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Public Health Risk of Arsenic Contamination in Food at Old Kahna, Lahore, Pakistan

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Poisoning from arsenic in drinking water is a very serious problem in Pakistan stressing the need for analysis of water, soil, food and other environmental samples to gauge the extent of risk posed to the health of general public and for remedial measures. Kahna (old) is a small locality of Lahore which was selected as a test site and drinking water samples and diverse food samples were collected randomly and analyzed for arsenic contents by arsenic testing kit and atomic absorption spectroscopy (graphite furnace). The arsenic amount in samples of drinking water (from sunken tube-wells installed in houses), milk, locally grown vegetables, mutton, beef, rice is 71 ppb, 13.50 ppb, 1.5, 1.6, 0.8, 3.7 and 0.3 mg/kg, respectively. Food values are under permissible levels but arsenic in water is much higher than standard thus exposing the population of Old Kahna at high cancer risk and other diseases.

Key Words: Arsenic contamination, Assessment, Lahore, Pakistan.

INTRODUCTION

In recent past, arsenic contamination in groundwater has emerged as an epidemic in different Asian countries such as Bangledesh, India and China[1]. Human activities have also introduced arsenic to water from urban runoff, pesticides, fossil fuel combustion, treated wood and smelting and mining wastes. Additional arsenic may enter water supplies from municipal and industrial waste sites[2]. Elevated concentrations of arsenic in drinking water are considerable hazard to human health[3-6]. The occurrence of arsenic in drinking water supplies, drawn from a variety of ground water environment has been reported in Argentina[7] and Bangladesh[6].

Drinking arsenic-rich water over a long period is unsafe and in some countries around the world the health effects are well known. However, delayed effects from arsenic poisoning, the lack of common definitions and poor reporting and local awareness in affected areas are major problems in determining the extent of the arsenic-in-drinking-water problem and developing adequate solutions according to WHO report[8].

Non-occupational human exposure to arsenic in the environment is primarily through the ingestion of food and water. Of these, food is generally the principal contributor to the daily intake of total arsenic. In some areas arsenic in drinking-water is a significant source of exposure to inorganic arsenic. In these cases, arsenic in drinking-water often constitutes the principal contributor to the daily arsenic intake. The daily intake of total arsenic from food and beverages is generally between 20 and 300 µg/d. Limited data indicate that *ca.* 25 % of the arsenic present in food is inorganic. But this depends highly on the type of food ingested. Inorganic arsenic levels in fish and shellfish are low (< 1 %). Foodstuffs such as meat, poultry, dairy products and cereals have higher levels of inorganic arsenic. Pulmonary exposure may contribute up to *ca.*10 µg/d in a smoker and about 1 µg/d in a non-smoker and more in polluted areas. The concentration of metabolites of inorganic arsenic in urine [inorganic arsenic, monomethyl arsonic acid (MMA) and dimethyl arsinic acid (DMA)] reflects the absorbed dose of inorganic arsenic on an individual level. Generally, it ranges from 5 to 20 µg As/L, but may even exceed 1000 µg/L.

Where exposure of an individual or population to arsenic is suspected examination of biomarkers can provide useful information and could be included in a public health surveillance programmed. The most commonly used biomarkers are hair, nails, blood and urine; with hair and nails being an indicator of past arsenic exposure, while blood and urine is markers of recent exposure.

In Pakistan, the problem has surfaced during the past decade when elevated levels of arsenic in drinking water were reported from Punjab and Sindh. First screening was undertaken in the Attock and Rawalpindi districts of Punjab jointly by UNICEF and PCRWR[9]. To gauge the extent of risk posed to the health of general public around Lahore, Kahna (old) a small locality was selected as a test site and drinking water samples and diverse food samples were collected randomly and analyzed for arsenic contents by arsenic testing kit and atomic absorption spectroscopy (graphite furnace). The arsenic amount in samples of drinking water (from sunken tube-wells installed in houses), milk, locally grown vegetables and staple food like wheat and rice was found to be very high and needed immediate attention of Government for available mitigation options.

EXPERIMENTAL

Selection of site: A small village Kahna situated at 28 kilometers from Lahore with a population of around 27000 was selected as a test site. Tap water from 10 houses and water from tube well used for irrigation, all randomly selected. The samples of water were collected in triplicate from each location in clean plastic bottles with screw cap and stored at 4 °C. The water samples were tested *in situ* with arsenic testing kit (Highly sensitive: range 0-500 ppb of $As^{3+/5+}$) Merck. According to a report published by Pakistan Council of Research in Water resources that there is very less percentage difference between the results of samples exceeding 50 ppb, 50-100 ppb and above 100 ppb analyzed by arsenic testing kit and atomic absorption spectroscopy[10].

Water analysis: Water samples from the houses were collected in polyethene bottles pre-washed with nitric acid and water (1:1). The water samples were collected at a depth of 80 ft. Immediately after sampling of water, nitric acid (1.0 mL/L) was added to all the samples as preservative.

Rice, wheat and vegetable analysis: Since rice, wheat and vegetables constitute a major portion of diet, samples of vegetables from the study area were collected at marketable stage of development, to assess the dietary intake of arsenic by human. Samples were washed carefully with tap water, followed by double distilled water. One gram of dried (at 65 °C) sample was digested with HNO_3/$HClO_4$/H_2SO_4 (10:1:1) and the solution was made up to 50 mL and analyzed for arsenic[11].

Milk analysis: Milk samples were collected in sterile polyethylene sampling bottles with $KMnO_4$ as preservative. Milk samples were digested following the procedure of Ayyadurai *et al.*[12].

Preparation of food samples: Rice, wheat and fresh vegetables cultivated locally were collected from households randomly selected. Meat and beef samples were purchased from local market. Milk samples were collected from houses raring cattle (buffalos) and digested, filtered through a 0.45 μm membrane filter and analyzed by Hitachi A-3000 atomic absorption spectrophotometer.

Statistical treatment of data: Hitachi A-3000 atomic absorption spectrophotometer (graphite furnace) was used for analysis of arsenic. Known standards were used to calibrate the instrument and to keep a good quality control, our goal was to obtain a correlation coefficient value of as close to 1.0 as possible.

RESULTS AND DISCUSSION

Contamination analysis: Daily intake of arsenic in food is an important source of arsenic in body. In some cases arsenic in drinking water is significant because as arsenic in drinking water increases cancer risk also increases. Kahna a small village about 28 kilometers from Lahore was selected as a test site for the evaluation of the extent of exposure to arsenic by general population. Water supply in the village is generally from tube wells. For the analysis of contaminated food and drinking water, food and water samples were collected in the month of March 2007 from different locations. Different food samples were collected to evaluate the arsenic contamination in Kahna. These samples were analyzed. Drinking water and milk samples have shown high arsenic concentration. All the values are under standard limit. Local vegetables grown in kahna were also checked for arsenic contamination to asses the health risk due to arsenic in vegetables. It was found that all the samples were under standard value. For the assessment of human body arsenic, hair samples were analyzed.

Exposure estimation: It has been reported that 100 mg/L (ppm) arsenic in water = 0.5 mg/kg arsenic in hair. Nails could also be helpful but in the following study only hairs are used. It has been observed that all food samples were under the standard value (0.5-2.0 ppm) (Table-1). Analysis of hair samples has shown arsenic concentration 5.82, 5.95 and 8.609 ppb respectively with age group. It could be noted that with increasing age arsenic is increasing. But still arsenic in hair samples is in normal range (0.02-0.5 mg/kg). This means that at this time body arsenic is under the normal permissible limits in people residing in the affected areas. Although food contained arsenic in the standard value but arsenic in water was much higher.

TABLE-1
CONCENTRATION OF ARSENIC CONSUMED IN TAP WATER AND AMOUNT OF ARSENIC CONSUMED IN MILK AND FOOD SAMPLES PER WEEK

	Tap water (ppb)	Milk sample (ppb)	Vegetable 0.6 Kg/person (mg/kg per week)	Mutton 0.2 Kg/person (mg/kg per week)	Beef 0.2 Kg (mg/kg per week)	Rice 0.2 Kg/person (mg/kg per week)	Wheat 2 Kg /person (mg/kg per week)
Arsenic concentration	25	27.06	1.1040	1.0400	0.1240	4.000	2.00
	35	16.90	1.9320	0.0000	0.7200	2.800	2.10
	25	5.13	0.9120	0.4000	0.0600	2.550	0.50
	60	16.29	1.2360	3.2520	2.0200	1.990	1.70
	40	14.19	0.9840	2.8380	1.0400	3.250	1.50
	200	10.01	1.8720	2.8390	0.5400	3.940	0.90
	175	14.21	1.4280	2.0020	1.2200	4.900	0.20
	75	12.20	3.7800	2.8942	0.1000	6.320	2.10
	175	10.00	0.8520	2.0000	0.7200	4.900	0.80
	75	9.01	1.2360	1.8308	1.6200	3.200	1.70
Mean	71	13.2	1.5336	1.6257	0.8164	3.786	1.35

Peoples using this water without any treatment are at higher cancer risk. It is very difficult to draw a correlation between arsenic in hair/nails/blood/urine with age and number of patients as many factors like period of intake of arsenic contaminated water, quantity of water, quantity of arsenic contaminated vegetables consumed, quantity of arsenic contaminated milk taken and the health of the person play an important role. The economic condition of the people residing in these sites does not permit them to afford for rich nutritious diet.

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