Final Draft

Health Consultation

Green Valley Groundwater Wells

Green Valley, Pima County, AZ

Prepared by

Arizona Department of Health Services
Office of Environmental Health
Environmental Health Consultation Services

Summary

INTRODUCTION

In the *Green Valley Groundwater Wells*, the Arizona Department of Health Services' (ADHS') top priority is to ensure that the community and residents have the best information possible to safeguard their health.

This report was written in response to a request from the Arizona State Laboratory. The Environmental Toxicology Program was asked to evaluate the public health risks due to exposure to arsenic and other metals detected in the groundwater.

CONCLUSIONS

Arsenic: The detected levels of arsenic in all sampled wells are not expected to cause short-term or long-term (non-cancerous) adverse health effects among the exposed population. However, the estimated cancer risks of the following wells exceeded the protective levels of public health (10^{-4} ~ 10^{-6}) set by the EPA.

RMBC 2000 RMBC 2001 RMBC 2002 RMBC 2003 RMBC 2004
RMBC 2005 RMBC 2006 RMBC 2007 RMBC 2008 RMBC 2009
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RMBC 2018

Cesium: the detected levels of cesium are not expected to cause adverse health effects among the exposed population.

Tungsten: the detected levels of tungsten are not expected to cause adverse health effects among the exposed population.

NEXT STEPS

ADHS will continue to review and evaluate additional groundwater sampling results if they are available. ADHS will attend public meetings, make presentations, and develop educational information on the public health implications of perchlorate when requested by the community or other agencies.

FOR MORE INFORMATION

If you have concerns about your health, you should contact your health care provider. Please call ADHS at 602-364-3128 and ask for more information on the Perchlorate site.

Introduction

The Arizona Department of Health Services (ADHS) State Laboratory conducted a biomonitoring study in Green Valley, Arizona. In 2008, the groundwater samples were collected as part of the Rocky Mountain Biomonitoring Consortium (RMBC). The local community members requested additional information regarding the arsenic levels detected in their well water samples. ADHS' Environmental Toxicology conducted an evaluation to see if there is any potential health concern associated with the groundwater exposures.

Discussion

General Assessment Methodology

ADHS generally follows a three-step methodology to assess public health issues related to environmental exposures. First, ADHS obtains representative environmental data for the site of concern and compiles a comprehensive list of site-related contaminants. Second, ADHS identifies exposure pathways, and then uses health-based comparison values to find those contaminants that do not have a realistic possibility of causing adverse health effects. For the remaining contaminants, ADHS reviews recent scientific studies to determine if the extent of environmental contamination indicates a public health hazard.

Environmental Data

The Arizona State Laboratory collected 18 ground water samples (including 2 blanks) and conducted metals analysis by Inductively Coupled Plasma Mass Spectrometry (ICP/MS). Fourteen metals were selected for analysis: antimony, arsenic, barium, beryllium, cadmium, cesium, cobalt, lead, molybdenum, platinum, selenium, thallium, tungsten, and uranium. A summary of the analytical results can be found in Table 2.

Exposure Pathway Analysis

Identifying exposure pathways is important in a health consultation because adverse health impacts can only happen if people are exposed to contaminants. The presence of a contaminant in the environment does not necessarily mean that people are actually coming into contact with that contaminant. Exposure pathways have been divided into three categories: completed, potential, and eliminated.

There are five elements considered in the evaluation of exposure pathways: (1) a <u>source</u> of contamination, (2) a <u>media</u> such as soil or ground water through which the contaminant is transported, (3) a <u>point of exposure</u> where people can contact the contaminant, (4) a <u>route of exposure</u> by which the contaminant enters or contacts the body, and (5) a <u>receptor</u> population. Completed pathways exist when all five elements are present and indicate that exposure to a contaminant has occurred in the past and/or is occurring presently. In a potential exposure pathway, one or more elements of the pathway cannot be identified, but it is possible that the element might be present or might have been present. ADHS generally evaluates completed and

potential pathways to determine if there are potential public health impacts. In eliminated pathways, at least one of the five elements is or was missing, and will never be present. Completed and potential pathways, however, may be eliminated when they are unlikely to be significant.

The most likely human exposures are by consuming perchlorate-containing water through drinking or cooking. Residents can also be exposed to the perchlorate-containing water via dermal contact during bathing/showering or other household activities. However, it is unlikely that dermal absorption of perchlorate would pose a concern for human health and will not be considered in this health consultation. Inhalation is also not a significant exposure pathway. People are not likely to breathe in dangerous levels of perchlorate due to its low vapor pressure.

Table 1. Exposure pathway evaluation

Exposure Pathway Elements					Time Frame	Type of Exposure Pathway
Source	Media	Point of Exposure	Route of Exposure	Estimated Exposed Population		
Naturally occurring arsenic in rocks and soil[1]	Water	Residences	Ingestion, dermal contact	Residents	Past	Completed
					Current	Completed
					Future	Potential

Comparison to environmental and health-based comparison values

The environmental and health-based comparison values (CVs) are screening tools used with environmental data relevant to the exposure pathways. The environmental and health-based CVs are concentrations of contaminants that the current public health literature suggest are "safe" or "harmless." These comparison values are quite conservative, because they include ample safety factors that account for the most sensitive populations. ADHS typically uses comparison values as follows: if a contaminant is never found at levels greater than its CV, ADHS concludes the levels of corresponding contamination are "safe" or "harmless." If, however, a contaminant is found at levels greater than its comparison value, ADHS designates the pollutant as a *contaminant of interest* and examines potential human exposures in greater detail.

Comparison values are based on extremely conservative assumptions. Depending on site-specific environmental exposure factors (e.g. duration and amount of exposure) and individual human factors (e.g. personal habits, occupation, and/or overall health), exposure to levels greater than the comparison value may or may not lead to a health effect. Therefore, the comparison values should not be used to predict the occurrence of adverse health effects.

Table 2. Summary of the analytical results for metals and their respective comparison values

[1] The average arsenic background soil concentration is 10 micrograms per kilogram of soil (mg/kg).

Chemical	Range of the detected concentrations (µg/L)	Comparison values (µg/L)	Source of the comparison value	Number of samples exceeded the comparison value	Is it a contaminant of interest?
Antimony	0.20 – 0.32	6	MCL[1]	0	No
Arsenic	4.13 – 14.39	10	MCL	6	**Yes**
Barium	< 0.73 – 80.39	2,000	MCL	0	No
Beryllium	< 0.097	4	MCL	0	No
Cadmium	< 0.053	5	MCL	0	No
Cesium	< 0.64 – 5.42	NA[2]			**Yes**
Cobalt	< 0.083 – 0.26	4.7	RSL[3]	0	No
Lead	0.35 – 3.30	15	MCL	0	No
Molybdenum	< 6.23 – 56.79	78	RSL	0	No
Platinum	< 0.05	NA			No[4]
Selenium	< 2.48	50	MCL	0	No
Thallium	0.06 – 0.20	2	MCL	0	No
Tungsten	0.34 – 6.04	NA			**Yes**
Uranium	0.68 – 7.92	30	MCL	0	No

1. MCL: EPA Maximum Contaminant Level
2. Not Available
3. RSL: EPA Regional Screening Level
4. Platinum is not considered to be a chemical of interest because all samples have concentrations below the detection limit of platinum (0.05 µg/L).

Arsenic

Arsenic is a naturally occurring element widely distributed in the earth's crust and can be found in air, water and soil. In Arizona, background levels for arsenic are: 10 mg/kg for soil, and 28–40 µg/L for groundwater (AAC 2004; Radden 2005). Arsenic exists as inorganic arsenic, organic arsenic and arsine gas. In general, organic arsenic is less toxic than inorganic arsenic. The general population is likely to be exposed to arsenic through food and water ingestion. The average dietary exposures to total arsenic are: 50.6 µg/day for females, and 58.5 µg/day for males. Fish and seafood contain the highest concentrations of arsenic; however, most of this is the less toxic organic form of arsenic (ATSDR 2007).

Non-Cancer Health Effects

Short-term Exposure (0-14 days):

Overview: Drinking water containing high levels of arsenic (60 mg/L) can result in death. Drinking lower levels of arsenic-containing water (0.3–30 mg/L) can cause irritation in stomach and intestines, with symptoms such as stomachache, nausea, vomiting, and diarrhea (ATSDR 2007). Mizuta et al. (1956) reported an arsenic poisoning incident in Japan. Two hundred and twenty poisoned individuals were exposed to arsenic contaminated soy sauce (0.1 mg/mL, probably as calcium arsenate) for approximately 2–3 weeks. The primary symptoms were edema of the face, and gastrointestinal (nausea, vomiting and diarrhea) and upper respiratory symptoms initially, followed by skin lesions and neuropathy in some patients. The estimated consumption of arsenic for Mizuta et al. (1956) is about 3 mg/day (i.e. 0.05 mg/kg/day, assuming 55-kg body weight for the Asian population). ATSDR established an acute minimal risk level[2] (MRL) of 0.005 mg/kg/day based on the characteristics of the initial poisoning reported in Mizuta et al. (1956), and an uncertainty factor of 10 for using Low Observed Adverse Effect Level (LOAEL)[3] (ATSDR 2007).

Site Specific: ADHS calculated the short-term exposure dose using the highest measured concentration of 14.39 µg/L. The results showed that the estimated exposure doses were below the acute MRL of 0.005 mg/kg/day. Therefore, ADHS does not expect to see symptoms associated with short-term exposure among the residents.

Long-term Exposure (> 365 days):

Overview: In humans, skin is the most sensitive target organ after ingesting arsenic for a long period of time. Typical effects include hyperkeratosis (patches of hardened skin, especially on the palms of the hands and soles of the feet), hyperpigmentation of the skin, and changes in the blood vessels of the skin. These symptoms typically begin to manifest at exposure levels of about 0.002–0.02 mg/kg/day. Ingestion of arsenic can also result in effects on other organs such as cardiovascular and respiratory organ systems. Nausea, vomiting and diarrhea are also common symptoms in humans after repeated exposure to low doses of arsenic; their effects are due to a direct irritation of the gastrointestinal mucosa (ATSDR 2007).

ATSDR established a chronic MRL of 0.0003 mg/kg/day based on the incidence of Blackfoot Disease and dermal lesions (hyperkeratosis and hyperpigmentation) in a population exposed to high levels of arsenic well water in Taiwan. The control-, low-, medium-, and high-exposure levels correspond to doses of 0.0008, 0.014, 0.038, and 0.065 mg/kg/day, respectively. The identified NOAEL is 0.0008 mg/kg/day. Hyperpigmentation and keratosis of the skin (less serious LOAEL) were observed in the low-level exposure group, and increased incidences of dermal lesions were observed in the medium- and high-level exposure groups. The identified NOAEL is limited by the fact that the majority of the population was <20 years of age and the

[2] Minimal Risk Level (MRL): it represents the daily dose of a chemical that people could be exposed to for a specific period of time without experiencing adverse health effects. There should be no risk for developing non-cancer health effects at an exposure dose less than the MRL. If the MRL is exceeded, further evaluation is needed to determine if health effects may occur.

[3] The lowest exposure level at which there are biologically significant increases in frequency or severity of adverse effects between the exposed population and its appropriate control group

incidence of skin lesions increased as a function of age, and because the estimates of water intake and dietary arsenic intake are highly uncertain (ATSDR 2007). The NOAEL would be doubled (0.0016 mg/kg/day) by using the arsenic dietary intakes from rice and yams based on the food analyses conducted by Schoof et al (1998).

Site Specific: Six out of 19 wells had arsenic concentrations that exceeded the MCL of 10 ppb (0.01 mg/L). ADHS estimated the daily exposure dose of long-term exposure for children and adults. The estimated values were compared to health guideline values (i.e. MRL) to determine if the users of the wells were at risk for non-cancer health effects. There should be no risk for developing non-cancer health effects at an exposure dose less than the MRL. If the MRL is exceeded, further evaluation is needed to determine if health effects may occur. There could be concern if the estimated exposure dose approaches the LOAEL (within an order of magnitude). ADHS used the highest detected concentration (14.39 μg/L) to calculate the long-term exposure doses for adults and children. The result showed that the highest estimated exposure dose (0.0014 mg/kg/day for 0-1 year old children) was an order of magnitude lower than the LOAEL. Therefore, ADHS does not expect to see adverse effects among the exposed population.

Cancer Health Effects

Overview: Arsenic has been identified as a known human carcinogen. Ingestion of arsenic can increase the risk for developing cancers of skin, lung, bladder, and to a less extent, kidney, liver and prostate (ATSDR 2007). EPA has calculated an oral cancer slope of 1.5 $(mg/kg/day)^{-1}$ (EPA 2012). ADHS conducted a cancer risk evaluation to determine if drinking the water in these wells over many years could result in an increased risk for cancer. A cancer risk is estimated by using EPA cancer slope factor with the estimated exposure dose (Appendix A). These calculated values may not represent actual risk, but allows regulatory and public health officials a way to identify potential cancer risks. Cancer risks are explained in terms of the likelihood that an additional case of cancer will occur in a population. For example, one additional cancer case in 10,000 exposed individuals indicates that there is a low cancer risk (Appendix B).

Site Specific: ADHS conducted a cancer risk evaluation by using the measured arsenic concentrations and the EPA's standard cancer risk evaluation methodology. ADHS estimated the additional cancer risks from consuming arsenic-contaminated well water for 30 years. According to EPA, it is considered to be protective of the public health if the estimated excess lifetime cancer risk is below or within the range of 1 in 1,000,000 to 1 in 10,000 (10^{-6} to 10^{-4}). The estimated long term cancer risks for 16 wells were more than 4 in 10,000, which is considered to be unacceptable based on EPA's guidance:

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<u>*Cesium*</u>

Cesium is similar to potassium; it enters cells and helps to maintain a balance of electrical charges between the inside and the outside of cells so that cells can perform tasks that depend on those electrical charges. Cells like muscle cells and nerve cells require changing electrical charges in order to function properly and allow you to think and move. After uptake, some cesium is quickly removed from the urine, and a small amount of cesium is removed from the feces. Some cesium stays in the body for weeks or month, which is excreted slowly in urine and feces (ATSDR 2004).

There is no standard for the exposure to stable cesium. The general public is not likely to be exposed to high levels of cesium because the level of stable cesium is low (< 1ppm) in the earth's crust. One study showed that an individual exposed to high levels (34 mg/kg) of cesium after morning and evening meals for 36 days was reported to have decreased appetite, nausea, and diarrhea. This man also experienced neurological changes within 15 minutes of dosing (ATSDR 2004). The detected levels in wells is more than 6,200 times lower than what the man ingested; therefore ADHS does not expect to see residents to experience adverse health effects due to exposure to cesium.

Tungsten

Tungsten was found in all water samples at levels ranging from 0.34 to 6.04 μg/L. EPA has no MCL for tungsten and does not list the element in its IRIS databank. The health effects and levels of concern for tungsten in drinking water are not known. Little is known about the toxicity of tungsten compounds. Keith et al. (2007) provides a comprehensive review of tungsten compounds and its relevance to public health. Limited study results implicate reproductive, developmental and neurological effects as endpoints of concern following oral exposure to tungsten. Acute toxicity does not appear to be a particular toxicological concern based on high values of LD50 (240~11,300 mg/kg/day). LD50 is the dose required to kill 50% of the population. Determining the LD50 is a method used by toxicologists to understand the toxicity of a chemical. Animal studies show long term exposure to tungsten may have effects on body weight. These studies were used to derive non-observed adverse effects levels (NOAEL) of 0.75 mg/kg/day and 8,256 mg/kg/day for chronic and intermediate exposure, respectively. The estimated daily exposure dose for the highest detected concentration (6.04 μg/L) was small compared to the available NOAELs. Tungsten has not been classified for carcinogenic effect by the US Department of Health and Human Services (DHHS), the International Agency for Research on Cancer (IARC), or the US EPA. No evidence exists to suggest that tungsten, at the levels detected at the study area, will cause adverse health effects among the exposed population.

Child Health Considerations

ADHS considers children in its evaluations of all exposures, and we use health guidelines that are protective of children. In general, ADHS assumes that children are more susceptible to chemical exposures than are adults. Children six years old or younger may be more sensitive to the effects of pollutants than adults because their organ systems are not fully developed, and they consume more food on a per mass basis as compared with adults.

If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. The CVs used in this health consultation were developed to be protective of susceptible populations such as children.

Conclusions

Arsenic: The detected levels of arsenic in all sampled wells are not expected to cause short-term or long-term (non-cancerous) adverse health effects among the exposed population. However, the estimated cancer risks of the following wells exceeded the protective levels of public health (10^{-4} ~ 10^{-6}) set by the EPA.

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Cesium: The detected levels of cesium are not expected to cause adverse health effects among the exposed population.

Tungsten: The detected levels of tungsten are not expected to cause adverse health effects among the exposed population.

Recommendations

- For groundwater wells containing arsenic above the safety level, a treatment system that effectively removes arsenic should be installed. Meanwhile, residents should have an alternative water source, such as bottled water, for drinking and cooking.
- All residents in the Green Valley area who use private well water for drinking or cooking should have their well water tested yearly for bacteria and nitrates, and every 3 years for chronic contaminants including arsenic, radon, uranium, lead and copper. If any parameter is found to be above the recommended levels, a confirmation sample should be collected before making any decisions regarding water treatment.

Public Health Action Plan

- ADHS will continue to review and evaluate water monitoring results from the site when data are acquired by the agencies overseeing the site.
- ADHS will attend public meetings, make presentations, and develop educational information on the public health implications of perchlorate when requested by the community or other agencies.

References/Information Sources

ATSDR (Agency for Toxic Substances and Disease Registry), 2004. Toxicological Profile for Arsenic. Atlanta, GA: U.S. Department of Health Services, Public Health services.

ATSDR (Agency for Toxic Substances and Disease Registry), 2007. Toxicological Profile for Cesium. Atlanta, GA: U.S. Department of Health Services, Public Health services.

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