

Health Consultation

ARSENIC IN PRIVATE DRINKING WATER WELLS

CORNVILLE, YAVAPAI COUNTY, ARIZONA

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

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In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members.

This document has previously been released for a 30 day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The health consultation has now been reissued. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

ARSENIC IN PRIVATE DRINKING WATER WELLS

CORNVILLE, YAVAPAI COUNTY, ARIZONA

Prepared by:

Arizona Department of Health Services
Office of Environmental Health
Environmental Health Consultation Services
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Background and Statement of Issues

Cornville, Arizona, is a growing, unincorporated rural community in eastern Yavapai County, approximately 100 miles north of downtown Phoenix. The estimated population in the area is 5,000. Residents rely almost exclusively on private domestic wells for potable water. Some residents share wells between households. Virtually all residents' well water contains some arsenic, which occurs naturally in rock formations in the Verde River area and in the Agua Fria Basin, to the south.

In March 2004, a resident of Cornville contacted the Arizona Department of Environmental Quality (ADEQ) to request information on arsenic in drinking water. The resident collected six well water samples from their own well and neighbors' wells and submitted them to a private laboratory for arsenic analysis. The laboratory found arsenic in the water samples at levels ranging from 15 to 952 micrograms per liter ($\mu\text{g/L}$). ADEQ and the community members asked the Arizona Department of Health Services (ADHS) to provide health information about using the water. Initial conversations with the well owner and other community members revealed that many people had concerns about potential health effects from arsenic exposure.

Data

ADHS reviewed the laboratory results submitted by the area residents for sampling accuracy and laboratory methodology. The data are presented in Table 1.

Table 1. Arsenic in Private Wells

Chemical	Frequency of Detection	Range ($\mu\text{g/L}$)	ATSDR Child Comparison Value ($\mu\text{g/L}$)	Frequency of Detection Above Comparison Value	Contaminant of Concern?
Arsenic	6/6	15–952	3	6/6	Yes

ADHS selected arsenic for toxicological evaluation because it was detected at levels exceeding the Agency for Toxic Substances and Disease Registry's (ATSDR's) chronic exposure comparison value for children. Comparison values are screening values used to determine whether further investigation of a contaminant is necessary. Concentrations of contaminants less than the comparison values are unlikely to cause health effects.

Results

Arsenic was detected in all six water samples in excess of the ATSDR chronic exposure comparison value for children.

Discussion

To evaluate the health effects of exposure to contaminants in specific environmental media, including water, soil, and air, ATSDR has developed a *minimal risk level* (MRL) comparison value for common chemical contaminants. The MRL is an estimate of daily human exposure to a contaminant below which non-cancerous, adverse health effects are unlikely to occur. MRLs are developed for acute (less than 14 days), intermediate (14–365 days), and chronic (greater than 365 days) exposure.

That health guidance values such as MRLs represent a level above which toxicity is likely to occur is a common misconception. The MRL is neither a threshold for toxicity nor a level beyond which toxicity is likely to occur. MRLs are established as screening tools to determine whether further evaluation of the contaminant is necessary. Toxicological information used to derive MRLs and to evaluate the likelihood of health effects resulting from exposures to contaminants are contained in documents known as toxicological profiles, published by ATSDR. These chemical-specific profiles provide information on health effects, environmental transport, human exposure, and regulatory status.

When exposure estimates exceed MRLs, additional evaluation is necessary to determine whether a health hazard exists. Literature sources are reviewed to determine what exposure doses through different routes of exposure (ingestion, inhalation, or dermal contact) have been documented to actually cause a health problem. The *no-observed-adverse-effect level* (NOAEL) is the highest exposure dose at which no adverse effect was observed on the animal or human population in a study. The *lowest-observed-adverse-effect level* (LOAEL) for a chemical is the lowest exposure dose at which a measurable adverse health effect is observed in a human or animal study population. When evaluating possible health effects from exposure to the contaminant, NOAELs and LOAELs from studies in humans are reviewed, if available. If, however, no human studies exist, studies on laboratory animals are reviewed. The health assessor might include safety factors to address human differences when evaluating animal studies. The Appendix contains a discussion of potential health effects from chronic oral arsenic exposure.

To quantify exposures, ADHS made several assumptions regarding dose intake: Adults residing in the area are assumed to drink 2 liters of water per day for 30 years from their private wells. Children are assumed to drink 1 liter of water per day from the well throughout childhood, defined as 0–6 years of age. Bathing and oral hygiene are not considered to contribute to exposure because only a negligible amount, if any, of the arsenic is absorbed through dermal contact with contaminated water (ATSDR 2000).

Health Hazard Analysis

Arsenic

ADHS calculated the estimated daily exposure doses of arsenic for each well in which the arsenic concentration exceeded the ATSDR chronic childhood comparison value of 3 µg/L. The range of arsenic exposure from this set of samples reflects the wide range of arsenic groundwater concentrations. All six samples contained detectable concentrations of arsenic exceeding the comparison value. The estimated daily dose of arsenic for children ranged from 0.0096 milligrams per kilogram per day (mg/kg/day) at the lowest detected concentration of 15 µg/L to 0.061 mg/kg/day for the sample with 952 µg/L.

The NOAEL for chronic exposure to arsenic is 0.0004 mg/kg/day (6 µg/L in water). Exposures lower than this level would not be expected to result in adverse health effects in exposed persons. The health effects observed at the LOAEL of 0.015 mg/kg/day (23 µg/L) include reports of fatigue, headache, dizziness, and numbness (ATSDR 2000). Health effects at slightly higher doses than the LOAEL include scaling of the skin and slight changes in skin pigmentation (ATSDR 2000). More significant health effects, such as striking changes in skin pigmentation (hyperkeratosis), increased blood pressure, kidney problems, and lung problems, have been observed at doses in the 0.05 mg/kg/day range (790 µg/L).

To evaluate the potential for adverse health effects, estimated arsenic exposure doses were compared to the chronic MRL, NOAEL, and LOAEL for each category. Table 2 summarizes the results of the sampling information.

Table 2. Frequency of wells exceeding health standards for arsenic

Category 1	Category 2	Category 3	Category 4
Frequency less than 10 µg/L	Frequency between 11 µg/L and 50 µg/L	Frequency between 50 µg/L and 780 µg/L	Frequency exceeding 780 µg/L
0/6	2/6	3/6	1/6

Category 1 (no detection to 10 µg/L)

No adverse health effects would be expected in children or adults who use water for domestic purposes, including drinking water, containing arsenic concentrations less than the U.S. Environmental Protection Agency’s new *maximum contaminant level* of 10 µg/L. Drinking water from these wells would result in exposure doses within the NOAEL range of between 0.0004 mg/kg/day (6 µg/L) and 0.0014 mg/kg/day.

Category 2 (11 µg/L to 50 µg/L)

Minor adverse health effects, including fatigue, headache, dizziness, and numbness, are possible in children or adults who drink water containing arsenic between 11 µg/L to 50 µg/L. Estimated exposure doses for children range from 0.0007 mg/kg/day (11µg/L) to 0.003 mg/kg/day (50 µg/L). Because of the uncertainty associated with the development of the NOAEL and LOAEL, the Arizona Department of Health Services recommends that persons with arsenic concentrations in this range limit the amount of untreated water that they use for drinking and cooking. Two of the wells had arsenic concentrations of 11–50 µg/L. Well owners have been advised of this recommendation.

Category 3(51 µg/L to 780 µg/L)

Adverse health effects, including fatigue, headache, dizziness, and numbness, are possible for children or adults who consume water that containing 50–780 µg/L of arsenic. Using water for domestic purposes, including drinking and cooking, in this range can result in doses of 0.0032–0.049 mg/kg/day. The health effects observed at the LOAEL of 0.005 mg/kg/day include reports of fatigue, headache, dizziness, and numbness (ATSDR 2000). Health effects at slightly higher doses than the LOAEL include scaling of the skin and slight changes in skin pigmentation (ATSDR 2000). Arsenic concentrations greater than 78 µg/L (0.005 mg/kg/day) could result in health effects such as significant changes in skin pigmentation (hyperkeratosis), increased blood pressure, kidney problems, and lung problems. Three wells had arsenic concentrations between

50 µg/L and 780 µg/L. ADHS recommends that no one drink water having arsenic concentrations above 50 µg/L.

Well owners in Category 3 have been advised to avoid using untreated water for domestic purposes, including drinking and cooking. Using water from Category 3 wells for other domestic purposes, such as bathing and personal hygiene, does not pose a health threat.

Category 4 (More than 780 µg/L)

Adverse health effects, such as fatigue, headache, dizziness, numbness, changes in skin pigmentation (including hyperkeratotic warts and precancerous skin lesions), increased blood pressure, kidney problems, and lung problems, are possible in children or adults who consume water that contains more than 780 µg/L of arsenic (0.05 mg/kg/day). One well had arsenic levels in this range.

Well owners in Category 4 have been advised to avoid using untreated water for domestic purposes, including drinking and cooking. Using water from Category 4 wells for other domestic purposes, such as bathing and personal hygiene, does not pose a health threat.

Child Health Considerations

All exposure dose estimates were calculated assuming childhood exposure, thus incorporating exposure assumptions that reflect a child's greater intake of water relative to body weight. All conclusions and recommendations about using water from these wells were based on this sensitive population.

Conclusions

All six samples submitted for arsenic analysis contained concentrations above the ATSDR comparison value of 3 µg/L. All six samples also contained arsenic at levels exceeding EPA's new drinking water standard of 10 µg/L. Well water use for two of the wells should be limited if a treatment system is not installed, and four of the wells should not be used without treatment. The four wells that contain arsenic levels greater than 50 µg/L pose a public health hazard.

Recommendations

- Residents should install a treatment system that effectively removes arsenic, find an alternative source of drinking water, or use bottled water for drinking and cooking if their home drinking water comes from wells in which the arsenic level exceeds 10 µg/L.
- All residents in the Cornville area who use well water for drinking or beverage preparation should have their well water tested for arsenic.

Public Health Action Plan

- ADHS will notify well owners whose wells were determined to be a health hazard in this study.
- ADHS will present the findings of this investigation at a public forum in the Cornville area.
- ADHS will work with the Arizona Department of Water Resources to notify private well owners in the Cornville area and recommend having their well water tested for arsenic.
- ADHS will provide information to any community member or health care provider regarding arsenic exposure and health effects; however, those with arsenic levels in their water greater than 50 µg/L will receive priority.

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Certification

This Health Consultation for Arsenic in Private Drinking Water Wells, Cornville, Arizona, was prepared by the Arizona Department of Health Services under cooperative agreement with the Agency for Toxic Substances and Disease Registry. It is in accordance with approved methodology and procedures existing at the time the exposure investigation report was begun.

Technical Project Officer
CAT, SSAB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this health consultation and concurs with the findings.

Team Leader-Cooperative Agreement Program
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Appendix 1

Health Effects From Chronic Arsenic Ingestion

One of the most common effects of both acute and long-term arsenic ingestion is a pattern of skin changes, including changes in skin pigmentation (hyperpigmentation, interspersed with small areas of hypopigmentation of the face, neck, and back), generalized hyperkeratosis, or thickening of the skin, and formation of hyperkeratotic warts on the palms and soles. These effects are most often reported at chronic dose levels ranging from about 0.01–0.1 mg/kg/day.

Human studies document gastrointestinal irritation from chronic oral exposure to arsenic at dose levels of about 0.01 mg/kg/day and above. Symptoms include nausea, diarrhea, and vomiting. Damage to the liver and elevated levels of hepatic enzymes are reported at dose levels of 0.01 to 0.01 mg/kg/day. Hematological effects, including anemia, have been documented at chronic oral exposures of 0.05 mg/kg/day and above. Neurological effects, including peripheral neuropathy and numbness in hands and feet, are reported at chronic oral doses of 0.03–0.01 mg/kg/day.

Cardiovascular effects include cardiac arrhythmia and myocardial depolarization. A serious vascular condition called blackfoot disease is endemic in an area of Taiwan where residents are exposed to about 0.014–0.065 mg/kg/day arsenic in drinking water. Studies in Chile indicate that consumption of drinking water doses of 0.02–0.06 mg/kg/day increases in the incidence of Raynaud's disease and cyanosis of the fingers and toes (ATSDR 2000).

Arsenic has been classified as a human carcinogen by the U.S. Environmental Protection Agency, the National Toxicology Program, and the International Agency for Research on Cancer. Reports indicate that arsenic in drinking water increases the risk of skin, liver, bladder, kidney, lung, and prostate cancer. Studies suggest that cancer effects might occur following long-term exposure (ATSDR 2000).

Appendix 2

Exposure Dose Equations

The Arizona Department of Health Services used the Agency for Toxic Substances and Disease Registry's exposure assessment documents to calculate an exposure dose for persons living in the New River area. The doses were calculated using the following equations:

Ingestion of chemicals in water:

$$\frac{CDI = CW \times IR \times EF \times ED}{BW \times AT}$$

CDI: chronic daily intake (mg/kg/day)

CW: concentration in water (mg/L)

IR: intake rate (L/day)

EF: exposure frequency (days/year)

ED: exposure duration (years)

BW: body weight (kg)

AT: averaging time (days)

Variable Assumptions	Adults	Children
IR (ingestion, water):	2	1
EF:	350	350
ED:	30	6
BW:	70	15
AT:	10,950	2,190

Water intake rate for tooth brushing

Fluoride concentration: 1 mg/mL water*

Estimated fluoride ingestion: 0.3 mg/ brushing*

Estimated water intake: 0.3 mL/ brushing x 2 brushings = 0.6 mL/day

* Barnhart 1974