

Contribution of arsenic from agricultural food chain to cow milk in highly arsenic prone zone in Nadia District of West Bengal in India

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Abstract

Shallow tube well water is highly contaminated with arsenic (As) in arsenic affected area in West Bengal. The results of a total 25 samples in that area showed increased level of arsenic contents in soil (range: 9.671 to 14.964 ppm, n=5), tube well water (range: 0.171 to 0.497 ppm, n=5), paddy plants (range: 0.994 to 3.059 ppm, n=5) and the concentration of cow milk (mean: 0.156 ± 0.009 ppm) was 12 times higher than the healthy cattle (0.013 ± 0.011 ppm) from non affected area. Extensive withdrawal of arsenic contaminated ground water contaminates surface soils and plants and causes hazardous effect on animals and arsenic contaminated milk would be dangerous for human consumption through food chain.

INTRODUCTION

Arsenic is one of the most toxic metals derived from natural environment. It is relatively common element that occurs in air, soil and all living tissues. Ground water is one of the most important sources of drinking water and the contamination of ground water with arsenic is one of the serious problems encountered in India. Soil contamination with arsenic occurs through the vehicle-contaminated groundwater being used for irrigation. Arsenic contamination of plants occurs by irrigation with contaminated ground water. The input of arsenic to soil from various sources may prove detrimental to plant through its uptake to the toxic limit, thereby facilitating its entry into the food chain. There is also the possibility of biomagnification of the toxin as it travels up in the food web (Sanyal and Nasar, 2002, Ghosh et al., 2004). The present study was undertaken with the following objectives:

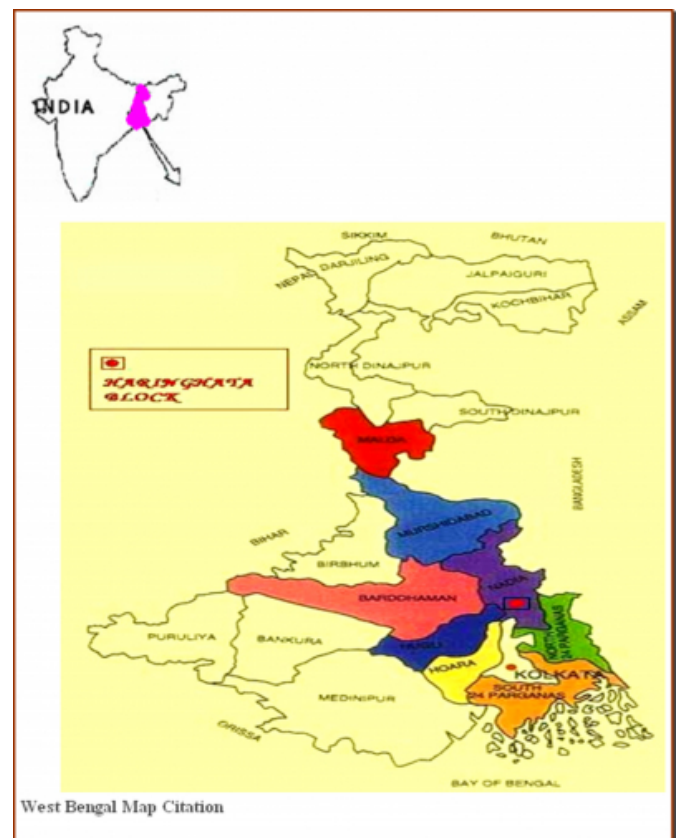
To determine the concentration of arsenic in soil and to correlate these level with the amount of arsenic this is contaminated with ground water.

To determine the concentration of arsenic in paddy plants that are consumed by cattle.

To determine the contribution of arsenic from agricultural food chain to cow milk.

Figure 1

Figure 1: showed the location of highly arsenic prone zone (indicated by red circle) in Nadia district of West Bengal in India.



MATERIALS AND METHODS

SAMPLING

Soil, drinking water, plants and milk collected at Nonaghata area of Haringhata block of Nadia District of West Bengal in India.

SOIL

The soil samples for analysis were collected from the grazing field of animals. The profile pit was excavated deep enough (6'-1') so that profile was uniformly lighted and revealed the principle features and to extend down to the parent material. Each soil sample thus collected was placed in a double walled cloth or paper bag. The soil sample was then air dried at a temperature of about 25°C to 35°C. The bulk soil samples for chemical analysis were passed through a 2mm (10 meshes per inch) sieve, usually by rubbing with the fingers or with the use of grinders or pestle and mortar (Jackson, 1967).

DRINKING WATER

Water samples were preserved with 4 ml concentrated hydrochloric acid (HCl) per litre and analyzed within 7 days of collection (Das et al. , 2000).

PLANTS

The envelop containing samples was put in a hot air oven, at 100°C for drying up of sample and the samples were processed further as per the method described by AOAC (1975).

MILK

Cow's milk was obtained during the cow's milking and 1-L was placed into a polyethylene bottle previously rinsed with 20% nitric acid in deionized water (Rosas et al, 1999).

ARSENIC ANALYSIS

EXTRACTION PROCEDURE

SOIL

Soil samples (1 gm each) were digested with 10 ml of tri-acid mixture of nitric acid (HNO₃), sulphuric acid (H₂SO₄) and perchloric acid (HClO₄) at the ratio of 6:4:1(V/v) after properly weighing in electronic weighing balance and the samples were placed on heating platform at the temperature of less than 150°C until watery colour of the solution appeared. After the samples completely digested were cooled and the clear mixture is transferred to a 10 ml of volumetric flask and the volume was made upto mark with

triple distilled deionised water. The solution was then filtered through Whatman filter paper (No. 1) and the filtrate was used for arsenic estimation within few hours (Sarder, 2004).

DRINKING WATER

Water samples were preserved with 4 ml concentrated hydrochloric acid (HCl) per litre and directly estimated in atomic absorption spectrophotometer.

PLANTS

Oxidation of the organic matter of the plant tissue and release of the mineral elements were affected through wet oxidation by means of oxidizing acid such as HNO₃, H₂SO₄ and HClO₄ acid mixture in the ratio of 10:1:4 (V/v) respectively. 0.5 gm of the dried plant sample was taken in 100 ml conical flask. 10 ml of tri-acid mixture was added to it. It was kept for overnight. Then digestion was completed on hot plate at 180-200° C until dense white fumes of H₂SO₄ and HClO₄ were evolved. The content in the flask after digestion was transformed to mineral crystal of each sample. After cooling it was transferred to 50 ml volumetric flask by several washings through Whatman filter paper (No. 42.). Washing of each sample was done by triple distilled water and made up the final volume to 50 ml (Jackson, 1967).

MILK

Samples of 10 g of raw milk were digested with concentrated nitric and sulfuric acids and 30% hydrogen peroxide, and diluted to 50 ml with 20 ml of concentrated hydrochloric acid and deionized water. (Rosas et al. , 1999)

ANALYSIS

A Perkin-Elmer Model 460 atomic absorption spectrophotometer equipped with MHS-10 Mercury/Hydride System and an HGA-2100 graphite furnace was used. To determine total arsenic in soil, drinking water, plants and milk, 1 ml of 10% potassium Iodide solution was added to 10 ml of sample or an aliquot diluted to 10 ml. After 60 min, arsenic was determined by the hydride evolution method with sodium borohydride and the MHS-10 Mercury/Hydride System (Perkin-Elmer, 1979). Calibration was performed by preparing series of standards adding specific chemicals from the various matrices. The As was measured by Graphite Furnace Atomic Absorption Spectrometry (GFAAS) by injecting 20 µL of the MIBK phase into the graphite tube. (Rosas et al. 1999). All the data obtained were analysed in SPSS (version 10.0) following general linear model. The

means were compared using Independent t tests. Probability of $P < 0.01$ and $P < 0.05$ were described as highly significant (at 1% level) and significant (at 5% level) respectively.

Criteria for selection of soil, drinking water and plants for analysis:

The total no of 15 samples were analysed for estimation for arsenic in soil, plants and drinking water.

The following samples were as follows.

Figure 2

Name	No. of samples	Types of cases.
soil	5	Pit from the grazing area
Drinking water	5	From deep tube well and surface water
Plants	5	Paddy plants

CRITERIA FOR SELECTION OF CLINICAL CASES AND EXPERIMENTAL DESIGN

A total number of ten clinical cases suspected to be suffering from arsenic toxicity with the clinical signs including depression, prostration, weight loss, weakness, dehydration, anaemia, anorexia, diarrhoea with blood, ruminal stasis, lethargy, dermatosis, reddish urine, dry dull rough, epilated hair coat, anoestrus were screened by haemato-biochemical examinations. They were selected for inclusion in the present study based on the significant alterations suggesting of arsenic toxicity. These ten healthy animals were kept as a healthy control group (Gr. I) and the ten clinical cases of each species which were randomly selected for this study were kept as experimental group (Gr.II).

CRITERIA FOR ANALYSIS OF MILK OF ANIMALS

Figure 3

Samples name	No. of samples	Types of cases.
Milk	10(Gr. I) 10(Gr. II)	Cow's milk was obtained during the cow's milking and 1-L was placed into a polyethylene bottle previously rinsed with 20% nitric acid in deionized water.

RESULTS AND DISCUSSION

ARSENIC IN SOIL

The analytical result of mean As concentration in soils (12.08 ± 0.94 ppm) of the grazing field was 1.2 times higher than the recorded report of natural concentration of 10 ppm worldwide (Berrow and Reaves, 1984). The concentrations

varied from 9.671 to 14.964 ppm (table.1.), which was simulated with the report of Ghosh et al. (2004) and Sanyal and Dhillon (2005).

ARSENIC IN DRINKING WATER

The results of shallow tubewell water showed in table 1. The mean As concentration (0.307 ± 0.054 ppm) in shallow tubewell (94-163 feet's depth) water was about 6 times higher than the maximum permissible limit of 0.05 ppm in India. Arsenic content in water samples varied from 0.171 to 0.497 ppm. The water samples randomly collected from 5 distinguished areas of Nonaghata mouza of Haringhata Block had total arsenic contents above the [USEPA (1980) and DOF (1996) National Drinking Water Standards (50 $\mu\text{g/L}$), and WHO (1993) standard of 10 $\mu\text{g/L}$]. The present findings in respect with the status of As in the drinking water was in close similarity with Chakravarty and Saha (1987) and Ghosh et al. (2004).

ARSENIC IN PLANTS OF GRAZING FIELD

Paddy is the most important amongst the crops grown in India. Paddy grown on the soils adjacent to the contaminated water is analyzed for total arsenic. The mean arsenic concentration in paddy plants was 1.750 ± 0.39 ppm that was varied from 0.994 to 3.059 ppm (table 1). This was higher than the detection limit of 0.005 mg/kg (Korenovska, 2001). The present findings in respect with the status of As in the plants were in close similarity with Das et al. (2003), Ghosh et al. (2004) and Sanyal and Dhillon (2005). The arsenic present in soil was absorbed by paddy plants (*Oriza sativa*) and among 5 samples one sample was higher than 2.6 $\mu\text{g/gm}$ of As, considered as permissible limit for edible crops by US Public Health Service (Jones and Hatch, 1945).

Figure 4

Table 1: Mean ± S.E. of the values of arsenic level in soil, drinking water and plants

Name of the site		Total arsenic in soil (n=5) ppm=µg/gm	Arsenic in drinking water (n=5) ppm=µg/ml	Arsenic in rice plants (n=5) ppm=µg/gm
Nonaghata Mouza of Haringhata Block, Nadia, West Bengal, India	Site1	10.413	0.258	1.171
	Site 2	14.964	0.343	1.235
	Site 3	12.215	0.497	0.994
	Site 4	9.671	0.264	3.059
	Site 5	13.137	0.171	2.292
Mean ± S.E		12.08 ± 0.94	0.307 ± 0.054	1.750 ± 0.39

ARSENIC IN MILK OF ANIMALS

From the table 2, statistical analysis showed that the arsenic concentration in milk of Gr. II (0.156 ±0.009 ppm) was higher than the healthy control animals of Gr.I. (0.013 ± 0.011 ppm).The concentration of As in milk was significantly increased (P<0.01) which suggested the presence of As in food chain that would be dangerous for human consumption in public health point of view.The fact that the heavy metals have been capable of translocating into bovine milk has been previously reported (Sharma et al., 1982).There was report that the permitted arsenic level should be less than 10 ng/g (International Dairy Federation, 1986).

Figure 5

Table 2: Mean ± S.E. of the value of arsenic level in cowmilk of Control (Gr.I) and Affected (Gr.II)

Parameters	Healthy control (Gr I)	Affected(Gr. II)
Milk samples	0.013±0.011	0.156±0.009

Superscript (a, b) denotes there is significance difference exist between two mean.

Significant value (P<0.01) indicates highly significant at 1% level.

Significant value (P<0.05) indicates significant at 5% level.

SUMMARY

The present study was carried out on the basis of status of arsenic in soil, drinking water and plants and milk of animals at arsenic prone zone. The content of arsenic in soil, drinking

water and paddy plants in affected zone were found to be in the range from 9.671 to 14.964 ppm, 0.171 to 0.497ppm and 0.994 to 3.059 ppm respectively. While comparing with the literature it was found that all the values were above the permissible limit. The arsenic concentration milk of arsenic affected cattle were (0.156 ±0.009 ppm) where as in control animals it was 0.013 ± 0.011 ppm).

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