Lead in Drinking Water
An Investigation of Arizona Schools

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Purpose

In March 2004, the U.S. Environmental Protection Agency (USEPA) requested information on efforts to monitor and protect children from exposure to lead in drinking water at schools. The Arizona Department of Health Services (ADHS) reviewed the state lead poisoning registry, and analyzed drinking water samples from 45 randomly selected schools. Funding for the collection and analysis of these samples was provided by the Children's Environmental Health Section located within ADHS. The Office of Environmental Health provided this consultation to help document our findings and supplement our response to USEPA.

This work was also undertaken to help provide useful information should hazardous waste sites be discovered in the future near these schools. We also wanted to apply the ATSDR health assessment process in support of state and federal efforts to protect the health of children.

Introduction

In 2004, homes served by the District of Columbia (DC) Water and Sewer Authority (WASA) was found to have elevated levels of lead in their drinking water. This discovery resulted in national attention on lead in drinking water in DC and in states. Many school districts in the greater DC area, tested their drinking water and found elevated lead levels. School systems located in Seattle, Baltimore and Philadelphia also reported elevated lead levels in drinking water[1]. As a result, in March 2004 USEPA requested information from state environmental and health agencies on local efforts to monitor and protect children from exposures to lead in drinking water at school facilities.

In response this request, ADHS collected and analyzed water samples from drinking fountains and cafeterias at 45 randomly selected schools throughout Arizona. Depending on available funding and staff resources, 35 more schools will be tested in the fall of 2004.

Background

Children are susceptible to adverse health effects from lead, such as impaired mental development, IQ deficits, shorter attention spans, and lower birth weights. Exposure to lead is a significant health concern, particularly for young children and infants whose growing bodies tend to absorb more lead than the average adult. Testing water in schools and day care facilities is important because children spend a significant portion of their days in these facilities and likely consume water while there. There is no federal law requiring sampling of drinking water in schools that receive water from public water systems[1].

Currently, there are 1,080 elementary schools in Arizona, with 48% of the schools located in Maricopa County. Pima County has 17% of the schools, and the remaining 13 counties each have less than 5% of the elementary schools[2].

ADHS Lead Poisoning Prevention Program

ADHS administers the Arizona Lead Poisoning Prevention Program through the Children's Environmental Health Program. This program maintains the state lead poisoning registry, provides case management for lead poisoned children and adults, and conducts educational outreach activities throughout the state.

The most frequently identified lead sources in Arizona are lead-based paint and lead-based paint contaminated dust and soil. Lead-containing home remedies and imported pottery are important sources of lead exposure in Arizona. These sources have caused the most severe cases of lead poisoning documented in the state. According to the state's lead poisoning registry, very few cases of elevated blood lead levels in the past 10 years have been attributed to lead-contaminated drinking water in Arizona.

Lead in Drinking Water

Eliminating lead in drinking water is an important step in reducing a child's overall exposure to lead in the environment. The irregular water use patterns of most schools can result in elevated lead levels in drinking water. Water standing in pipes or in contact with lead-containing plumbing components overnight, and during weekends and extended breaks may result in elevated lead levels in the drinking water[3].

Lead may enter drinking water from a building's plumbing system. Lead may be present in various parts of the plumbing system such as lead solder, brass fixtures, and lead or galvanized pipes that leach lead into the drinking water present in the plumbing system. The amount of lead in a plumbing system will depend on the materials from which the system was constructed and the pH of the water. The age of the building is not relevant when addressing lead concerns because new plumbing fixtures may leach lead into the drinking water[3].

The length of time water is in contact with a lead source is the greatest factor contributing to lead in drinking water. The longer water remains standing in the plumbing system, the more lead it can absorb from any lead sources that are present. The lead concentrations may be highest after the water has remained unused for a length of time, such as overnight, weekends, and extended breaks. Additional factors, such as water chemistry and temperature, can also affect the rate at which water absorbs lead[3].

Methods

ADHS randomly selected 100 schools to participate in this study. This was done by first obtaining a list of the 1,080 Arizona elementary schools from the Arizona Department of Education. Each school was then assigned a number (1-1,080), and this range of numbers was processed at the website www.random.org to get a randomized list of assigned school numbers. Schools represented by the first 100 assigned numbers on this list were contacted by mail and phone to request their participation in the study.

Forty-five schools agreed to participate and were sampled during May to June 2004. Three to five water samples from water fountains and cafeteria kitchen sinks were collected from each school. Sampling locations within each school were selected by proximity to high-use areas such as playgrounds, cafeterias, and kindergarten and 1st grade classrooms.

Samples were collected in 1-liter bottles, preserved with nitric acid and submitted to the Arizona State Health Services Laboratory for lead analysis by EPA Reference Method 200.9.

EPA protocol for sampling drinking water in schools recommends obtaining a first-draw water sample. ADHS did not use this approach because personnel were not available to collect first-

draw samples at some of the rural schools. The schools with drinking water samples that had lead results greater than the laboratory method reporting limit (MRL) will receive confirmatory sampling in the fall of 2004.

Results

ADHS collected 191 drinking water samples from 45 schools throughout Arizona. Three schools located in rural Arizona had lead values that exceeded the laboratory's method reporting limit (Table 1). Each of these schools is supplied by a public drinking water system that meets federal and state drinking water standards and guidance levels. Lead was not detected in drinking water samples from the other 42 schools. A summary of the results for all 45 schools is provided in Appendix A.

Table 1. Drinking Water Results above the Laboratory Method Reporting Limit for Lead.

School	County	Year Built	Sample Location	Result (mg/l)	Exceeds .015 mg/L[1,2]	Exceeds 0.020 mg/L[3]
1	Apache	2004	Cafeteria Kitchen Cold Tap	0.018	**Yes**	No
1	Apache	2004	Inside Water Fountain	0.012	No	No
1	Apache	2004	Inside Water Fountain	0.021	**Yes**	**Yes**
19	Navajo	1977	Water Fountain Kindergarten Room	0.013	No	No
37	Cochise	1980	Hallway Water Fountain	0.005	No	No
37	Cochise	1980	Outside Water Fountain	0.005	No	No

[1] mg/L = milligrams per liter

[2] USEPA action level for lead in drinking water

[3] USEPA action level for 250 mL first-draw samples from water fountains and outlets in schools. This type of sample is used to pinpoint specific fountains and outlets that require remediation (typically water cooler replacement). The two lead action levels differ because of the problems they seek to detect and the sampling protocols used. Appendix B provides additional information on the EPA action levels. The ADHS used the .015 mg/L action level to define which schools would require confirmatory testing.

Discussion

School #1

This school is located in Apache County, Arizona and will have an enrollment of 35 students in pre-kindergarten through fifth grade in the fall of 2004. This school was constructed in 2004 and replaces the original school built in 1932. Results for the two water fountains located in the 2004 buildings were 0.012 and 0.021 milligrams per liter. The water sample from the cafeteria kitchen faucet contained 0.018 milligrams lead per liter. These samples were taken after the school construction was completed and the water had not been in use. The school administrator has turned off the water fountains in the school until further testing can be done. The school was advised to flush plumbing lines after periods of non-use before using the water. Confirmatory sampling has been done at the school and laboratory results should be available by October 2004.

School #19

This school is located in Navajo County, in northern Arizona. It was built in 1973 and expanded in 2003. The enrollment is 356 students from kindergarten to eighth grade. The water sample collected from the drinking fountain in the kindergarten room contained 0.013 milligrams lead per liter, which is below the USEPA action level for drinking water.

School #37

This school is located in Cochise County, in southeastern Arizona. Enrollment is 498 in grades kindergarten through 5th grade, plus 2 preschool programs. The school was constructed in 1980. Two water fountains, one in the hallway by the kindergarten rooms and one at an outside playground, tested positive for low levels lead at 0.005 milligrams per liter.

Age of schools

The ages of the three schools with detectable levels of lead in drinking water ranged from new construction to 31years. School #1 is a new construction that was not occupied until August 2004. School #37 was built in 1980. School # 19 was built in 1973 and was expanded in 2003.

In Pennsylvania, a review of drinking water test results from 300 schools indicated that there was no correlation between the age of the school building and the number of water fountains or water outlets with elevated lead concentrations. The age of a building may not necessarily indicate the age of the plumbing when repairs and renovations are considered[1].

Information regarding the history of plumbing repairs in these three schools is not known at this time. It is unknown if the age of the building or past plumbing repairs contributed to the detectable lead levels in the drinking water.

IEBUK Model

The Integrated Exposure Uptake Biokinetic (IEUBK) Model for lead in children is used to predict the risk of elevated blood lead levels in children under the age of seven that are exposed to environmental lead from many sources. The model combines estimates of lead intake from air, water, soil, dust, diet, and paint with an absorption module for the uptake of lead from the lungs and gastrointestinal tract, and a biokinetic model of lead distribution and elimination from a child's body. The model predicts plausible distributions of blood lead levels in children from 6 months to 7 years of age.

Standard default values were used for air, soil, dust, diet, and paint exposures based on national data supplied by the model. The highest water sample result of 0.021 mg/L from School #1 was used for the water exposure concentration. The model estimated that a 60–72 month old child's blood lead level would be 2.4 ug/dL. This is based on conservatively assuming that a child's entire daily intake of water would be from this fountain. This estimated blood lead level is well below the Centers for Disease Control and Prevention guidance level of 10 micrograms per deciliter of blood for children[4]. The lead model is provided in Appendix C.

School Education Outreach

ADHS and the Arizona Department of Environmental Quality (ADEQ) have established an interagency Children's Environmental Health Workgroup to enhance cooperation and collaboration between the agencies and expand the exchange of information on issues affecting children's environmental health[4].

Through this project, ADEQ is developing a curriculum module for schools. This module will provide education about lead in drinking water to both students and administrators. The module will actively engage children in conducting drinking water investigations at their schools. The

ADEQ will also provide practical ways administrators and other school personnel can reduce potential risks to children by following U.S. Environmental Protection Agency recommendations to reduce lead levels in drinking water[5]. The recommendations are provided in Appendix D.

Child Health Concerns

According to the Centers for Disease Control and Prevention, many children with lead poisoning have no symptoms; others have only nonspecific symptoms such as headache, stomachache, or irritability. At high levels, lead poisoning can result in stupor, coma, kidney damage, or severe brain damage.

Medical research shows lead to be a toxic metal that can be harmful to human health even at low exposure levels. Young children, infants, and fetuses are particularly vulnerable to lead because the physical and behavioral effects of lead occur at lower exposure levels in children than in adults. Overexposure to lead can permanently impair a child's mental and physical development. Low levels of exposure have been linked to damage to the central and peripheral nervous system, learning disabilities, shorter stature, impaired hearing, and impaired formation and function of red blood cells.

The degree of harm depends upon the total exposure to lead from all sources. In recent years, government initiatives such as federal controls on lead in gasoline have significantly reduced our overall exposure to lead. However children are still exposed to lead from a number of sources including air, soil, dust, food, and water. Lead in drinking water can be a significant contributor to overall exposure to lead[6].

Conclusion

ADHS found **no apparent public health hazard** in the 45 Arizona schools that were sampled for lead in drinking water. The three schools that showed detectable amounts of lead in the drinking have removed the drinking fountains that were sampled from use. Some of the confirmatory water sampling from these points of service has been conducted and the laboratory results are pending at this time. Other locations in these schools will also be sampled. An additional 35 schools will be tested in the fall of 2004 based on available funding and staff resources. ADEQ will provide Arizona elementary schools with educational materials about lead in drinking water.

Recommendations

ADHS recommends that Arizona schools follow USEPA's Recommendations for Drinking Water in schools (Appendix D).

Public Health Action Plan

ADHS will review follow-up sampling results, and results from any additional Arizona schools that are sampled for lead in drinking water.

ADHS will work with the ADEQ and the Arizona Department of Education to provide an educational curriculum for lead in drinking water to Arizona schools.

ADHS will make Appendix of this document and any education curriculum that is developed available on the ADHS web site.

ADHS and ADEQ will use the interagency Children's Environmental Health Workgroup to enhance cooperation and collaboration between the agencies and expand the exchange of information on issues affecting children's environmental health.

References

[1] U.S. Environmental Protection Agency. Letter from Benjamin H. Grumbles. Acting Assistant Administrator. Washington D.C. March 18, 2004.

[2] Internet access: http://www.azsba.org/factoids.htm Last accessed August 11,2004.

[3] Washington State Department of Health. Fact Sheet: Lead in School Drinking Water. March 2004. DOH Pub331-255)

[4] Internet access: http://epa.gov/superfund/programs/lead/ieubk.htm. Last accessed 8/13/2004.

[5] Internet access: ttp://www.azdeq.gov/function/news/2004/jan.html#011. Last accessed on 8/16/2004.

[6] U.S. Environmental Protection Agency. Lead in School Drinking Water. EPA 5709-89-001. 1989.

[7] Internet access**: www.epa.gov/superfund/programs/lead/products/tsd.pdf.** Last accessed on August 10, 2004.

Author

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CERTIFICATION

The Arizona Department of Health Services, under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), prepared this lead in schools health consultation. It was prepared in accordance with approved methodology and procedures existing at the time.

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Allen Robison
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The Division of Health Assessment and Consultation has reviewed this health consultation and concurs with its findings.

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Appendix A

School Drinking Water Sampling Results

School [1]	County	City	Year Built	Enrollment in 2003	No. of Samples	Results (mg/L)	Exceeds EPA Action Level 0.015 mg/L?
1	Apache	Alpine	2004	35	4	ND – 0.021	**Yes**
2	Apache	Alpine	1932/1973	35	2	ND	**No**
3	Maricopa	Arlington	2004	186	4	ND	**No**
4	Mohave	Bullhead City	1991	450	4	ND	**No**
5	Maricopa	Phoenix	2001	932	4	ND	**No**
6	Maricopa	Phoenix	1958-1995	663	5	ND	**No**
7	Maricopa	Phoenix	1962	1014	4	ND	**No**
8	Maricopa	Cave Creek	2000	675	5	ND	**No**
9	Maricopa	Chandler	1982-1986	737	4	ND	**No**
10	Yavapai	Clarkdale	1985	358	5	ND	**No**
11	Maricopa	Phoenix	1954	1135	5	ND	**No**
12	Maricopa	Surprise	1989	953	4	ND	**No**
13	Maricopa	Phoenix	2002	691	5	ND	**No**
14	Maricopa	Gilbert	1988	619	4	ND	**No**
15	Maricopa	Gilbert	1995	861	4	ND	**No**
16	Maricopa	Glendale	1992	919	5	ND	**No**
17	Navajo	Overgaard	1980-1998	156	4	ND	**No**
18	Maricopa	Phoenix	1980	1079	4	ND	**No**
19	Navajo	Joseph City	1973-2003	356	4	ND-0.013	**No**
20	Navajo	Kayenta	1960-1995	387	4	ND	**No**
21	Maricopa	Phoenix	1988	623	5	ND	**No**
22	Maricopa	Litchfield Park	2000	705	4	ND	**No**
23	Maricopa	Phoenix	1988	791	5	ND	**No**
24	Maricopa	Mesa	1986	724	4	ND	**No**
25	Maricopa	Mesa	1960-1994	904	4	ND	**No**
26	Maricopa	Mesa	1985	730	5	ND	**No**
27	Maricopa	Phoenix	1953-2000	924	4	ND	**No**
28	Maricopa	Wittman	1991	556	5	ND	**No**

School [1]	County	City	Year Built	Enrollment in 2003	No. of Samples	Results (mg/L)	Exceeds EPA Action Level 0.015 mg/L?
29	Maricopa	Wittman	1990-1994	436	4	ND	**No**
30	Maricopa	Phoenix	1985	774	4	ND	**No**
31	Maricopa	Peoria	1980	755	4	ND	**No**
32	Maricopa	Peoria	2000	1395	5	ND	**No**
33	Maricopa	Phoenix	1970-1981	576	5	ND	**No**
34	Maricopa	Phoenix	1981	657	5	ND	**No**
35	Maricopa	Scottsdale	1987	674	5	ND	**No**
36	Navajo	Show Low	1983-1999	201	3	ND	**No**
37	Cochise	Sierra Vista	1980	498	4	ND-0.005	**No**
38	Pima	Tucson	1960-1977	585	4	ND	**No**
39	Maricopa	Tolleson	2002	500	3	ND	**No**
40	Maricopa	Tolleson	2002	696	5	ND	**No**
41	Pima	Tucson	1962-1987	521	3	ND	**No**
42	Pima	Tucson	1968-1980	554	5	ND	**No**
43	Pima	Tucson	2001	600	4	ND	**No**
44	Yuma	Yuma	1993	954	4	ND	**No**
45	Yuma	Yuma	1956-1993	689	4	ND	**No**

1 School names are not provided. Schools agreed to participate based on anonymity.

Appendix B

Action Levels for Lead in School Drinking Water.

In January1989, the EPA published a manual "Lead in Schools Drinking Water" which was updated in 1994 to assist school officials in identifying whether a school had a problem with lead in drinking water, the steps to reduce or eliminate this problem, and information on training personnel in sampling and remedial programs. As a part of this program, EPA recommended that schools collect 250 ml first-draw samples from water fountains and outlets and that the water fountains and/or outlets be taken out of service if the lead level exceeded 0.020 mg/L. The sample was designed to pinpoint specific fountains and outlets that required remediation (water cooler replacement).

The final rule establishes a lead action level of 0.015 mg/L at the 90^{th} percentile. The action level in the final rule is based on 1 liter first-draw samples collected from numerous targeted sampling sites throughout a distributions system and is designed to identify system-wide problems and not problems in single outlets. This is quite different from the sampling conducted in schools where EPA is concerned with locating individual outlets that require remediation. The school sampling protocol maximizes the likelihood that the highest concentrations of lead are found because the first 250ml sample are analyzed for lead after overnight stagnation (usually much longer than the 6 hour minimum specified for this regulation. Consequently, the two lead action levels differ because of the different problems they seek to detect and the different monitoring protocols used in the two situations[7].

Appendix C

LEAD MODEL FOR WINDOWS Version 1.0

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Model Version: 1.0 Build 261
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research
The time step used in this model run: 6 - Every 30 Minutes (48 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	5.530
1-2	5.780
2-3	6.490
3-4	6.240
4-5	6.010
5-6	6.340
6-7	7.000

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 0.021 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 150.000 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	200.000	150.000
1-2	200.000	150.000
2-3	200.000	150.000
3-4	200.000	150.000
4-5	200.000	150.000
5-6	200.000	150.000
6-7	200.000	150.000

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

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CALCULATED BLOOD LEAD AND LEAD UPTAKES:
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Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	2.563	0.000	0.002
1-2	0.034	2.667	0.000	0.005
2-3	0.062	3.022	0.000	0.005
3-4	0.067	2.937	0.000	0.005
4-5	0.067	2.879	0.000	0.006
5-6	0.093	3.056	0.000	0.006
6-7	0.093	3.383	0.000	0.006

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	4.077	6.663	3.6
1-2	6.448	9.154	3.8
2-3	6.506	9.596	3.6
3-4	6.576	9.584	3.4
4-5	4.958	7.909	2.8
5-6	4.490	7.645	2.4
6-7	4.252	7.734	2.2

Appendix D

Lead in School Drinking Water

U.S. Environmental Protection Agency. Lead in School Drinking Water. EPA 5709-89-001. 1989. Available online: www.epa.gov.

From : Lead in School Drinking Water

Schools should follow these recommendations to reduce any lead contamination in drinking water:

1. Use only cold water for the preparation of food and beverages in school cafeterias and cooking classes. Hot water dissolves lead more quickly than cold water and is likely to contain higher levels of lead. If hot water is needed, it should be drawn from the cold-water tap and heated on a stove.

2. Purchase bottled water if school drinking water exceeds the EPA action levels. Bottled water sold in interstate commerce is regulated by the U.S. Food and Drug Administration. Water that is bottled and sold within a state is under state regulation. The U.S. EPA recommends that schools require a written statement from the bottled water distributor guaranteeing that lead levels in the water do not exceed 5 ppb.

3. Do not use water that has been in contact with your school's plumbing for more than 6 hours, such as overnight, or after weekends or vacations. Have the water system flushed by the school maintenance personnel. Before school begins, flush those outlets where test results indicated lead levels over 0.020 mg/L. If the test results show widespread contamination within your building, flushing the interior plumbing may also be necessary.