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Arsenic Contamination in Rice Production Irrigation Water in Bangladesh

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Abstract

Background: As a developing country, Bangladesh is totally dependent on irrigation water in respect of food production. This study aimed to assess the arsenic concentration in rice production irrigation water in Bangladesh. **Methods:** The cross-sectional analytical study was carried out in the Department of Biochemistry and Molecular Biology, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh. Total 100 water samples from the deep tube-wells (Used for irrigation) were collected. No major Ethical Implication was required. Statistical analysis was done by SPSS 24 version. **Result:** Maximum arsenic concentration in water was found in Bancharampur 132 µg/L and Minimum arsenic concentration in water was found in Sirajdi khan 4 µg/L. In Bajitpur mean±SD was 48±15.56, in Arihajar mean±SD was 64±23.6, in Bancharampur mean±SD was 47±35.2, in Shariyatpur mean±SD was 43±28.3 and in Sirajdi khan mean±SD was found 70±47.2. Inferential statistics was done at a 95% confidence interval and 5% level of significance. **Conclusion:** On account of arsenic-contaminated irrigation water, any adverse effects on the nutrient content of food would only enhance not only produce the nutritional problem but also produced chronic arsenicosis followed by various health hazards.

Keywords:- Arsenic, Contamination, Rice production, Irrigation water.

INTRODUCTION

The name arsenic is derived from the Greek word "arsenikon" which means yellow orpiment. Arsenic is not a typical metal. Being a metalloid it exhibits metallic as well as non-metallic characteristics and the corresponding chemical process. Arsenic is acquainted as one of the severely toxic industrial along with geochemical pollutants.[1] Arsenic inhabits in foods in two forms- organic and inorganic. The inorganic form includes As+3 and As +5. Arsenobetaine and arsenocholine are two common arsenic found in food. The inorganic arsenic form is toxic to humans. Among the inorganic ones, as+3is 60 times more poisonous than As+5 and inorganic arsenic is 100 times more toxic than its methylated form.[2] Many acute and chronic health consequences are occurred by exposure to these substances. It gets into the human body through ingestion (water and meals), inhalation or skin absorption and also may be inorganic and organic form. The main route of involuntary exposure to arsenic is the presence of arsenic in drinking water.[3] The term chronic arsenicosis is defined as a chronic condition due to prolonged exposure (six months to two years or more) of arsenic above safe level generally

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manifested by skin lesion with or without the involvement of internal organs and malignancies. The dermatological variations appear in almost all cases of chronic arsenicosis.[4] In the case of chronic arsenic poisoning, the long term retention of arsenic is most obvious in hair and skin, squamous epithelium of the upper gastrointestinal tract (oral cavity, esophagus, and the esophageal part of the stomach mucosa), the epididymis, thyroid, lens and skeleton as well. In Bangladesh, drinking water is extensively contaminated with arsenic. An alarming point that has to be raised is that the people of this region are continuously getting exposed to the arsenic toxicity which causing serious health hazards. Approximately 70 million peoples are thought to be potentially at risk of consuming arsenic contaminated water.[4] The maximum permissible concentration of arsenic in water is 0.05 mg/L(5) is narrated by World Health Organization.[5] Ground water from depth of more than 150-200 m seems to be inevitably arsenic free.The ground water arsenic problem in Bangladesh emerges because of unfortunate three combinations of these factors: arsenic is present in the ground water, arsenic is released from the sediments of ground water and arsenic is flushed away in the natural groundwater circulation.[6]

Food monitoring data reveal that trace concentration of arsenic is present in all food stuffs. Total arsenic concentration in food from various countries vary broadly which is dependent upon the food type, growing condition (type of soil, geochemical activities, use of arsenical pesticides) and processing techniques. Studies exhibit that highest concentration of total arsenic is found in the sea food, meats and cereals are in higher concentration than vegetables, fruit and dairy products.[7] Initial findings suggests that inorganic arsenic accounts for 75% in dairy products, and 65% in cereals.[8] Most of the national data on dietary intakes are derived from total diet studies. Since it is difficult to analytically differentiate the chemical forms of arsenic in food, although many countries have surveillance program to assess health risk form chemicals through diet studies. Average estimated dietary intake of arsenic in various countries are as follows: Australia- 0.061 mg/day; Canada- 0.59 mg/day; Japan- 0.182 mg/day; Spain- 0.291 mg/day; UK- 0.063 mg/day; USA- 0.053 mg/day.[9] This study is aimed to find out arsenic contamination in rice production irrigation water in Bangladesh.

MATERIAL AND METHODS

The cross-sectional analytical study was carried out in the Department of Biochemistry and Molecular Biology, Bangabandhu Sheikh Mujib Medical University, Shahbag, Dhaka. The duration of this study was approximately 1 year. This study was conducted in water collected from the deep tube-wells used for the cultivation of rice. Total 100 water samples from the deep tube-wells (Used for irrigation) were collected. Both water samples were collected from 5 upstairs of Bangladesh (Bajitpur, Arihazar, Bancharampur, Shariyatpur, Sirajdikhan). Due to nil potential risks, no informed consent from the subjects was taken. No major Ethical Implication was required. Statistical analysis was done by SPSS 24 version. Irrigation water collected from the arsenic-contaminated areas was included and irrigation water collected from any arsenic-free areas was excluded from the study.

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The freeze-dried sample was at first thawed, then kept under the sun for three consecutive days to remove the moisture. After sundry. The samples were homogenized using a commercial home vegetable grinder. After grinding each sample, the grinder was cleaned with detergent and de-ionized water, so that no arsenic could transfer from one sample to another. A sub-sample of 0.5 gm was weighed from the homogenized sample and transferred to a test tube in order to use later on for digestion purposes.

All the samples were digested in the water bath at 95c, using nitric acid (HNO3) and hydrogen per oxide. Nitric acid and hydrogen per oxide added at time of interval as per schedule. The digestion was thought to be completed when the final digestant was cleared or straw colored. Following digestion each digestant was cooled and diluted with de-ionized water to a final volume of 25 ml.

Rice digestant analyzed for total arsenic, using Graphic furnabnce Atomic absorption sphectophotometer-6650 of shimadzu using WizArd software and a 60 sample capacity auto sampler. The WizArd software recommended optics parameters was followed, as well as built in furnace program of the software for arsenic measurement. Three replicate readings were taken for each sample and the mean value was considered as sample concentration. The value for the maximum allowable RSD 7.0 was adapted for this study. Before each analytical run the GFAAS was freshly calibrated for arsenic measurement. The calibration curves were performed using calibration standard, preparation by diluting the stock Arsenic Standard Solution of Wako. Arsenic in Nitric acid solution dropped on the platform in the graphite tube was thermally stable up to 600c. Addition of matrix modifier extends the range of arsenic stability to 1100c. Numerous modifiers were used to stabilize arsenic in high furnace temperature, here 5 percent magnesium nitrate was used in this study as a modifier.

RESULTS

Arsenic concentration in water at Bajitpur area of Bangladesh was showed in [Table 1]. Arsenic concentration in water at Arihajar area of Bangladesh was showed in [Table 2]. Arsenic concentration in water at Bancharampur area of Bangladesh was showed in [Table 3]. Arsenic concentration in water at Shariyatpur&Sirajdikhan area of Bangladesh was showed in [Table 4, 5] respectively. Graphical presentation of maximum values of arsenic-contaminated water of the selected areas was showed in [Figure 1] and minimum values of arsenic-contaminated water were showed in [Figure 2].

Table 1: In Bajitpur area, arsenic concentration in irrigation water

Name of the area	Arsenic concentration in irrigation water group (µg/L)	Count of Union (n=20)	%
Bajitpur	0-25	1	5
	26-50	10	50
	51-75	8	40
	76-100	1	5
	101-125	0	0

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	126-150	0	0
Total		20	0
Max-Min=84-23		Mean±SD=48±15.5	

Table 2: Arsenic concentration in irrigation waterof Arihajar area

Name of the area	**Arsenic concentration in irrigation water group (µg/L)**	**Count of Union (n=20)**	**%**
Arihajar	0-25	2	10
	26-50	2	10
	51-75	10	50
	76-100	6	30
	101-125	0	0
	126-150	0	0
Total		20	0
Max-Min=91-13		Mean±SD=64±23.6	

Table 3: Arsenic concentration in irrigation water of Bancharampur area

Name of the area	**Arsenic concentration in irrigation water group (µg/L)**	**Count of Union (n=20)**	**%**
Bancharampur	0-25	7	35
	26-50	4	20
	51-75	6	30
	76-100	1	5
	101-125	1	5
	126-150	1	5
Total		20	100
Max-Min=132-6		Mean±SD=47±35.2	

Table 4: Arsenic concentration in irrigation water of Shariyatpur area

Name of the area	**Arsenic concentration in irrigation water group (µg/L)**	**Count of Union (n=20)**	**%**
Shariyatpur	0-25	7	35
	26-50	6	30
	51-75	4	20
	76-100	2	10
	101-125	1	5
	126-150	0	0
Total		20	100
Max-Min=108-9		Mean±SD=43±28.3	

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Table 5: Arsenic concentration in irrigation waterSirajdikhan area

Name of the area	Arsenic concentration in irrigation water group (µg/L)	Count of Union (n=20)	%
Sirajdikhan	0-25	6	30
	26-50	2	10
	51-75	1	5
	76-100	2	10
	101-125	9	45
	126-150	0	0
Total		20	100
Max-Min=122-4		Mean±SD=70±47.2	

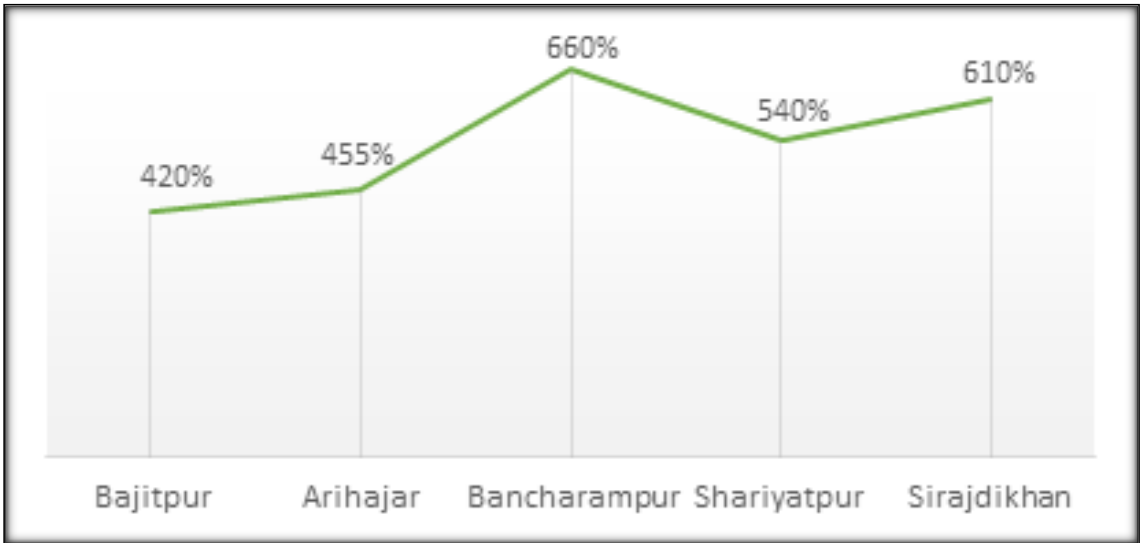

Figure 1: Maximum arsenic concentration in water (µg/L) (n=100)

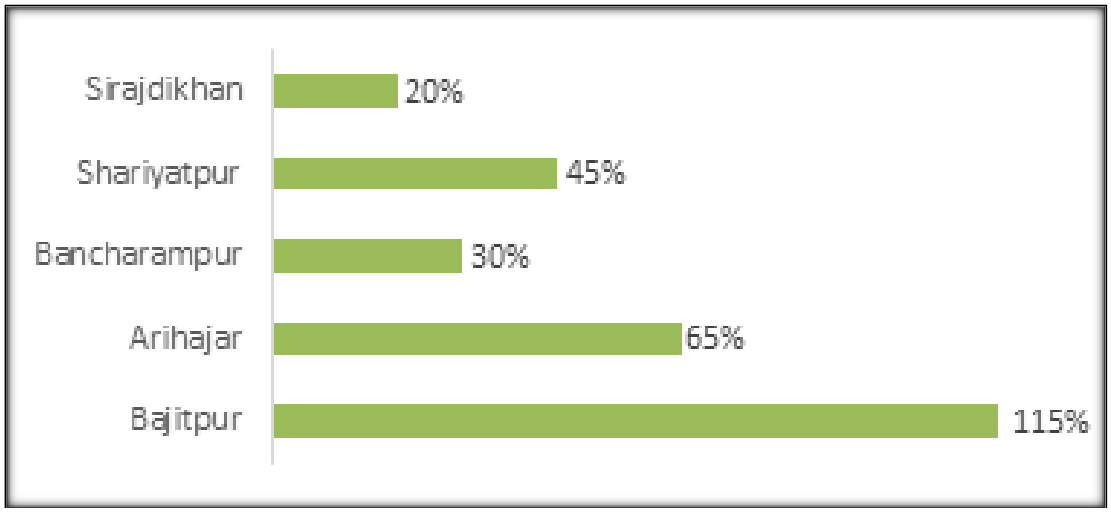

Figure 2: Minimum arsenic concentration in water (µg/L) (n=100)

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DISCUSSION

The current drinking water standard for arsenic in Bangladesh is estimated that approximately 27% of the tube-wells are contaminated with levels above 50ppb (WHO standard is 10 ppb). Large-scale use of groundwater for irrigation began 20 years ago in Bangladesh with the "green revolution".[10] In this study, arsenic concentration of water from the selected spots recorded a maximum value of 660% in Bancharampur and minimum value of 20% in Sirajdikhan where arsenic concentration in natural water was revealed by as 10–5000µg/1 in baseline groundwater.[11,12,13] Highest concentration of arsenic was found up to 38.8mg/1 where in present study the mean range of arsenic in irrigation water was 43.01-70.49 µg/L. Water contamination by arsenic is a hazardous threat to humanity throughout the world.[12] Utmost value of arsenic concentration was found upto 3oo µg L−1.[13] Arsenic concentrations in water being significantly below the Class III water national standard for surface water (0.05 µg L−1),[14] among the water samples 59% contained arsenic levels above 50 µg/L of WHO recommendation.[15] In the environment arsenic and its compounds are mobile. Arsenic sulfides converted into arsenic trioxide through weathering of rocks, by dissolution in rain, rivers, or groundwater it enters the arsenic cycle as dust. A study revealed the arsenic concentration level below the limit proposed by international standards.[16,17] Another study statedthat there was no significant correlation between arsenic concentration in water and arsenic concentration in rice which might be due to the production process.[18] The total inorganic arsenic concentration in well water ranged from 7 to 740 µg L−1 and about 90% of the total arsenic was found as As(V).[19] Water pumped from one of the most productive wells of Zimapán Valley, Mexico where arsenic contamination of groundwater had been detectedas much as 1.097 mg/L were observed.[20] Irrigation water had arsenic concentrations up to 780µg/1 arsenic in that study area.[21] Arsenic concentration exceeding 10µg/1 observed frequently in western United State, water is significantly associated with arsenic concentration ≥10g/1 particularly in the west.[22,23,24] The most important route of exposure is through the oral intake of food and drinking-water, including beverages made from drinking-water except occupationally exposed to arsenic individuals. Findings showed the mean daily intake of arsenic from drinking-water was generally be less than 10 µg. Arsenic concentration level in natural waters, including open ocean seawater, generally ranges between 1 and 2 µg/1.[22] In 1993 in the Nawabganj district of Bangladesh, arsenic contamination of water in tube-wells was confirmed at first.At least 100000 cases of skin lesions caused by arsenic.[23] Arsenate containing irrigation water diminished plant height, mitigated rice yield and invaded development of root growth.[25]

Limitations of the study:

This study was conducted in some selected areas. The results were not reflected all the areas of Bangladesh.

CONCLUSIONS

The distribution of arsenic in water was explored in order to investigate the influence of irrigation water with arsenic on the soil–plant system, and to determine its impact on

the environment and human health. The findings hopefully will facilitate to know the accurate arsenic concentration ofwater simultaneously in different arsenic contaminated areas.

Recommendation

Develop proper management options so that the policy makers may take some necessary steps for arsenic contamination in water along with rice according to need.

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