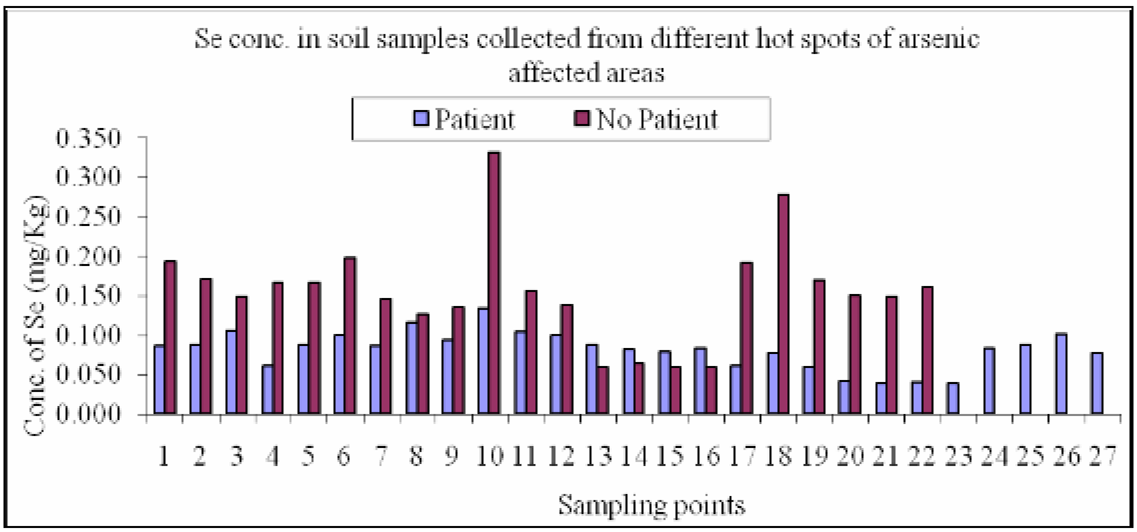

Fig. 2. Se conc. in soil samples collected from different arsenic affected areas.

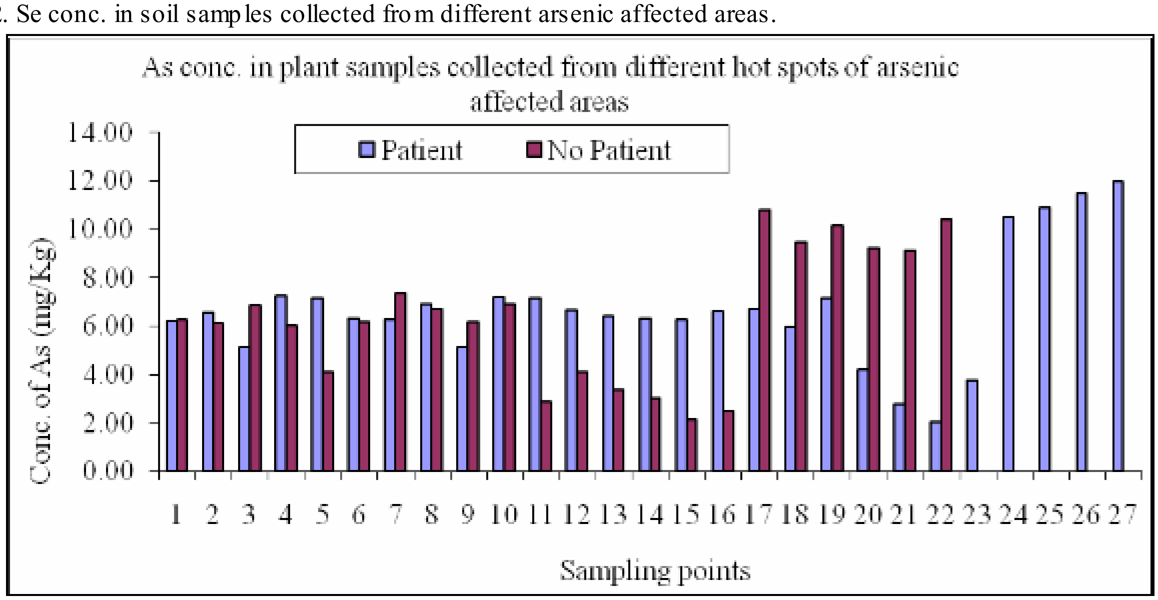

Fig. 3. As conc. in plant samples collected from different arsenic affected areas.

As conc. in Arum collected from different hot spots of arsenic affected areas

Concentration of As in the edible parts of Arum samples collected from different hot spots for the two different locations is shown in figure 3.

The concentration of As in the edible part of Arum samples collected from different hot spots of arsenic affected locations ranged from 0.80 mg/kg to 4.95 mg/kg with an average of 3.00 mg/kg where arsenicosis patients are found and in plants from those arsenic affected areas where no arsenicosis patients are identified ranged from 0.78 mg/kg to 4.32 mg/kg with an average value of 2.66 mg/kg.

Se conc. in Arum samples collected from different hot spots of arsenic affected areas

Concentration of Se in the edible part of Arum samples collected from different hot spots for the two locations is shown in figure 4.

The concentration of Se in the edible part of Arum samples collected from different hotspots of arsenic affected areas where arsenicosis patients are found ranged from 0.010 mg/kg to 0.051 mg/kg with an average of 0.027 mg/kg whereas it ranged from 0.021 mg/kg to 0.121 mg/kg with an average of 0.053 mg/kg in locations where no arsenicosis patients are reported.

As conc. in water samples collected from different arsenic affected areas

Concentration of As in water samples collected from different hot spots of the As affected areas for the two locations is shown in figure 5.

The concentration of As in water samples collected from different arsenic affected areas where arsenicosis patient are found ranged from 0.041 mg/kg to 0.089 mg/kg with an average of 0.062 mg/kg and in water samples from the other location ranged from 0.036 mg/kg to 0.089 mg/kg with an average of 0.053 mg/kg.

Se conc. in water samples collected from different arsenic affected areas

Concentration of Se in water samples collected from different hot spots was found below detection limit (bdl - detection limit of Se is 0.01 mg/kg).

Correlation between As and Se of soils and plant

Correlation coefficient was calculated to see any relationships between the concentration of As and Se in soil and in the edible parts of Arum for the two situations. The correlation coefficient values between the concentration of soil As & plant As, soil As & plant Se, soil Se & plant Se, plant As & plant Se and soil As & soil Se in both categories of the samples are presented in table 2.

DISCUSSION

In the present study soil, water and edible plants grown in the arsenic hotspots sites of different arsenic affected areas in two situations, where arsenicosis patients are reported and where no patients have been identified, were collected and analyzed for As and Se content in them. From the results it has been observed that the average value of As in the soil samples where the incidence of arsenicosis in human beings is prominent was 3.56 mg/kg which is higher than the average value of As in situations where cases of arsenicosis have not been reported, the value being 2.83 mg/kg. Similarly the average value of As in edible part of Arum in the first situation was (3.00 mg/kg) which is also higher than the average value of As in the plant (2.66 mg/kg). On the contrary, the average value of Se in the soils under the first situation was lower (0.082 mg/kg) than the average value of Se (0.156 mg/kg) in the second situation. So was the case with Se in them (the average value of Se was 0.027 mg/kg for the first situation and 0.053 mg/kg for the second situation). No detectable amount of Se was found in the water collected under either situations though the average As concentrations under both the situations were greater than the permissible limit of 0.05 mg/L for Bangladesh standard, more for situation one than for situation two. The values, thus are indicative of higher concentration of As and a relatively lower concentration of Se in the environment and dietary sources where incidence of arsenicosis is prominent. From the statistical analysis it is apparent that correlation between the concentration of soil As & plant As, soil As & plant Se, plant As & plant Se, soil As & soil Se and soil Se & plant Se in both category of the samples collected from the hotspots showed positive correlation with each other in all the cases; significant positive correlation existed between the concentration of soil As & plant Se and soil Se & plant Se for both the situations. Presence of higher amounts of Se will encourage higher accumulation of the element in the plant which will ultimately end up in the dietary budget.

In the study it was observed that both arsenicosis and non-arsenicosis individual exist in the same As hot spots. The reasons could be many like, (1) difference between the nutritional levels of the two groups of individuals, (2) difference in food habit, and (3) difference in their genetic makeup etc. The other possibility could be related to the soil characteristics, particularly as it concerns the level of selenium. We hypothesized that the soils of the localities where no arsenicosis patient are reported might contain higher Se content that ultimately enters into the crops and the consumed crops provide a Se supplement minimizing the chronic effect of As. It is found that the soils in situations where no arsenicosis patients are found contain higher Se content than the soils where arsenicosis patients were found and the average value of Se in the edible parts of plant samples is also higher than the average value of

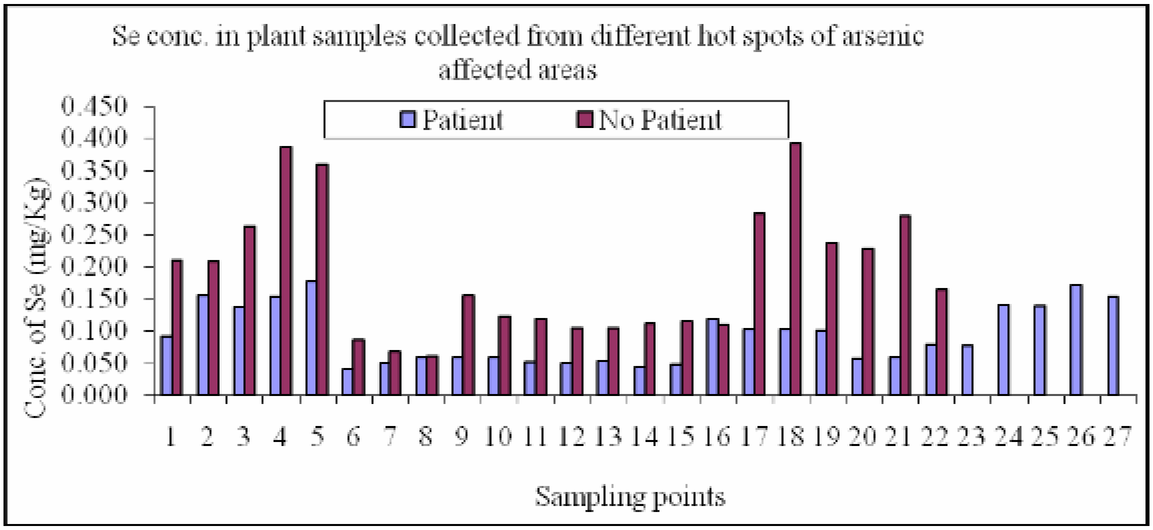

Fig. 4. Se conc. in plant samples collected from different arsenic affected areas.

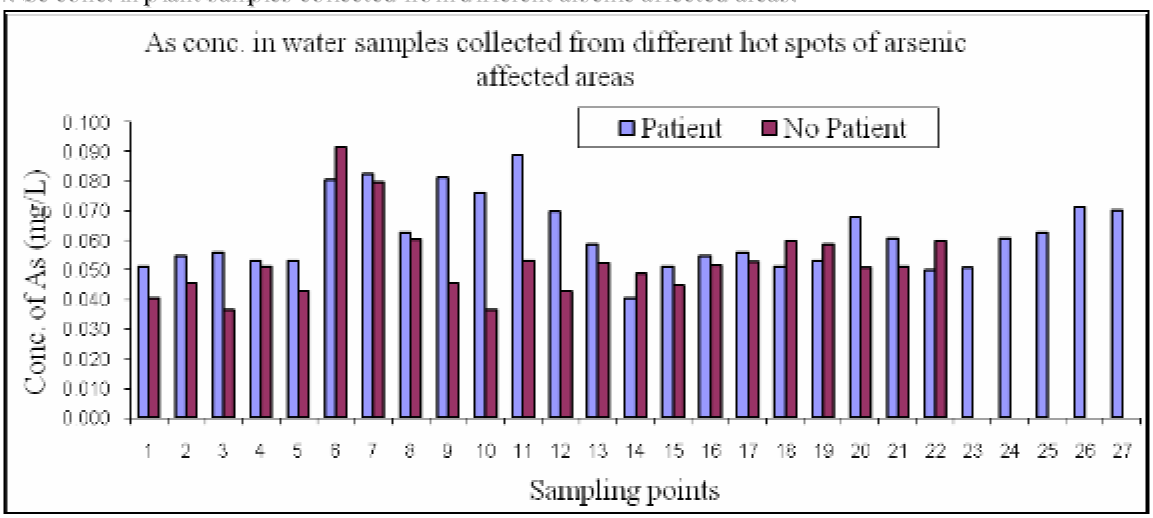

Fig. 5. As conc. in water samples collected from different arsenic affected areas.

Table 2. Correlation coefficient levels between various parameters.

Arsenicosis Patient Found				No Arsenicosis Patient Found			
	Plant-As	Plant-Se	Soil-Se		Plant-As	Plant-Se	Soil-Se
Soil-As	Positive (P=0.243)	Positive (P=0.000)	Positive (P=0.988)	Soil-As	Positive (P=0.434)	Positive (P=0.002)	Positive (P=0.160)
Soil-Se	Positive (P=0.009)	Positive (P=0.616)	-	Soil-Se	Positive (P=0.001)	Positive (P=0.225)	-
Plant-As	-	Positive (P=0.281)	-	Plant-As	-	Positive (P=0.378)	-

Se where arsenicosis patients are not identified. It could thus be rationalized that the soils of the hotspots of arsenic affected areas where no arsenicosis patients are prevalent contain higher Se content which ultimately enter into the food chain through edible plants grown and thus provide Se supplement which may help to minimize the effect of chronic As poisoning in human beings. Several reports are there in support of the present findings where it is stated that Se can directly counteract As toxicity in tissue culture (Sweins, 1983; Babich *et al*., 1989; Hu *et al*., 1996; Davis *et al*., 2000). Wang *et al*. (2001 and 2002) have shown that (1) after 14 months of Se supplementation the severity of symptoms of people with arsenicosis was reduced by 75%, (2) the people with arsenicosis taking Se supplements showed no deterioration of symptoms whereas 16 % of control showed symptomatic deterioration and (3) that As in blood, urine and hair declined with Se treatment over time in comparison to control subjects. It is also suggested that in areas of highly contaminated As ground water, selenium supplements might prevent, delay or ameliorate arsenicosis (Spallholz *et al*., 2004). According to the findings of the above reports it is apparent that the Se supplementation helps in minimizing the chronic effect of As in arsenic affected peoples or in arsenicosis patients. The findings of this study reveal that the soil and plant samples collected from both sites where arsenicosis patients are found and where no arsenicosis patients are found contain almost similar amount of As but the samples (soil and plant) collected from the sites where no arsenicosis patients are found contain higher amount of Se than the samples collected from the sites where arsenicosis patients are found. It could thus be concluded that as the soils of the areas where no arsenicosis patient are found are richer in Se content, this Se is providing Se supplement through food chain transfer thus alleviating or minimizing the chronic effect of As.

ACKNOWLEDGEMENT

The authors would like to acknowledge the Bangladesh Council of Scientific and Industrial Research (BCSIR), for providing financial assistance as well as for providing Laboratory facilities.

REFERENCES

APSU. 2005. The response to arsenic contamination in Bangladesh: A position. Paper published by DPHE. Dhaka, Bangladesh. pp. 57

Babich, H., Martin-Alguacil, N. and Borenfreund, E. 1989. Arsenic-Selenium interaction determined with cultured fish cells. Toxicol. Lett. 45:157-164.

BGS/DPHE. 1999. Groundwater studies for arsenic contamination in Bangladesh. Final report, (vol. 1): Summery. Department of Public Health and Engineering, Government of Bangladesh, Dhaka, Bangladesh.

BGS/DPHE. 2001. Arsenic Contamination of Groundwater in Bangladesh. In: Final Report. Eds. Kinniburg, DG. and Smedley, PL. British Geological Survey Report (vol. 2). WC/00/19.

Chakravarty, I., Sinha, RK. and Kalpana, G. 2003. Arsenic in Food Chain-A study on Both Raw and Cooked Food. In Arsenic Contamination: Bangladesh Perspective. Ed. Ahmed, MF. INT- Bangladesh. BUET, Dhaka-1000. pp. 230.

Combs, GF. Jr. 2001. Selenium in global food system. Br. J. Nutr. Rev. 85:517-547.

Correll, R., Imamul Huq, SM., Smith, E., Owens, G. and Ravi, N. 2006. Dietary intake of arsenic from crops. In: Managing Arsenic in the Environment: From Soil to Human Health. Eds. Naidu, R., Smith, E., Owens, G., Bhattacharya, P. and Nadebaum, P. CSIRO Publishing, Melbourne, Australia. 255-271.

Davis, CD., Uthes, EO. and Finlay, JW. 2000. Dietary selenium and arsenic affect DNA methylation in vitro in caco-2 cells and in vivo in rat liver and colon. J Nutr. 130:2903-2909.

Frausto da Silva, JJ. R. and Williams, RJP. 2001. The biological chemistry of the elements. Oxford University Press. Inc., New York, USA. pp. 497.

Hu, GG., Lui, X. and Lui, J. 1996. Protective effect of sodium selenite and selenomethionine on genotoxicity of human peripheral lymphocytes induced by arsenic. Chung Hua Yu Fang I Hsueh Tsa Chih. 30:26-29 (in Chinese).

Imamul Huq, SM. 2008. Fate of arsenic in irrigation water and its potential impact on food chain. In: Arsenic Contamination of Groundwater: Mechanism, Analysis, and Remediation (Ch. 2). Ed. Sutinder, A. John Wiley & Sons, Inc. ISBN 978-0-470-14447-3.

Imamul Huq, SM. and Alam, MD. 2005. A Handbook on Analyses of Soil, Plant and Water. BACER-DU, University of Dhaka, Bangladesh. ISBN: 984-32-1770-5. xxii+pp246.

Imamul Huq, SM. and Naidu, R. 2003. Arsenic in Groundwater of Bangladesh: Contamination in the Food Chain. In: Arsenic Contamination: Bangladesh Perspective. Ed. Ahmed, MF. INT- Bangladesh. BUET, Dhaka-1000. 203-204, 211.

Lakin, HW. 1961. Selenium in Agriculture. In: Agricultural Handbook. Agriculture Research Service, US Department of Agriculture in cooperation with the Geological Survey, US. Department of Interior, Washington, DC, USA.. No. 200. p. 3.

Lakin, HW. and Davidson, DF. 1967. In: Symposium: Selenium in Biomedicine. Ed. Muth, OH. Avi Publishing Co. Inc., Westport, Conn. pp. 27.

Portman, JE. and Riley, JP. 1964. Determination of arsenic in seawater, marine plants and silicates and carbonate sediments. Anal. Chem. Acta. 31:509-519.

Raymond, MP. 2000. The importance of selenium to human health. Lancet. 356:233-241.

Rosenfeld, I. and Beath, OA. 1964. Selenium-Geobotany, Biochemistry, Toxicity, and Nutrition. Academic Press, New York, USA. 129-133.

Spallholz, JE., Mallory, BL. and Rhaman, MM. 2004. Environmental Hypothesis: is poor dietary selenium intake an underlying factor for arsenicosis and cancer in

Bangladesh and West Bangal, India. Science of the Total Environment. 323:21-32.

Sweins, A. 1983. Protective effect of selenium against arsenic-induced chromosomal damage in cultured human lymphocytes. Hereditas. 98:249-252.

USDA. 1951. Soil survey manual. Handbook. 80.503

Wang, W., Yang, L., Hou, S., Tan, S. and Li, H. 2002. Effect of selenium supplementation on arsenism: an intervention trial in inner Mongolia. Environ Geochem Health. 24:359-374.

Wang, W., Yang, L., Hou, S., Tan, S. and Li, H. 2001. Prevention of endemic arsenism with selenium. Currt Sci. 81:1215-1219.

World Health Organization (WHO). 1996. Guidelines for Drinking water Quality. (2nd edi.). 2:158-162.

Received: Nov 29, 2014; Revised: Dec 26, 2014; Accepted: Dec 29, 2014