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Arsenic Exposure in a New Mexico Urban Community on Private Well Water

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Arsenic (As) in private well drinking water is a public health concern in New Mexico, where it has been measured in groundwater in several locations at concentrations above the Environmental Protection Agency (EPA) maximum contaminant level (MCL) of 10 µg/L[1-5]. Arsenic occurs naturally in soil, minerals, and ground water and inorganic arsenic is a known human carcinogen[6,7]. Approximately 20 percent of New Mexico residents rely on private domestic wells for drinking water[8]. New Mexico law does not require private well water quality monitoring. Owners of these private wells are solely responsible for the maintenance and monitoring of their drinking water quality.

The objective of this project was to estimate exposure to inorganic As among private well water consumers, inform participants of their potential exposure sources, and deliver health education so that they could make decisions to reduce their exposures, if appropriate.

Methods

Private well owners in an urban community with known presence of As in the groundwater participated in the project, providing two water samples, a urine sample, and an exposure assessment questionnaire. Education and health communication were delivered in various formats throughout project implementation.

Both total and speciated As concentrations were measured in drinking water samples to determine the As level and the valence state of the inorganic As (i.e., As III vs. As V). Valence states present in the water source drive the method of As removal, with high removal efficiencies (almost 100%) of As (V) through reverse osmosis (RO) systems and lower removal efficiency of As (III) at 46-75% [9]. Only total As concentrations were measured in urine samples. These total urinary As levels were corrected for urinary creatinine levels to adjust for sample dilution and will be referred to as urinary As (µg As/g creatinine) throughout this report. Laboratory analyses of total As in water and urine samples and urinary creatinine were performed by the New Mexico Department of Health (NMDOH) Scientific Laboratory Division and As speciation in private wells drinking water samples was performed by Hall Environmental Laboratory.

Elevated As concentrations in drinking water were defined as total amount of As equal to or above the EPA MCL. To determine the prevalence of elevated urinary As concentrations, comparisons were made with the 95^{th} percentile of the 2009-2010 National Health and Nutrition Examination Survey (NHANES)[5] measured levels for adults aged 20 years and older. Information collected from the exposure assessment questionnaire included participant demographics, water treatment practices, individual-level estimates of drinking water consumption from private wells, and dietary habits.

Data were analyzed using SAS 9.3. Urinary As concentrations were log-transformed for statistical analysis. The Pearson correlation coefficient was used to estimate the correlation between As in drinking water and log-transformed urinary As levels among participants.

Results of water quality and urinary As laboratory analyses were provided to participants along with interpretation. Households with well water As concentrations above the EPA MCL were advised to use an alternative drinking water source and were provided with information regarding private well maintenance, potential sources of As exposure and health effects, and drinking water treatment options for As removal from the water.

Results

A total of 87 individuals (59% male; median age of 53 years) were included in the statistical analysis. Most participants were non-Hispanic White (76%) and 16% were Hispanic; the majority of participants (94%) had greater than a high school education. For 87 participants, there were both water test results and completed exposure assessment questionnaires; for 85 participants there were also matched urine test results (2 urine samples were excluded from the analysis due to extreme dilution).

The mean total arsenic concentration in drinking water was 9.8 µg/L, ranging from 0.5 to 48.0 µg/L (Table 1). Twenty five participants (29%) had a total arsenic concentration exceeding the EPA MCL of 10 µg/L. Among households with As exceeding the MCL, all but one private well water sample contained both As (III) and As (V) (Table 2). Median well depth was 970 feet (range: 480-1,828 feet).

Total urinary As concentration ranged from 3.8 to 367.1 µg As/g creatinine, with a geometric mean of 21.4 µg As/g creatinine (Table 1) and 95th percentile value of 117.2 µg As/g creatinine (Table 3). Compared to NHANES levels, urinary As geometric mean levels were twice as high (1.98 times) and 95th percentile values were 34% higher (Table 3). Seven out of 85 participants (8%) had elevated urinary As concentrations above the 95th percentile of NHANES. A positive correlation (r=0.199; p=0.067) was found between drinking water and urinary As concentrations, but this correlation was not statistically significant at the 95% level (Figure 1).

Table 1. Water Consumption and Arsenic Characteristics in Drinking Water and Urine

Water and/or urine characteristic	Total arsenic concentration in drinking water (µg/L)	Total creatinine-corrected urinary arsenic concentration (µg As/g creatinine)	Number of 8 oz. cups of household tap water consumed per day
n	87	85	87
Mean	9.8 (arithmetic)	21.4 (geometric)	5.6
Median	5	18.1	5
95th Percentile	NA	117.2	NA
Range	0.5-48.0	3.8-367.1	0.0-15.0
Sample DL	1	NA	NA

DL = Detection Limit; NA = Not Applicable

Arsenic (As) Concentration Ranges and Number (%) of Households with Inorganic Arsenic Species Concentration				
	< 5 µg/L	5 - 9 µg/L	10 - 24 µg/L	25 - 49 µg/L
As(III)	86 (98.9%)	---	1 (1.1%)	---
As (V)	55 (63.2%)	13 (14.9%)	11 (12.6%)	8 (9.1%)

Thirty three (40%) households reported not having any water treatment system; eighteen households (12%) reported using a RO system to treat their well water for drinking water. Three of the households using RO systems had As levels exceeding the EPA MCL. Most participants (56%) reported eating fish/seafood 3 days before urine collection and most participants (72%) reported using vitamins (Table 4).

Received test results prompted most participants to further their knowledge about drinking water quality by visiting a project-dedicated web page that led participants to resources relevant to their interests and concerns (https://nmtracking.org/water). Web-user statistics showed 230 visits in a 2-month period, with the majority of visitors seeking water treatment information. Five participants followed-up with project staff to learn how to reduce arsenic exposure, specifically seeking information about appropriate water treatment options.

Potential sources of arsenic (excluding drinking water)	Number (%) of Project Participants Reporting
Fish and seafood consumption in past 3 days	
YES	49 (56%)
NO	38 (44%)
Use of folk/homeopathic remedies	
YES	8 (9.2%)
NO	79 (90.8%)
Use of topical folk/homeopathic remedies	
YES	12 (13.8%)
NO	75 (86.2%)
Vitamin use	
YES	63 (72%)
NO	24 (28%)

Discussion and Recommendations

This analysis demonstrates a positive association between total arsenic concentration in drinking water and total arsenic body burden (expressed as total creatinine-corrected urinary As concentrations) among participants in one urban New Mexico community using private wells. When these data were included in a multiple linear regression analysis using pooled urinary total arsenic levels (creatinine-corrected) and total drinking water arsenic levels from multiple projects, this association became statistically significant[10]. Further studies with larger sample sizes should be conducted to evaluate urinary As levels as a biomarker of exposure to total arsenic in drinking water. As seen in this analysis,

Urinary Total Creatinine-corrected Arsenic Geometric Mean Concentration (µg As/g creatinine)			Urinary Total Creatinine-corrected Arsenic 95th Percentile Concentration (µg As/g creatinine)		
Participants Geometric mean Concentration (95% Confidence Interval)	NHANES (2009-10) Geometric Mean Concentration (95% Confidence Interval)	Geometric Means Ratio	Participants 95th Percentile Concentration	NHANES 95th Percentile Concentration (95% confidence interval)	95th Percentiles Ratio
21.4 (17.3-26.6)	10.8 (9.71-12.0)	1.98	117.2	87.3 (70.0-105)	1.34

other factors, such as dietary habits, including fish consumption, may also contribute to urinary arsenic levels and urinary arsenic speciation could help distinguish between sources of arsenic exposure. Therefore, the use of total urinary arsenic data instead of speciated forms of urinary arsenic is a limitation of this analysis.

This limits the conclusions that could be drawn on the distribution of body burden with inorganic versus organic arsenic exposure among participants. In addition, spot urine samples were collected, which are not necessarily a true representation of urinary excretion of arsenic. Also, dietary information was self-reported, introducing potential respondent bias.

Education about the importance of water testing for arsenic and methods of reducing arsenic concentration in drinking water, especially for those on private wells, can positively affect health behavior of communities at risk for excessive exposure to arsenic. Based on preliminary information, some participants appeared to change their behavior and/or sought to learn more about reducing exposures. However, a comprehensive follow-up should be conducted to better understand the extent of health behavior change among all participants.

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Figure 1. Relationship between Arsenic Concentrations in Drinking Water and Urine of Participants (n=85)