Health Consultation

PERCHLORATE INVESTIGATION

GEORGETOWN, WILLIAMSON COUNTY, TEXAS

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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

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An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

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 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

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GEORGETOWN, WILLIAMSON COUNTY, TEXAS

Prepared by:

The Texas Department of State Health Services
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

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Purpose and Statement of Issues

The Texas Commission on Environmental Quality (TCEQ) requested the Texas Department of State Health Services (DSHS) to investigate potential health risks associated with perchlorate contamination found in water samples obtained in the city of Georgetown and Williamson County, Texas. The DSHS Health Assessment and Toxicology Program, under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), reviewed analyses of groundwater and surface water samples collected from residential (private water wells), commercial/industrial, and public water systems to assess the potential for exposure to perchlorate. (Note: Appendix A provides a listing of abbreviations and acronyms used in this report).

Background

Site Description and History

Georgetown is the county seat for Williamson County. It is located about 25 miles north of Austin, the state capitol. The 2000 U.S. Census reported the Georgetown population as 28,339, and the Williamson County population as 249,967 [1].

The county is divided into two geographic regions. The eastern half, an extension of the Coastal Plains, is gently rolling, with an average elevation of 600 feet above sea level. The western half, an extension of the Western Plains, is hilly brush land, with an average elevation of 850 feet [2]. The difference in elevation on the western portion of the county's midline is due to the Balcones Escarpment. This limestone escarpment formation is a result of a geologic fault. Water-bearing formations pass beneath the escarpment to produce numerous artesian springs throughout central Texas [3]. The most prolific water-bearing formation is known as the Edwards Aquifer. This aquifer provides water for millions of central Texas residents—from San Antonio to north of Austin, including the Georgetown area.

The site, or sampling area, is located mainly to the south and southwest of Georgetown. Sampling locations are both within and outside the Georgetown city limits. Water samples reviewed in this report were collected from residential (private wells), commercial/industrial, and public water systems. The residential and commercial/industrial users obtain groundwater from the Edwards Aquifer. The public water systems obtain groundwater from the aquifer as well as surface water from Lake Georgetown, which is approximately 5 miles northwest of the sampling area.

Samples were collected from Public Water Systems (PWS) that had been inspected, approved, and issued identification (ID) numbers by the TCEQ. The city of Georgetown (PWS ID 246001) and the city of Round Rock (PWS ID 2460003) serve populations of 37,774 and 77,104, respectively. Both of the cities' water systems obtain surface water from Lake Georgetown and groundwater from the Edwards Aquifer. Rabbit Hill School and Day Camp (PWS ID 2460079), a day care/school, serves a population of 120 children and teachers. Micropack Corporation (PWS ID 2460147) is a wholesaler of bottled water [4]. Micropack Corporation (a.k.a. Clear Source, Inc.) is licensed and approved by the Texas DSHS to bottle and sell water from its location in Georgetown. Groundwater is bottled on site and sold to major retailers [5].

Under the Unregulated Contaminant Monitoring Rule, The United States Environmental Protection Agency (EPA) required all large public water supply systems to monitor for perchlorate. The timeframe set by this rule required the monitoring to be conducted during 2001 to 2003. The TCEQ sampled the city of Georgetown municipal water supply beginning in March 2003. Samples collected in July and November 2003 contained perchlorate concentrations ranging from 4.3 to 4.58 parts per billion (ppb). These concentrations exceeded the 4-ppb Interim Action Level (IAL) set by the TCEQ. Because of these findings, a sampling of area groundwater was expanded to include area private, commercial/industrial, and other public water systems [6].

Environmental Sampling

From March 2003 to December 2004, the TCEQ collected 172 groundwater and 40 surface water samples from private, commercial/industrial, and public sources. TCEQ then analyzed the samples for perchlorate to document the presence and extent of chemical contamination.[1] Surface water samples were obtained from a location approximately 25 miles upstream of the nearest intake for a public drinking water system (Granger Lake, City of Taylor public water system) [7].

Eighty-eight groundwater samples were collected from private (residential) water wells that serve both homeowners and tenants. Eighty-six samples were collected from commercial or industrial wells, including three quarries, a concrete company, a distributor and manufacturer of explosives, a church, and a landscaping/nursery business. Samples collected at the quarries included surface water [(e.g., settling ponds, ditches, puddles, San Gabriel River) and groundwater (used for irrigation/livestock), and an abandoned/non-occupied residence]. A TCEQ investigation indicated that all of the quarries use an ammonium nitrate/fuel oil mixture as their primary explosive. While this mixture does not contain perchlorates, the water gel used with the explosive may contain 0 to 5% ammonium perchlorate and sodium perchlorate [7]. Samples collected from other businesses were of groundwater used for drinking and or irrigation purposes.

Thirty-eight PWS samples were collected from the city of Georgetown, the city of Round Rock, a day care/school, and a commercial water bottler.

Community Health Concerns

Through press releases dated December 3, 2003, Georgetown residents were notified of the perchlorate contamination. Private well owners who may have been potentially affected by perchlorate contamination were notified via first class mail by the TCEQ [6]. DSHS is not aware of any community health concerns.

Discussion

Perchlorate

Perchlorate (ClO_4^{-1}) is the most oxygenated member of a series of compounds made up of chlorine and oxygen. It can form an acid or a salt in combination with a hydrogen ion (H^+) or another

[1] The DSHS and ATSDR relied on the information provided in the referenced documents and assumed that adequate quality assurance/quality control (QA/QC) procedures were followed with regard to data collection, chain-of-custody, laboratory procedures, and data reporting.

cation such as a sodium, potassium, or ammonium ion. Perchlorate salts, which have been widely used as oxidizers in solid propellants for rockets and missiles since the mid-1940s, have a finite shelf-life and must periodically be replaced. As a result, large volumes of perchlorate have been disposed of since the 1950s. Outdated disposal practices in the decades prior to modern environmental laws may have allowed perchlorate to contaminate groundwater.

Perchlorates also are used in products such as explosives, fireworks, road flares, air-bag inflation systems, lubricating oils, nuclear reactors, and electronic tubes. Processes such as tanning and finishing leather, electroplating, aluminum refining, rubber manufacturing, and producing paints and enamels also may involve perchlorate compounds. In 2001, an EPA-conducted survey of fertilizer composition detected perchlorate in ore from Chile used as fertilizer and concluded that fertilizer would probably not be a major source of perchlorate contamination [8].

Perchlorate salts readily dissolve in water. The perchlorate anion (ClO_4^{-1}) is highly mobile in aqueous systems and can persist for many decades under typical groundwater and surface water conditions. Perchlorate is not well absorbed through the skin, and exposure through inhalation is negligible due to the low vapor pressure of perchlorate salts [8]. Drinking water contaminated with perchlorate is the most likely way that perchlorate can enter the body.

Toxicologic Evaluation

In the past, physicians used perchlorate to treat Grave's Disease, a disorder that causes an overproduction of thyroid hormones. This practice was discontinued in the 1960s when aplastic anemia and other irreversible hematological side effects were observed in treated patients.

Perchlorate competitively inhibits the uptake of iodide by the thyroid gland through its effect on a transport molecule called the "sodium-iodide symporter" (NIS), which is responsible for the active transport of iodide into the thyroid. Iodine is an essential trace element that can be rate-limiting in thyroid hormone synthesis. Because of this inhibitory effect, the adverse health effects associated with exposure to perchlorate are expected to be similar to those caused by iodine deficiency. Possible effects from exposure include a decrease in the production of thyroid hormones (T3 and T4), an altered metabolic rate, hypothyroidism, and thyroid tumors.

Pregnant women and developing fetuses may be particularly susceptible to the effects of perchlorate exposure in drinking water, especially in the first and second trimesters of pregnancy. Pregnancy itself puts stress on the thyroid. Women with critically low levels of iodine may miscarry, or their developing fetuses can suffer congenital hypothyroidism, which may stunt fetal growth and affect the proper development of the central nervous system. Under these conditions, pregnant women are at increased risk for pregnancy complications such as preeclampsia, placental abruption, and low birth weight infants.

The exposure levels that affect thyroid hormone levels are unknown and have not been well demonstrated in humans. Serum perchlorate levels in humans that resulted in iodine uptake inhibition ranging from about 15% to 70% showed no effect on either T4 or the thyroid-stimulating hormone (TSH). These individuals were given perchlorate in drinking water at doses as high as 0.5 mg/kg/day (about 18 ppm in drinking water assuming a 70 kg person consuming 2 L of water daily) for two weeks. Because perchlorate competitively inhibits the transport of iodine

into the thyroid, the lack of observable effect on thyroid hormone levels may be attributable to an adequate daily intake of iodine.

The National Toxicology Program (NTP) has not classified perchlorate as to human cancer risk and the concentration that may cause adverse health effects in humans is a subject of continuing scientific debate. Nevertheless, the Arizona Department of Health Services has developed a health-based drinking water guideline—specifically protective of children—of 14 ppb [9].

In 1999, California and Nevada studied the health effects of perchlorate in drinking water. One study found that drinking water containing perchlorate at concentrations ranging from 4 to 16 ppb did not increase the incidence of hypothyroidism during fetal development. Another study found that drinking water containing perchlorate at concentrations ranging from 4 to 24 ppb did not increase any thyroid condition.

A study of newborns and school age children in Chile found that drinking water containing perchlorate at levels ranging from 100–120 ppb did not suppress thyroid function [10]. In 2004, the state of California adopted a Public Health Goal of 6 ppb for perchlorate in drinking water, despite studies showing that health effects concerning the thyroid are not expected until about 245 ppb [11]. The Texas Commission on Environmental Quality (TCEQ) has established a health-based Interim Action Level (IAL) for perchlorate in drinking water of 4 ppb [12]. EPA has not established a maximum contaminant level (MCL) for perchlorate in drinking water.

In February 2005, EPA adopted recommendations of the National Academy of Science (NAS 2005) and established an official reference dose (RfD) of 0.0007 milligrams per kilogram/day (mg/kg/day) for perchlorate[2] (which assumes total intake from both water and food sources). According to NAS and EPA, the RfD for perchlorate is based on a no observable effect level (NOEL) of 0.007 mg/kg/day for iodide uptake inhibition—a non-adverse effect [13]. An intra-species uncertainty factor of 10 was applied to protect the most sensitive population—the fetuses of pregnant women who might have hypothyroidism or iodide deficiency. Both NAS and EPA concluded that using a non-adverse effect upstream of (i.e., occurring prior to) the adverse effect is a more conservative and health-protective approach to perchlorate hazard assessment [13]. Recently, however, the NAS report and EPA's adoption of that report have been questioned [14].

The RfD translates to a Drinking Water Equivalent Level (DWEL--which assumes that all of a contaminant comes from drinking water), of 24.5 ppb for adults and 7 ppb for a 10-kg child who drinks 1 liter of water daily. A DWEL is defined as a chemical concentration in drinking water that will have no adverse effect. Because margins of safety are built into RfDs and DWELs, exposures above them are not automatically considered unsafe. The following website (most recently accessed on 17 Oct 2005) provides some additional information: http://yosemite.epa.gov/opa/admpress.nsf/b0789fb70f8ff03285257029006e3880/c1a57d2077c4bfda85256fac005b8b32!OpenDocument.

For this investigation, we used DWELs of 24.5 ppb and 7 ppb to assess potential health risks to adults and children, respectfully. We also compared perchlorate levels to the more conservative

[2] A reference dose is an estimate of a daily dose that is not expected to result in adverse health effects in humans.

TCEQ IAL of 4 ppb. The presence of perchlorate above a DWEL or the IAL does not necessarily mean that adverse health effects will occur, but it does suggest that precautions may be warranted.

Results

Mandatory monitoring of perchlorate in large water systems and some small systems began nationwide in 2001. Levels of perchlorate reported in public drinking water supplies throughout the United States range from less than 4 ppb (the minimum reporting level) to 200 ppb. Approximately 98% of samples were less than 4 ppb, with a median concentration of value of 6.4 ppb [8].

Samples collected for this investigation included groundwater and surface water from residential (private water wells), commercial/industrial, and public water systems. Perchlorate levels ranged from non-detect to 72.3 ppb. Forty-one of the 212 samples (19.3%) exceeded the Texas Interim Action Level (IAL) of 4 ppb, with a greater percentage of commercial/industrial samples exceeding the IAL than residential and public water system samples (Table 1).

The concentration of perchlorate in the residential samples ranged from non-detect to 6.17 ppb, with an average concentration of 1.41 ppb; 10 of the 88 residential samples exceeded the IAL. None of the residential samples exceeded DWELs for children (7 ppb) or adults (24.5 ppb).

Perchlorate concentrations in commercial/industrial samples ranged from non-detect to 72.3 ppb, with an average of 3.86 ppb; 26 of the 86 samples (30%) exceeded the IAL (Table 1). A surface water sample from the San Gabriel River on quarry property had the highest perchlorate level found (72.3 ppb). This was the only sample exceeding the adult DWEL. While 12 samples exceeded the child DWEL, it is unlikely that water from these sources would be used by children.

The concentration of perchlorate in samples from the public water systems ranged from non-detect to 4.58 ppb, with an average of 2.64 ppb; 5 of the 38 samples (13%) exceeded the IAL (Table 1). None of the public water system samples exceeded the DWELs for children or adults.

Perchlorate levels in groundwater samples ranged from non-detect to 17.4 ppb. In surface water samples, perchlorate levels ranged from non-detect to 72.3 ppb. About 16% of groundwater samples and 35% of surface water samples exceeded the IAL (Table 2).

Public Health Implications

Children and pregnant women represent populations that may have unique vulnerabilities to the potential health effects resulting from exposure to perchlorate. Children are smaller than are adults, resulting in higher doses of chemical exposure per body weight, and their developing bodies may sustain permanent damage if such toxic exposures occur during critical growth stages.

Pregnant women and developing fetuses may be particularly susceptible to the effects of perchlorate during the first and second trimesters of pregnancy; pregnancy puts a stress on the thyroid. The combined effect of pregnancy, low iodine intake, and exposure to perchlorate theoretically could result in miscarriage and congenital hypothyroidism, stunting fetal growth and affecting the proper development of the central nervous system.

Under these conditions, pregnant women could be at increased risk for pregnancy complications such as preeclampsia, placental abruption, and low birth weight infants. Still, the only water samples exceeding the DWEL for children were collected from commercial/industrial properties. Thus, it is not likely that children would be exposed to perchlorate at levels above the DWEL.

Similarly, the only sample exceeding the DWEL for adults was collected from standing water in the San Gabriel River on quarry property, making it unlikely that adults, including pregnant or non-pregnant women, would be exposed to perchlorate at levels exceeding the DWEL.

Both NAS and EPA concluded that basing the RfD on a non-adverse effect upstream of the adverse effect is a conservative and health-protective approach to perchlorate hazard assessment. That children or adults would be exposed to perchlorate levels above the DWELs we calculated using the RfD is unlikely. Therefore, adverse health effects are considered similarly unlikely.

To some extent, potential effects of perchlorate depend upon adequate iodine in the diet. Thus, pregnant women and children should maintain adequate levels of iodine in their diets. According to the most recent National Health and Nutrition Examination Survey (NHANES III), iodine deficiency (<5 micrograms per deciliter, µg/dL) was found in 11.7% of the total population, 6.7% of pregnant women, and 14.9% of reproductive-age women. This observation represents a 4.5-fold increase over the proportion of iodine deficiency found in the previous NHANES I [15].

Conclusions

Using sample results and the perchlorate information reviewed, the concentrations of perchlorate found in residential and public water supplies are unlikely to result in adverse health effects in children or adults. Thus, we conclude that the perchlorates in the drinking water pose no apparent public health hazard.

Recommendations

- Although the concentrations of perchlorate found in the drinking water are unlikely to result in adverse health effects, pregnant women and children who have continuing concerns about the perchlorate levels in their drinking water should ensure their diet includes an adequate iodine level
- Continue to monitor perchlorate concentrations in public and private water supply systems.
- The Texas Department of State Health Services and the Agency for Toxic Substances and Disease Registry will review additional environmental sampling results and toxicological information as they become available.

Public Health Action Plan

Actions Completed

- Georgetown residents were notified of the perchlorate contamination through press releases dated December 3, 2003.

- Private well owners who may have been potentially impacted by perchlorate contamination were notified by the Texas Commission on Environmental Quality (TCEQ) via first class mail.

Actions Planned

This health consultation will be made available to the public and will be provided to federal/state health and environmental agencies.

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Certification

This Georgetown/Williamson County perchlorate public health consultation was prepared by the Texas Department of State Health Services (DSHS) under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the public health consultation was initiated. Editorial review was completed by the Cooperative Agreement partner.

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Technical Project Officer, SPS, SSAB, DHAC, ATSDR

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

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Team Lead, CAT, SPAB, DHAC, ATSDR

Appendix A - Acronyms and Abbreviations

aka	Also known as
ATSDR	Agency for Toxic Substances and Disease Registry
DSHS	Department of State Health Services
DWEL	Drinking Water Equivalent Level
EPA	Environmental Protection Agency
IAL	Interim Action Level
ID	Identification
MCL	Maximum Contaminant Level
mg/kg/day	milligrams per kilogram per day
NAS	National Academy of Science
NHANES	National Health and Nutrition Examination Survey
NIS	Sodium Iodide Symporter
NOEL	No Observable Effect Level
NTP	National Toxicology Program
ppb	Parts Per Billion
PWS	Public Water System
QA/QC	Quality Assurance/Quality Control
RfD	Reference Dose
TCEQ	Texas Commission on Environmental Quality
TSH	Thyroid Stimulating Hormone

Appendix B - Tables

Table 1. Sample results by water usage which exceeded DWEL and/or IAL: March 2003–December 2004

Water usage	*Perchlorate range (ppb)*	*# samples exceeding DWEL (24.5 ppb) per total samples*	*# samples exceeding child DWEL (7 ppb) per total samples*	*# samples exceeding IAL (4 ppb) per total samples*
Residential	nd – 6.17 J	0/88 (0%)*	0/88 (0%)	10/88 (11.4%)
Commercial/Industrial	nd - 72.3	1/86 (1.2%)	12/86 (14%)	26/86 (30.2%)
Public Water Systems	nd - 4.58	0/38 (0%)	0/38 (0%)	5/38 (13.2%)
Total	nd - 72.3	1/212 (0.47%)	12/212 (5.7%)	41/212 (19.3%)

Table 2. Sample results by water type exceeding DWEL or IAL: March 2003 – December 2004

Water type	*Perchlorate range (ppb)*	*# samples exceeding DWEL (24.5 ppb) per total samples*	*# samples exceeding child DWEL (7 ppb) per total samples*	*# samples exceeding IAL (4 ppb) per total samples*
Groundwater	nd - 17.4	0/172 (0%)	5/172 (2.9%)	27/172 (15.7%)
Residential	nd - 6.17 J	0/88 (0%)	0/88 (0%)	10/88 (11.4%)
Commercial/industrial	nd - 17.4	0/46 (0%)	5/46 (10.9%)	12/46 (26.1%)
Public	nd - 4.58	0/38 (0%)	0/38 (0%)	5/38 (13.2%)
Surface water commercial/industrial	nd - 72.3	1/40 (2.5%)	7/40 (17.5%)	14/40 (35%)

* = percentage of samples exceeding DWEL
J = estimated value
DWEL = Drinking Water Equivalent Level
nd = not detected
IAL = Interim Action Level
ppb = parts per billion