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Entry of Arsenic into Food Material - A CAse Study

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Abstract: EPA has classified inorganic Arsenic (as) as a Group A, human carcinogen. Along with water and soil as also entered into the food chain prominently around the Gangetic belt of Bangladesh and India thus, posing threat on the exposed population. Therefore, the study was undertaken to investigate the entry of as in food materials along the levee of river Ganges in Bihar (India). Water samples were collected from Hand Tube Wells, soil and four representative food samples Wheat, Rice, Pulse and Maize, from the agricultural land. A standard Silver Diethyle Dithio Carbamate (SDDC) method was adopted to analyze the samples for as using Thermo (UV-1) Spectrophotometer. Per capita consumption of water through drinking and cooking sources was also calculated. Water samples were highly intoxicated with a mean value of 0.141mg/l (n=20). The mean value of as in soil was 0.027mg/kg (n=6). All food samples were as positive. Wheat recorded the maximum (0.024mg/kg) and the minimum was in maize (0.011mg/kg). These local food crops provide the majority of the nutritional intake of the people in this area. Poor nutrition and dependency on these contaminated water and food sources are therefore of great importance to their overall health.

Key words: Arsenic · Food-Chain · Phyto-accumulation · Contamination · Health Risk

INTRODUCTION

Arsenic (as) contaminated water from tube wells has become the major health problem threatening millions of people in Bihar [1]. as in groundwater was first reported in Semria Ojha Patti village of the Sahapur police station in Bhojpur district of Bihar, India in June 2002 [2]. Later in 2005-2006, the Public Health Engineering Department of Bihar and A. N. College, Patna, with assistance from UNICEF, conducted testing of ground water Arsenic contamination along the river Ganga in 50 blocks of these 11 districts; Patna, Vaishali, Bhojpur, Bhagalpur, Buxor, Chhapra, Munger, Khagaria, Begusarai, Samastipur and Katihar [3]. Out of the total 66,623 sources sampled, 7164 (10.8%) of the samples were found to contain arsenic concentrations>50ppb. Bhojpur and Bhagalpur was the worst affected district among others, as 1861ppb arsenic was detected in the water of the tube well of the Bhojpur area. Sixty persons with arsenical skin lesions were also reported in Bihar [2].

However, the as contaminated water was not being used only for drinking, but also to irrigate crops, washing and preparing food materials. Cultivation of different cereals and vegetables generally depend on rain water and groundwater in Bihar, but due to irregular precipitation in this area farmers mostly depend on ground water. Rice, Wheat, Maize, Lentils etc. are the widely cultivated crops in Bihar and are the main staple food and thus, require huge volume of groundwater for irrigation. But, the groundwater of Bihar has been highly contaminated with as. Thus there is a possibility of induction of as in cereals, cultivated with contaminated irrigation water and soil [4]. Contamination of agricultural soils by long-term irrigation with as contaminated water can lead to contamination and eventually phyto-accumulation of the food crops with as.

as poisoning from food and beverages, wine, beer and cider causing fatalities among consumers were reported from France, England, Japan and US in the early twentieth century, Soya sauce containing **A**s

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concentration as high as 5600-71600 μg/l was also reported from Japan [5]. Highest mean as was also found in the potato skin, leaves of vegetables, arum leaf, papaya, rice, wheat, cumin, turmeric powder, cereals and bakery goods, vegetables and spices [6]. A direct correlation between as concentrations in commonly consumed vegetables, rice and as concentration in irrigation water was also confirmed [7,8]. Roychowdhury et.al. found that cooked rice had approximately twice the levels of as in raw rice probably due to parboiling and/or boiling rice in as contaminated water clearly indicates, increasing as concentrations in rice over time period because of the prolonged input of as contaminated irrigation water [9,10]. Root levels of 2-3μg/1 and an averaged 0.65μg/1as in shoots was also reported in wheat exposed to2 mg of as L-1[11]. Huq *et. al.* has reported that the largest contributor to as intake by Bangladesh villagers in affected regions are contaminated drinking water, food and vegetables [12]. as is a nonessential element for plants and the concentrations in plant tissues generally reflect environmental levels [11].

This emphasized the need to further monitor the entry of as in food chain and develop appropriate management options since continued use of as contaminated irrigation water was likely to increase the probability and magnitude of dietary arsenic intake [13]. In plains, the most important source of drinking and irrigation water had been the ground water rather than surface water. Therefore, continuous use of as contaminated ground for irrigation purposes, posing a significant risk of this toxic element accumulation in the soil and consequently entering into the food-chain through plant uptake and consumption by animals and humans.

Project Area Maner: Maner is one of the most important blocks of Patna district situated on the bank of the river Ganges between 25.65A° North latitude and 84.88A° East longitude. Two important panchayat Haldichapra (HC) and Rampur Diara (RD) of this block was selected for this study with a population of about 7,000. HC has been known as a flood affected area whereas; RD is partially affected by flood. There is another river 'Sone' passes through this panchayat. People are mainly depending on agriculture in both the area for their survival. Soil is highly fertile and Rice, Wheat, Maize, Pulses, Vegetables etc. are the dominant species cultivated in the area. About 70% of the vegetables from this area supplied to the nearest district town Patna. Communities mainly depend on ground water for drinking, cooking and irrigation also.

MATERIALS AND METHODS

Water Samples: Water samples were collected from Hand Tube Wells (used for mainly drinking, cooking and irrigation purposes by the communities) from both the Panchayats. The water samples were stored in polyethylene bottles, prewashed with concentrated Hydrochloric acid (1:1) and after collection it was been added as preservative. An arsine generator was used to produce arsine gas attached with the scrubber and detector units. All the prepared samples were immediately tested on the calibrated UV-spectrophotometer at 520nm for total as concentration.

Food Samples: Grains of one Sonam Dhan (Rice), 2338 Wheat (Wheat), K-H-101(Maize) and Lentils were collected from the farmers of RD only. These cereals were cultivated on the as affected field of RD only. The plants cultivated in the sub-lands, during field survey were Rice, Wheat, Maize and Lentil. After collection of food samples it was being carefully placed in individual polyethylene bags, stored in a box and transported to the laboratory. Dried food samples were digested and analyzed by standard SDDC method on Thermo-UV-1 Spectrophotometer.

RESULTS AND DISCUSSION

Ground Water of RD and HC was highly intoxicated with as. Out of total 20 water samples surveyed, assessed and analyzed, 100% samples were found to be contaminated with as (Table 1). The samples were collected from hand tube wells of different depth, ranges from 80 feet to 155 feet with a mean value of 108.5feet (n=20).

As concentration ranges from 0.008mg/l to 0.498 mg/l was about 50 times higher than WHO limit of 0.010 mg/l and about 10 times higher than BIS standard of 0.050 mg/l for drinking water. About 80 % water samples had Arsenic >0.050 mg/l, 15% with >0.010 <0.050 mg/l and only 5% sample was having <0.010mg/l of as with a mean value of 0.141mg/l (n=20) (Chart 1).

Total six soil samples were also collected from the project area and also tested for as contamination. All soil samples were as contaminated with the highest concentration of 0.044mg/kg (data not published)

All the four cereal digested and analyzed for as. Out of the entire cereals husk from rice grains were also separated and tested. All food samples were as positive. (Table 2). The highest value of as was detected in wheat

Table 1: Ground Water Arsenic Contamination in Maner, Patna (Bihar)

S. No.	Sample ID	Village	Source	pH	As (mg/l)
1	10/28/0001/900/PMRDW001	Rampur Diara	Hand Pump	6.5	0.070
2	10/28/0001/900/PMRDW002	Rampur Diara	Hand Pump	6.5	0.008
3	10/28/0001/900/PMRDW003	Rampur Diara	Hand Pump	7.0	0.015
4	10/28/0001/900/PMRDW004	Rampur Diara	Hand Pump	6.5	0.015
5	10/28/0001/900/PMRDW005	Rampur Diara	Hand Pump	7.5	0.040
6	10/28/0001/900/PMRDW006	Rampur Diara	Hand Pump	6.5	0.066
7	10/28/0001/900/PMRDW007	Rampur Diara	Hand Pump	6.0	0.077
8	10/28/0001/900/PMRDW008	Rampur Diara	Hand Pump	6.5	0.070
9	10/28/0001/900/PMRDW009	Rampur Diara	Hand Pump	6.5	0.057
10	10/28/0001/900/PMRDW010	Rampur Diara	Hand Pump	6.5	0.103
11	10/28/0001/900/PMHCPTW001	Haldichapra	Hand Pump	7.5	0.158
12	10/28/0001/900/PMHCPTW002	Haldichapra	Hand Pump	6.5	0.106
13	10/28/0001/900/PMHCPTW003	Haldichapra	Hand Pump	6.0	0.210
14	10/28/0001/900/PMHCPTW004	Haldichapra	Hand Pump	6.5	0.143
15	10/28/0001/900/PMHCPTW005	Haldichapra	Hand Pump	6.5	0.225
16	10/28/0001/900/PMHCNTW001	Haldichapra	Hand Pump	6.5	0.498
17	10/28/0001/900/PMHCNTW002	Haldichapra	Hand Pump	7.0	0.314
18	10/28/0001/900/PMHCNTW003	Haldichapra	Hand Pump	6.0	0.216
19	10/28/0001/900/PMHCNTW004	Haldichapra	Hand Pump	6.5	0.255
20	10/28/0001/900/PMHCNTW005	Haldichapra	Hand Pump	7.0	0.185

DESRIPTION OF CODES USED- 10/28/0001/900 - State/District/Block/Village

PMRD- P- Patna
M- Maner
RD- Rampur Diara

PMHCNT - P- Patna
M- Maner
HCPT- Haldichapra, Puranka Tola
HCNT- Haldichapra, Nayka Tola

Table No.-2: Arsenic in Food Samples of Maner, Patna (Bihar)

S. No.	Sample ID	Village	Food Items	Variety	As (mg/kg)
1	10/28/0001/900/PMRDF001	Rampur Diara	Wheat	Ub-2338	0.024
2	10/28/0001/900/PMRDF002	Rampur Diara	Maize	K-H-101	0.011
3	10/28/0001/900/PMRDF004	Rampur Diara	Rice- Grain	Sonam	0.019
4	10/28/0001/900/PMRDF004	Rampur Diara	Rice-Husk	Sonam	0.022
5	10/28/0001/900/PMRDF005	Rampur Diara	Lentil	NA	0.015

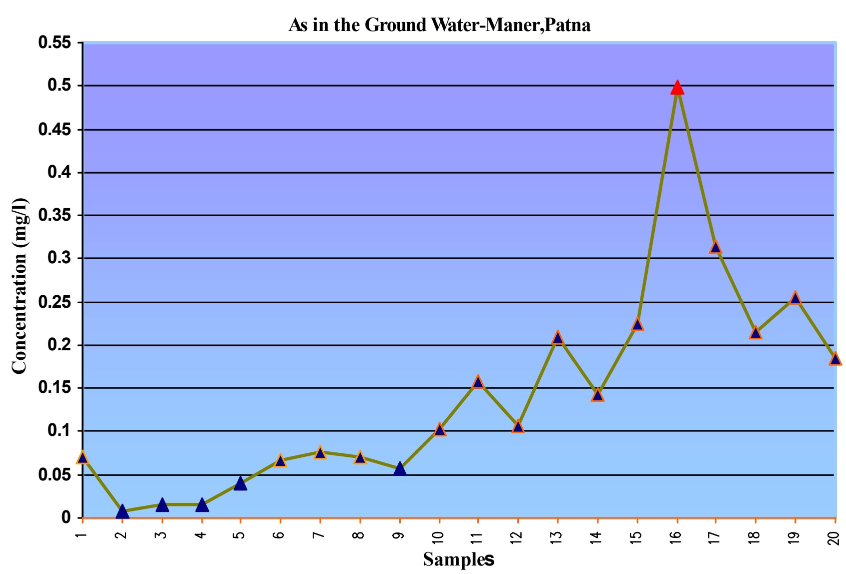

Chart 1: Arsenic in the Ground Water of Maner Block, Patna (Bihar)

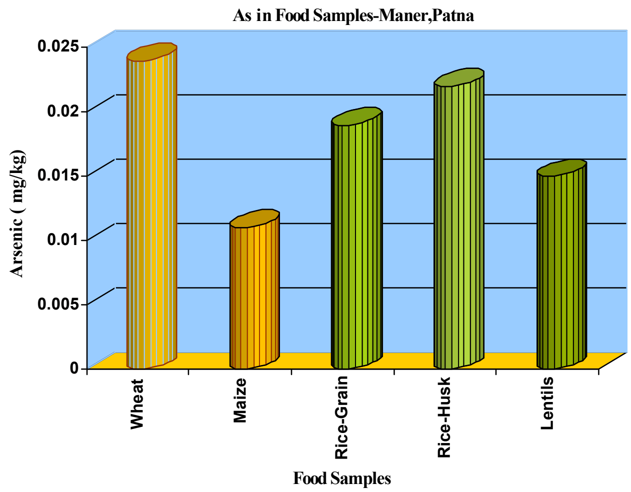

Chart 2: Arsenic in Food Samples of Maner, Patna (Bihar)

Table 3: The Daily Intake of Arsenic through different sources:-

Area	Person	Per Capita Consumption of Water through Different sources (In Ltr.) Drinking Water	Rice	Pulse	Vegetables	Total Consumption of Water /day (In Ltr.)	Level of as in Water (mg/l)	Intake of Arsenic / day (In mg/l)
Rampur Diara	Children	2.4	0.17	0.09	0.01	2.67	0.141	0.376
	Young	4.9	0.38	0.17	0.04	5.49	0.141	0.774
	Adult	5.8	0.34	0.16	0.03	6.33	0.141	0.893
	Old	6.1	0.24	0.14	0.02	6.50	0.141	0.917
Haldichapra	Children	2.5	0.184	0.099	0.068	2.85	0.141	0.402
	Young	5.3	0.351	0.168	0.126	5.94	0.141	0.838
	Adult	5.85	0.399	0.161	0.112	6.52	0.141	0.920
	Old	6.36	0.252	0.157	0.135	6.90	0.141	0.973

grains minimum in the maize. The concentration sequence of as in different food samples were *Wheat>Rice Husk>Rice Grains>Lentils>Maize*, with a mean value of 0.018mg/kg (n=5) (Chart 2). Rice husk showed more as concentration than the rice grain. In comparison with the Australian food standard i.e. one milligram/kg, the as value in different cereals were within the limit but, cumulative effect of as along with as contaminated drinking and irrigation water significantly affects human health.

In addition, as rice husk showed more as accumulation than rice grains therefore, it may also affects the cattle's health in these areas. Rice husk is one of the most favorite fodders for cattle's. However, there is a need of study of accumulation of as in the different parts of the different cereals and vegetables in these areas. After these kinds of studies we can be able to state that, who is more vulnerable, human beings or animals.

A survey was also conducted in both the panchayats to know the average intake of drinking water, water consumed through cooked food and consumption of food materials. A calibrated glass of 500 ml volume was used to know the consumption of water. The average drinking water consumption was recorded 2.4 ltr., 4.90 ltr., 5.80 ltr. and 6.10 ltr. by children , young person, adults and old persons respectively in RD and 2.50 ltr., 5.30 ltr., 5.85 ltr. and 6.36 ltr. in HC respectively (Table 3). Therefore, the total consumption of water through different sources was calculated to know the consumption of as per capita per day. The average total water consumption through drinking water, cooked rice, pulse and vegetables was 5.25 ltr. per capita per day in RD and 5.55ltr. in HC. The average per capita consumption of as through different sources was 0.740 mg/l per day in RD and 0.783 mg/l in HC respectively.

The highest consumption of as was by old persons in both the area followed by adults, young person and children respectively. It demonstrated that, the community was consuming arsenic as high as; 0.376 mg/day, 0.774mg/day, 0.893mg/day and 0.917 mg/day by children, young, adults and old persons respectively in RD and 0.402 mg/day, 0.838mg/day, 0.920 mg/day and 0.973 mg/day in HC respectively. Therefore, the as consumption by the communities exceeded the maximum allowable limit of consumption of as through food by a person 0.2 mg/kg/day the community were consuming more than twice and thrice. Hence, the cumulative effect of all is, they are eventually getting slowly poisoned by this hazardous menace.

CONCLUSIONS

The Ground Water of RD and HC panchayats of Maner block, Patna were highly intoxicated and the as level was 50 times more than the WHO permissible limit of 0.010mg/l. A significant as contamination was also found in soil and major cereals cultivated on the as contaminated ground, irrigated with as containing water. The confirmation of entry of as into food materials indicates future threats of entry into the food chain and its bioaccumulation. Therefore, all the three confirmed sources of Arsenic; Water, Soil and Food posing a serious threat to the residing communities and hence their health is at risk. Its cumulative effect can be fatal. In addition, the different parts of the harvested or tender plants and used grains/husks of these as contaminated plants is being used as the main source of fodders for the cattle's. Relatively higher accumulation of as in rice husk than rice grains also a threat for cattles. The community depends for milk, eggs and meat for animals. Therefore, there is high probability of entry of as into the food chain of Maner block. However, the current study suggests a regular monitoring of entry of as in water-soil-plant system with as species analysis in this area to confirm also the different form of as is being accumulated and available for soil and plant environment. The issue should also be dealt by providing various feasible mitigation options for as contaminated ground water and by ameliorating the nutritional status of the population.

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