STUDY ON ARSENIC LEVEL IN PUBLIC WATER SUPPLY OF DELHI USING HYDRIDE GENERATOR ACCESSORY COUPLED WITH ATOMIC ABSORPTION SPECTROPHOTOMETER

Sanjeev Lalwani, T.D. Dogra, D.N. Bhardwaj, R.K. Sharma, O.P. Murty

Department of Forensic Medicine & Toxicology, All India Institute of Medical Sciences, New Delhi (India)

ABSTRACT

Exposure to arsenic has been associated with several health hazards. Worldwide the main reason for chronic human intoxication with arsenic is intake of contaminated drinking water. Air acetylene type of atomic absorption spectrophotometer in combination with hydride generator accessory was used to analyze arsenic level in 25 water samples collected from 25 booster pumping stations and 313 water samples collected from tap water supply of 62 areas of Delhi. Results were analyzed using SPSS and Barlett's Chi Square Test. Mean arsenic level detected in water samples collected from booster pumping stations was 0.00976 ppm (Range 0.000-0.017 ppm, Standard Deviation 0.006 and Standard error of Mean 0.00118). Maximum arsenic level (0.017 ppm) was found in water samples of booster pumping stations of Mehrauli, Punjabi Bagh and Ramjas Road. Mean arsenic level detected in samples collected from tap water supply was 0.013 ppm (Range 0-0.0430 ppm, Standard Deviation 0.00911 and Standard error of Mean 0.000515). In water samples of 42 areas arsenic level detected was exceeding WHO/EPA permissible limit of 0.01 ppm (10 ppb). The mean arsenic level detected in water samples of booster pumping station was within WHO/EPA permissible limit while mean arsenic level detected in tap water samples was marginally higher. Mixing of ground water and contamination through broken or leaking channel could be the possible reason of higher arsenic level in tap water. Continuous monitoring of quality of drinking water is required particularly in view of water contamination caused by industrial waste and uncontrolled ground water extraction.

KEY WORDS

Water, arsenic, contamination, WHO/EPA permissible limit

INTRODUCTION

Water pollution is a growing hazard in many developing countries. Present concern is much related to the chemical pollutants in water that have cumulative toxic properties, carcinogenic potential and cause adverse health effects on prolonged exposure such as heavy metals (1).

Arsenic is ubiquitous, naturally occurring element present in food, soil, air and water (2-4). Since Hippocrates's time, it has been used in medicinal and homicidal preparations. In addition, occupational and environmental exposure occasionally causes toxic manifestations (2). All human beings are exposed to

it in one form or other. However, water and food constitutes major source of exposure to population (3, 4). About 64% of total intake is accounted for by organic arsenic such as arsenocholine and arsenobetaine which are relatively nontoxic and rapidly excreted unchanged in urine. Inorganic arsenic which is more toxic accumulates in various body tissues such as liver, kidney, gastrointestinal tract, spleen. Pentavalent arsenic undergoes methylation in liver and forms monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA) which are less reactive with tissue constituents, less toxic and more readily excreted in urine. But once this process gets saturated, there is accumulation of arsenic in tissues leading to health hazards (5, 6). These hazards involve dermatological manifestations, involvement of neurological, endocrine, hematological, immunological and cardiovascular system to malignancy of skin, lungs, liver, colon and bladder (5, 7-24). Adverse pregnancy outcomes in terms of spontaneous abortion, stillbirth and pre term birth rates have been reported to be higher in women chronically exposed to arsenic (25-26).

Author for Correspondence :

Dr. Sanjeev Lalwani
Department of Forensic Medicine
Room No. 1054, T. Block, AIIMS, Ansari Nagar
New Delhi-29 (India)
E Mail: drsalal@rediffmail.com
sanjulalwani2001@yahoo.com

Worldwide, the main reason for chronic human intoxication with arsenic is intake of contaminated drinking water (27). The current WHO (1993)/ Environmental protection agency (USA, 2001) permissible limit of arsenic in drinking water is 0.01 ppm (10 ppb) (28, 29). Cancer risk from drinking water containing arsenic at 50ppb may be as high as one in 100 (30, 31). Chronic exposure of arsenic through drinking water is known in different continents (32). In India, natural exposure of man to arsenic through drinking water of wells, hand pumps and springs in Chandigarh and its surrounding areas was first highlighted in 1976 (33). Arsenic level exceeding WHO permissible limit has been reported in ground water of West Bengal, some areas of Bihar and Madhya Pradesh (6, 34, 35). Similar results have been reported from other countries also (36-41). While considering exposure of contaminant through drinking water it is important to ensure that exposures are assessed from water delivered through the consumer tap as this supply is fulfilling the minimum basic requirement of life to large number of population and may affect their health. Present study was aimed to analyze arsenic level in water samples of booster pumping stations and community water supply of different areas of Delhi.

MATERIALS AND METHODS

Total 25 water samples were collected from 25 booster pumping stations located in different areas of Delhi as shown in Table 1. Similarly 313 water samples were

collected from tap water supply of 62 different areas of Delhi as shown in Table 2. Details pertaining to collection and preparation of samples have been reported elsewhere (43). Arsenic level in water was estimated by method of Wyatt et al(17) using Air - Acetylene flame type of Atomic Absorption Spectrophotometer (microprocessor based model, AAS 4127) along with hydride generation accessory, both of ECIL Company. Arsenic stock solution containing 980mgm per ml (Sigma, St. Louis USA) was used for preparing the standards. Statistical analysis of results was done using SPSS and Barlett's Chi Square Test.

RESULTS

The mean arsenic level in water samples collected from 25 booster pumping stations was found to be 0.00976 ppm. (Range -0.000-0.017 ppm, SD-0.006 and SEM- 0.00118). Maximum arsenic level (0.017 ppm) was found in water samples of booster pumping stations of Mehrauli, Punjabi Bagh and Ramjas Road followed by 0.016 ppm at Talkatora, RK Puram, Delhi Cantt, Janakpuri and 0.015 ppm at Deer Park, Patel Road, Greater Kailash (North) (Table 1).

The mean arsenic level detected in 313 water samples collected from tap water supply of 62 different areas in Delhi was 0.013 ppm (Range 0.000-0.0430 ppm, SD 0.00911 SEM 0.000515). Out of 62 areas in 20 areas arsenic level was less than 0.010 ppm in 31

Table 1. Showing arsenic level in water samples collected from booster pumping stations from different areas of Delhi

Area	As (ppm)	Area	As (ppm)
Greater Kailash (South)	0.007	New Rajender Nagar(*)	0.008
Greater Kailash (North)	0.015	Tilak Nagar	0.000
Mehrauli	0.017	Tilak Vihar (*)	0.000
Lado Sarai(*)	0.008	Kalkaji	0.007
Deer Park	0.015	Naya Bazaar	0.009
Hauz Khas(*)	0.008	Geeta Colony	0.000
Jal Vihar	0.007	Punjabi Bagh	0.017
Janakpuri	0.016	Ramjas Road	0.017
Moti Bagh	0.008	Talkatora	0.016
Delhi Cantt.	0.016	Old Rajender Nagar	0.007
R.K. Puram	0.016	Okhla	0.007
Shadipur Reservoir	0.008	Peera Garhi	0.000
Patel Road (*)	0.015		

(*) = Sub Station, One sample was collected from each booster house
Total number of samples = 25
Mean arsenic level (ppm) = 0.00976
Standard Deviation = 0.006
Std. Error of Mean = 0.00118

Table 2. Showing arsenic level in water samples collected from public water supply through taps from different areas of Delhi

Area of Booster Pumping Station	Area of Supply	No. of Samples	Arsenic Level (ppm)			
			Range	Mean	SD	SEM
Greater Kailash (South)	Malviya Nagar	8	0.009-0.026	0.019	0.005	0.002
	Saket	4	0.009-0.043	0.026	0.013	0.007
Greater Kailash (North)	Masjid Moth	6	0.000-0.024	0.015	0.010	0.004
	Neeti Bagh	7	0.007-0.023	0.013	0.006	0.002
	Gulmohar Park	4	0.016-0.023	0.020	0.003	0.001
Mehrauli	Mehrauli Village	9	0.007-0.028	0.018	0.008	0.003
Lado Sarai (*)	Lado Sarai	3	0.017-0.025	0.020	0.005	0.004
Deer Park	Arjun Nagar	7	0.000-0.024	0.010	0.009	0.003
	Green Park	5	0.000-0.016	0.009	0.007	0.003
Hauz Khas (*)	Gulmohar Encl.	5	0.000-0.015	0.007	0.007	0.003
Jal Vihar	Lajpat Nagar	6	0.000-0.022	0.011	0.008	0.003
	KM Pur	7	0.015-0.029	0.020	0.005	0.002
Janak puri	Janakpuri	5	0.008-0.024	0.016	0.006	0.003
	Virender Nagar	4	0.008-0.024	0.016	0.007	0.003
	Shiv Nagar	4	0.008-0.016	0.014	0.004	0.002
Delhi Cantt.	Sagarpur	5	0.007-0.028	0.015	0.009	0.004
	Nangal Raya	4	0.007-0.021	0.014	0.008	0.004
	Brahmpuri	5	0.000-0.014	0.008	0.006	0.003
Moti Bagh	Moti Bagh	6	0.000-0.008	0.003	0.004	0.002
	Satya Niketan	4	0.000-0.016	0.012	0.008	0.004
R.K. Puram	Sector-7	5	0.000-0.017	0.010	0.008	0.003
	Sector-4	4	0.000-0.017	0.010	0.007	0.003
	Sector-6	5	0.000-0.025	0.011	0.012	0.007
Karala	Karala	9	0.016-0.033	0.020	0.006	0.002
	Kanjhawala Road	4	0.016-0.024	0.020	0.005	0.002
Rithala	Rohini Sector-5	5	0.000-0.016	0.008	0.008	0.004
	Rohini Sector-3	6	0.000-0.008	0.001	0.003	0.001
	Rohini Sector-6	4	0.000-0.008	0.004	0.004	0.002
Naraina	Naraina	10	0.018-0.026	0.022	0.004	0.001
	Inderpuri	4	0.018-0.026	0.022	0.005	0.002
Khyala	Raghubir Nagar	5	0.007-0.015	0.011	0.010	0.004
	Khyala	5	0.000-0.022	0.010	0.004	0.002
	Tagore Garden	2	0.026-0.034	0.030	0.005	0.004
Shadipur Reservoir	East Patel Nagar	6	0.000-0.008	0.003	0.004	0.002
	West Patel Nagar	6	0.000-0.008	0.001	0.003	0.001
1. Patel Road	NPL Colony	4	0.000-0.008	0.002	0.004	0.002
	New Raj. Nagar	6	0.000-0.008	0.003	0.004	0.002
2. New Rajender Nagar	Double Storey	4	0.000-0.008	0.002	0.004	0.002
	Old Raj Nagar	10	0.000-0.014	0.009	0.004	0.001
Tilak Nagar	Tilak Nagar	3	0.000-0.000	0.000	0.000	0.000
	Jail Road	5	0.000-0.008	0.006	0.004	0.002
Okhla	Jamia Nagar	4	0.000-0.014	0.007	0.006	0.003
	Kainal Colony	5	0.007-0.014	0.008	0.003	0.001

Kalkaji	Govindpuri	9	0.000-0.015	0.007	0.005	0.002
Talkatora	Mandir Lane	3	0.000-0.016	0.016	0.000	0.000
	RK Marg	2	0.000-0.024	0.024	0.000	0.000
	Birla Mandir	4	0.008-0.024	0.012	0.008	0.000
Punjabi Bagh	Lawrence Road	3	0.017-0.026	0.022	0.005	0.003
	Keshav Puram	5	0.017-0.020	0.020	0.005	0.002
Raney Well no.7	Pandav Nagar	5	0.017-0.026	0.022	0.005	0.002
	Khichripur	5	0.017-0.026	0.022	0.005	0.002
Geeta Colony	Geeta Colony	3	0.000-0.017	0.011	0.010	0.006
	Gandhi Nagar	4	0.000-0.017	0.017	0.000	0.000
Ramjas Road	Dev Nagar	4	0.009-0.017	0.015	0.004	0.002
	Karol Bagh	3	0.009-0.017	0.012	0.005	0.003
Peera Garhi	Paschim Vihar	6	0.000-0.016	0.008	0.008	0.003
	Meera Bagh	5	0.000-0.008	0.003	0.003	0.002
Naya Bazaar	GB Road	4	0.009-0.026	0.015	0.008	0.004
	Naya Bazaar	9	0.009-0.017	0.012	0.004	0.001
Raney Well No.3	Alipur	3	0.026-0.043	0.031	0.010	0.006
	Palla	3	0.017-0.034	0.026	0.009	0.005
	Bakhtawarpur	4	0.017-0.034	0.026	0.007	0.003

Total number of Samples = 313
Standard Deviation = 0.009

Mean arsenic level (ppm) = 0.013
Std. Error of Mean = 0.0005

areas it was between 0.010-0.020 ppm and in 11 areas it was more than 0.020 ppm. The minimum level was found in Tilak Nagar (0.000 ppm), while maximum level of 0.031 ppm (SD 0.009, SEM 0.005) was found in samples of Alipur (Table 2).

DISCUSSION

Drinking water supply to population of Delhi is from sources like Yamuna River and Ground water of tube wells, hand pumps and borings. Raw water of Yamuna River is treated by conventional methods at various treatment plants to make it suitable for drinking purposes. Treated water is then pumped to various booster pumping stations and reservoirs for onward supply to the community through taps for domestic use and drinking purposes. Ground water is used directly. Arsenic level in water of Yamuna River, filtered water and ground water of Delhi have been reported earlier (43, 44).

The hydride generation technique with subsequent atomic absorption spectrophotometer in suitable flame as used in present study is a well known method for determination of arsenic. Simplicity and sensitivity of both the instrument in combination, best meet the requirement for economic and fast analysis of arsenic and other hydride forming element even if they are present in trace amount in environmental media and biological fluid (42). This technique has been used in various studies reported in literature (7-9, 17, 36, 44).

Mean arsenic level (0.00976 ppm) detected in water samples collected from booster pumping stations is within the WHO/EPA recommended value for arsenic in drinking water. While in tap water samples, mean arsenic level (0.013 ppm) was marginally higher than the WHO/EPA recommended value of 0.01 ppm (28, 29). In 69.5% of tap water samples arsenic level detected was above 0.01 ppm. Maximum arsenic level detected was 0.043 ppm. Sandhu *et al.* reported that in 2% of samples arsenic level was exceeding the mandatory limit of 0.05 ppm and 72% exceeded the recommended level of 0.01 ppm in drinking water supplies of 161 rural communities in Georgetown County (45). Wyatt *et al.* reported arsenic content in water supply of Northern Mexico in the range of 0.002-0.305ppm in 8.92% of samples (17).

Arsenic level in tap and or tap/filtered water samples in Maryland was found to be in the range of 0.2-13.8 ppb (46). Morton *et al.* reported lane county water arsenic level in rural region in range of 0-2150 ppb and in urban region 0-860 ppb (47). Bates *et al.* reported arsenic level in range of 0.5-160 ppb in 88 water samples from community supplies in Utah (48). Comparatively in our study, arsenic level detected in tap water was in range of 0.000-0.043 ppm (0-43 ppb).

Several population in the United States have been exposed to arsenic contaminated drinking water at levels near 100 ppb (49). Concentration of arsenic level in drinking water from Siena and Grosseto

districts, South Tuscany, Italy at sources or at the terminals of the water webs have been reported to be high (14.4 ppb) (50). Levels of arsenic in Moira lake and river north to Deloro exceed (Up to 75ppb in surface water of river and 50 ppb in lake) the Ontario drinking water standard (Permissible Limit 25 ppb) (51, 52). Ontario Government Ministry of Environment and the Medical Officer of Health for Hastings and Prince Edwards Health Unit Counties issued a drinking water reminder to the public who might be drawing water from the Moira river in Eastern Ontario, could lead to arsenic poisoning (53). In Southern Nigeria concentration of arsenic in drinking water supplied through taps and treated water from public water sources were within WHO permissible limit (54). In tap water supply of Tilak Nagar area in Delhi arsenic could not be detected. In East Karachi district arsenic could not be detected in drinking water supply (55).

In water samples collected from some of the booster pumping stations and from tap water of some areas, the arsenic level was exceeding the WHO/EPA recommended limit of 0.01 ppm (28, 29). This could be due to contamination as the result of breakdown or leakage in channel. Other reason could be use of ground water sources for water supply as in the area supplied by Raney Well No. 3 & 7 or there may be mixing of ground water and treated water received from treatment plants to meet the requirement of growing water consumption along with growing population. Ground water of Delhi contains arsenic level in concentration exceeding WHO/EPA permissible limit (44, 56). Most arsenic enters water supplies from natural deposits in the earth's crust or from industrial and agricultural pollution (9, 57-58).

There is a significant difference in arsenic level in water of Yamuna River (Mean 0.051 ppm, Range 0.032-0.064, SD 0.013, SEM 0.00363) and Ground water (Mean 0.0431, Range 0.017-0.100 ppm, SD 0.0136, SEM 0.00194) in comparison to arsenic level found in water samples collected from various booster pumping stations (Mean 0.00976 ppm, Range 0.000-0.017 ppm, SD 0.006 and SEM 0.00118) and public water supply (Mean 0.0129 ppm, Range 0.000-0.0430 ppm, SD 0.00911 SEM 0.000515) (43, 44). But on comparison of arsenic level in water samples at booster pumping stations and treated water samples collected from water treatment plants (Mean 0.00192, Range 0-0.009, SD 0.0004, SEM 0.00001341) the difference is less significant as the arsenic level remains within the acceptable limits (43).

Arsenic level above 0.01 ppm (10 ppb) does NOT mean that it will cause problems, but it increases the risk. However, in view of increasing water consumption due to growing population, decreasing natural water resources mandating use of groundwater resources, industrialization with discharge of waste contaminated

with chemicals into raw water sources, continuous monitoring of quality of drinking water is required to prevent exposure of large population of Delhi from health hazards due to chemical contaminants.

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