

Health Consultation

Hills, Iowa Perchlorate Groundwater Contamination Site

Hills, Johnson County, Iowa

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Prepared by:
Iowa Department of Public Health
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

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Purpose

The U. S. Environmental Protection Agency (EPA) Region 7, as well as concerned citizens, asked the Iowa Department of Public Health (IDPH) Hazardous Waste Site Health Assessment Program to perform a health consultation for the Hills, Iowa Perchlorate Groundwater Contamination Site. Specifically, IDPH was asked to determine if EPA's action of providing bottled water to residents whose private wells had concentrations of greater than 18 µg/L (micrograms per liter) or 18 parts per billion (ppb) perchlorate is protective of public health, and to address some community health concerns. The information included in this health consultation was current at the time of writing. Data that emerges later could alter this document's conclusions and recommendations.

Background

Hills is a town within Johnson County, Iowa, approximately 10 miles south of Iowa City, Iowa. The town has a population of approximately 662 residents. A majority of the town has shallow sand point private wells (approximately 20-foot deep) that are used as the source of drinking water for residences and businesses (1). Perchlorate has been detected in some of these private wells and within the groundwater beneath Hills, Iowa. The EPA began a groundwater and soil investigation in 2001. This investigation is still on going.

In June 2001, the EPA performed a pre-CERCLIS site screening assessment at the former USDA grain storage facility located in the northwest portion of Hills, Iowa, an area now occupied by single family homes (2). During this assessment, perchlorate was detected in one of four drinking water well samples at a concentration of 29.7 ppb.

A second pre-CERCLIS sampling event occurred in May 2002 to verify and determine the extent of perchlorate contamination in groundwater. Perchlorate in groundwater was detected in samples obtained during the May 2002 sampling event from four of the eight drinking water wells sampled at concentrations ranging from 9.20 to 28.8 ppb (2).

In May and September of 2003, additional groundwater samples were obtained from 191 private and community wells. Twenty-one of the wells tested were categorized as community wells. These wells provide water to places other than single-family homes like; churches, community centers, an assisted living village, parks, businesses, fire stations, etc. Perchlorate was detected in water from 148 of these 191 wells at concentrations ranging from 0.45 to 66.0 ppb (2).

In February and March of 2004, additional groundwater samples were obtained from 65 private and community wells. Perchlorate was detected in water from 27 of these 65 wells at concentrations ranging from 4.10 to 18.5 ppb (3).

Table 1, below, is a summary of the range of concentrations of perchlorate detected in private and community wells during the June 2001, May 2002, May and September 2003, and February and March 2004 sampling events.

Sampling Event	Number of Drinking Water Wells Sampled	Range of Perchlorate Concentration in Wells, µg/L (ppb)
June 2001	4	29.7
May 2002	8	9.20 to 28.8
May and September 2003	191	0.45 to 66.0
February and March 2004	65	4.10 to 18.5

Figure 1, included at the end of the report, is a map that shows the location of private wells sampled and range of perchlorate detection levels during the September 2003 sampling event.

Soil and groundwater samples have also been obtained and analyzed in an attempt to determine the source of perchlorate contamination. At the present time, the source of contamination has not been determined.

Contaminant of Concern

The contaminant of concern at the site is perchlorate that has been found in the groundwater and private and community wells in Hills, Iowa. Perchlorate is an ionic compound made up of chlorine and oxygen (ClO_4^-) that can be either naturally occurring or man-made. It may be present in ground and surface waters as a breakdown of ammonium, potassium, magnesium, or sodium salts that contain perchlorate. Perchlorate salts have been used as oxidizing components in solid propellants for rockets, missiles, and fireworks for over 50 years. Perchlorates are also used in tanning and leather finishing, electroplating, aluminum refining, and rubber manufacturing. Perchlorate can also be found as an inert constituent in some fertilizers.

Perchlorate has been detected in private wells in Hills, Iowa, at levels of up to 66.0 ppb. At the present time the EPA has not established a maximum contaminant level (MCL) for perchlorate in drinking water. An MCL is the legally enforceable federal standard that applies to all public water systems. When determining an MCL, EPA considers the level at which a person could drink 2 liters of water containing the contaminant every day for 70 years without suffering any ill effects. Although EPA does not have an MCL for perchlorate at this time, the EPA has established a provisional cleanup range for perchlorate from 4 to 18 ppb, and is the basis for providing an alternate water supply for affected residents of Hills, Iowa (1).

Currently, there are 17 private wells in Hills, Iowa, that have been impacted by perchlorate at concentrations above 18 ppb. These impacted wells include 16 residences and 1 business. These 17 well owners have been provided bottled water as an alternate water supply. In addition to these 17 wells, bottled water has been provided to 7 residences whose private wells are in the

pathway of the perchlorate contamination plume, although the level of perchlorate in the wells serving these 7 residences is below 18 ppb. Bottled water was provided to these residences and business in September 2003, and has continued until this day.

EPA is continuing to monitor for levels of perchlorate within private wells in Hills, Iowa. A subsequent sampling event is scheduled for July 2004.

Community Health Concerns

Several EPA fact sheets have been made available to residents within Hills, Iowa, regarding the perchlorate contamination in private wells within the community. An initial fact sheet was distributed in March 2003 that informed the public how the discovery of perchlorate in private wells was made, and about health issues with regard to perchlorate. Additional fact sheets have been distributed in July, August, and September 2003 and included more information about the on-going investigation, sampling of private wells, additional information regarding perchlorate, notice of a public availability meeting on August 6, 2003, and notice of a public informational meeting on November 6, 2003.

Staff from the IDPH Hazardous Waste Health Assessment Program attended the public availability meeting on August 6, 2003, and the public informational meeting on November 6, 2003. The IDPH Hazardous Waste Health Assessment Program provided the Hills community with a fact sheet. A copy of this fact sheet is included with this health consultation in Appendix A.

During the public availability meeting and public informational meeting, community members mentioned several health issues and concerns. One of the concerns voiced by the Hills community was the feeling that there was no safe level of exposure to perchlorate. This concern was answered by the Hazardous Waste Site Assessment Program by discussing the dose / response concept with the public. It was explained that health effects from exposure to perchlorate occur only after a sufficient dose (or amount) of perchlorate is ingested. It was further explained that the action levels being applied in Hills include safety factors, so that action can be taken before any health effects occur.

Another concern of the public was whether the levels of perchlorate in the private wells are safe for pets. The Hazardous Waste Site Assessment Program answered this question by explaining that the health studies used to determine the action levels being applied in Hills were completed on one of the most sensitive animal species (Sprague-Dawley rats). As explained before, it was mentioned that safety factors were included in the determination of the action levels. Therefore the levels of perchlorate found in private wells within Hills would be safe for household pets.

Discussion

Exposure To Perchlorate

Exposure to perchlorate is determined by determining human exposure pathways. An exposure pathway has five parts:

1. A source of contamination,
2. An environmental medium such as air, water, or soil that can hold or move the contamination,
3. A point at which people come in contact with a contaminated medium, such as, in drinking water, or in surface soil,
4. An exposure route such as, drinking water from a well, or eating contaminated soil on a homegrown vegetable, and
5. A population who could come in contact with the contaminants.

An exposure pathway is eliminated if at least one on the five parts is missing and will not occur in the future. For a completed pathway, all five parts of the pathway must exist and exposure to a contaminant must have occurred, is occurring, or will occur. An exposure pathway to perchlorate was completed when residents of Hills ingested contaminated well water. However, the exposure pathway for residences above the action level of 18 ppb was broken when the residents were provided with bottled water.

Toxicological Evaluation

Human Health Impact From Perchlorate

Human exposure to perchlorate is occurring through ingestion of drinking water that contains perchlorate. Absorption of perchlorate through the skin does not readily occur. In addition, perchlorate does not volatilize easily from water or stream so that the contamination poses no health concern due to inhalation.

High doses of Perchlorate are known to impact the function of the thyroid gland in humans, and have been used as a pharmaceutical. Over 50 years of use as a medication has provided much information about perchlorate's interaction with body chemistry, and possible health risks (4). Perchlorate does not cause cancer in humans, cell mutagenesis or genetic damage, and it does not cause harm to the human immune system. In adults, perchlorate has limited biochemical effects, and these effects are limited to the thyroid gland (4).

High doses of perchlorate, (in the milligrams per day range) interferes with the iodide uptake into the thyroid gland, and can lead to hypothyroidism. The following sequence of events, are necessary for adverse health effects to occur in the case of perchlorate exposure. 1) A threshold amount of perchlorate must be ingested to inhibit iodide uptake into the thyroid gland. 2) A large percentage of normal iodide uptake must be prevented for a long time to deplete the

gland's iodine reserve, and cause a reduction in the thyroid hormone, thyroxine. 3) A reduction in thyroxine must be large enough to overwhelm the body's homeostasis process in which the pituitary gland releases thyroid stimulating hormone to cause the thyroid to produce more thyroxine. If all this happens, then hypothyroidism could result (4).

In adults, the thyroid helps to regulate metabolism. When the thyroid is affected, thyroid hormone production may decrease which can negatively affect that metabolic rate. It may cause signs of hypothyroidism, such as enlargement of the thyroid gland (a goiter).

Human Health Studies

The following two paragraphs summarize information obtained from several human health studies involving perchlorate. These studies are presented to provide information on impacts to human health from exposure to perchlorate in drinking water at levels at or slightly above the levels of perchlorate in private well water in Hills, Iowa.

Two health studies of the effects of perchlorate in drinking water in the states of Nevada and California were completed. In one study, an analysis of the Medicaid database from Nevada was undertaken to determine whether an increase in the prevalence of any thyroid disease was associated with levels of perchlorate in drinking water at 4 to 24 ppb (5). This study found no evidence that perchlorate-containing drinking water at levels ranging from 4 to 24 ppb increases the prevalence of acquired hypothyroidism or of any other thyroid condition. In the other study, data from the state health departments in California and Nevada were analyzed for any increase of congenital hypothyroidism (hypothyroidism acquired during fetal development) in counties that had levels of perchlorate in drinking water supplies at levels ranging from 4 to 16 ppb (6). The study found no evidence that perchlorate-containing drinking water at levels ranging from 4 to 16 ppb increased the incidence of congenital hypothyroidism.

An additional study was conducted to investigate the potential effects of perchlorate in drinking water on thyroid function in newborns and school-age children in northern Chile (7). The level of perchlorate in drinking water in northern Chile can be as high as 100 to 120 ppb. The findings of this study indicated that perchlorate in drinking water as high as 100 to 120 ppb did not suppress thyroid function in newborns or school-age children.

EPA's Perchlorate Action Level

In an effort to assess the risk posed by individual chemicals, the EPA establishes a reference dose (RfD). The RfD is defined as, "an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime". In an effort to develop a human health oral risk benchmark for perchlorate, the EPA established, in 1999, a provisional RfD range of 0.0001 to 0.0005 mg/kg-day for perchlorate-related assessment

activities. In determining this provisional RfD range, the EPA utilized data on the effects of perchlorate to rat thyroid tissue and then added safety factors of several orders of magnitude to calculate the above RfD range. The safety factors used in the calculation of the RfD are applied in order to determine an exposure level below which there is virtually no human health risk, even to sensitive subgroups

In order to determine the concentration of perchlorate in drinking water that would result in an exposure equal to the RfD, assumptions need to be made regarding human consumption of drinking water and average weight. EPA assumes that adults ingest an average of 2 liters of water per day and on average weigh 70 kg. By applying these assumptions to the provisional RfD range of 0.0001 to 0.0005 mg/kg-day, a provisional cleanup level in water would range between 4-18 ppb for perchlorate was established by the EPA. The EPA has used the upper limit of this range (18 ppb) as the action level for providing bottled water to residents in Hills, Iowa. Considering the above referenced human health studies, it can be concluded that the action level of 18 ppb that is being applied by EPA in Hills, Iowa, is protective of human health, even for sensitive sub-populations.

Children and Sensitive Populations

Children are not simply small adults. Pound for pound, children drink more liquid and breathe more air than adults. Therefore, children must be considered separately from adults when exposures are being determined at hazardous waste sites. In children, the thyroid plays a major role in proper development and metabolism. Infants and small children have less reserve of iodine in their thyroid gland than adults, putting them at higher risk. Impaired thyroid function in pregnant women may impact the fetus or newborn resulting in changes in behavior, delayed development, and decreased learning capability. Thus, exposure to perchlorate in drinking water may be a greater concern for women and the developing fetus.

People with reduced thyroid activity from other causes may also be unusually susceptible to perchlorate contamination. This includes people living in endemic goiter areas with low iodine intake, people with exposure to other anti-thyroid drugs (e.g., lithium) (8), and people with Hashimoto's disease (9) or other diseases that reduce thyroid hormone levels. Exposure to perchlorate may produce additional deficiencies in these people beyond those due to their pre-existing conditions, potentially increasing the severity of their conditions.

The EPA has established an action level of 18 ppb of perchlorate in well water, as the level they offered bottled water to residents. IDPH has considered exposures to perchlorate in well water for children, people with pre-existing thyroid conditions, and pregnant women living in Hills. It has been determined that these sensitive populations are not expected to be adversely impacted from the levels of perchlorate in private wells in Hills. Although it may be inconvenient, it is highly recommended that recipients use the bottled water that has been provided for them.

Summary Discussion

Perchlorate has been found in private well water within Hills, Iowa, at concentrations ranging from 0.45 to 66.0 ppb. Community concerns have been voiced regarding past exposures to well water that is contaminated with perchlorate for residents and their pets. Human health studies indicate that perchlorate concentrations in drinking water up to six times higher than the established action levels may not adversely affect human health, including sensitive sub-populations. These studies indicate that past exposures are not likely to produce any adverse health effects for residents in Hills, Iowa.

The EPA has established an action level of 18 ppb perchlorate in Hills. A degree of safety and caution must be used when determining levels of action in order to safeguard human health. EPA has provided bottled water to residences and business whose private wells have perchlorate contamination at greater than 18 ppb. EPA has also provided bottled water to residences whose private wells are in the pathway of the perchlorate contamination plume as a protective measure. The EPA is continuing their investigation in Hills, Iowa, and is continuing to sample and analyze water for perchlorate in private wells.

Conclusions

- The Hills perchlorate site currently poses No Apparent Public Health Hazard. This designation means that contamination is present, but not in amounts likely to cause long term adverse health effects.
- The EPA action level of 18 ppb and offer of bottled water to residents is protective of human health.

Recommendations

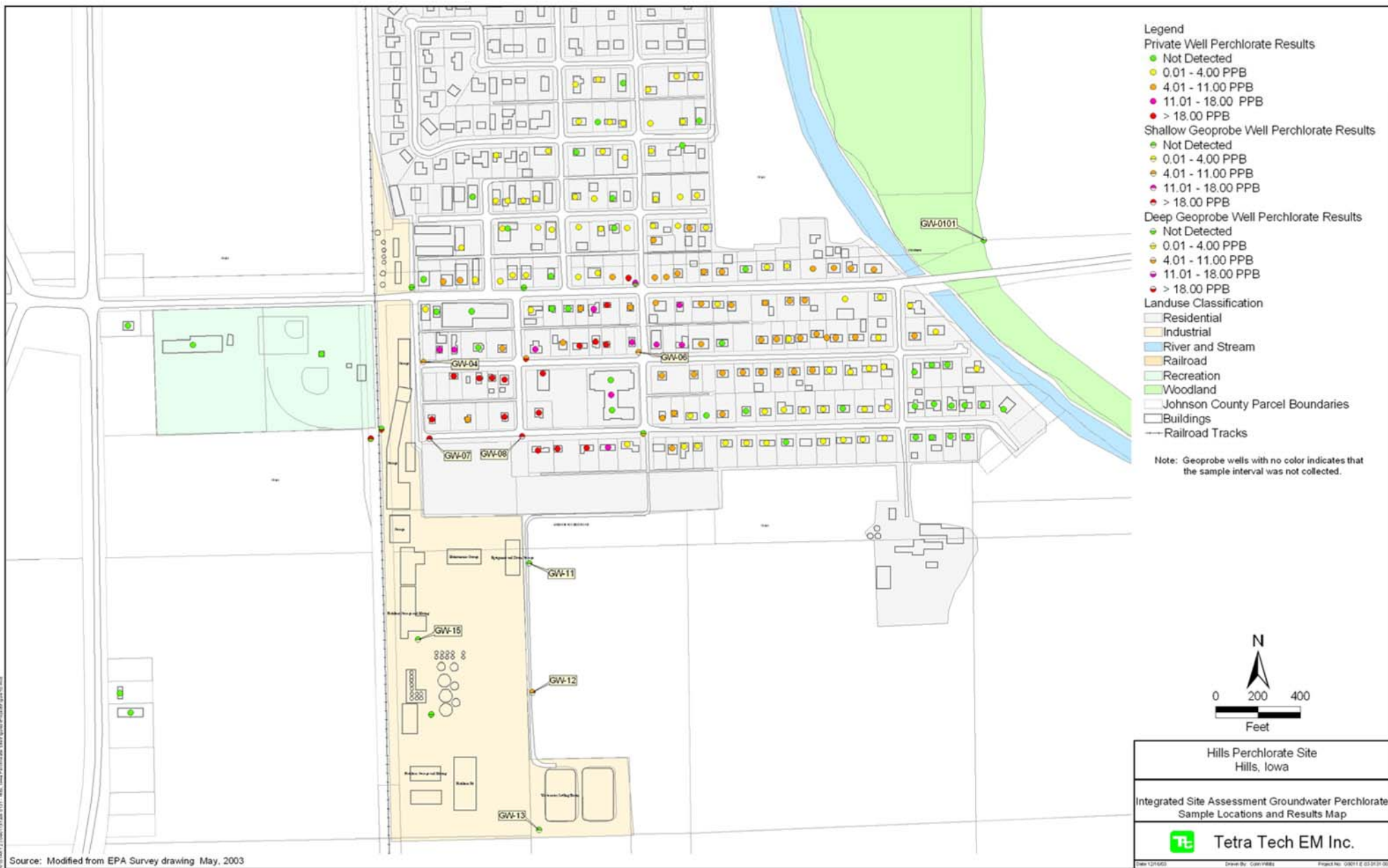
- EPA should continue to monitor the concentration of perchlorate in private well water in Hills.
- EPA should continue their investigation to determine the source of perchlorate contamination.
- Although it may be inconvenient, recipients of bottled water are strongly encouraged to use it for their personal consumption needs.

Public Health Action Plan

- IDPH will provide assistance with community health education as needed and requested.

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- IDPH will continue to review private well monitoring data provided by EPA and update health recommendations as necessary.
 - IDPH will work with the EPA to follow up with Hills residents to address any health concerns.

FIGURE 1



References

1. United States Environmental Protection Agency, Action Memorandum written by Daniel Garvey, September 5, 2003.
2. Tetra Tech EM Inc, Integrated Site Assessment, Hills, Iowa Perchlorate Site, January 4, 2004.
3. United States Environmental Protection Agency, Hills, Iowa, Perchlorate Site Executive Summary, April 2004.
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6. S. H. Lamm and M. Doemland, "Has Perchlorate in Drinking Water Increased the Rate of Congenital Hypothyroidism," *Journal of Environmental Microbiology*, Vol. 43: 630-634, April 1999.
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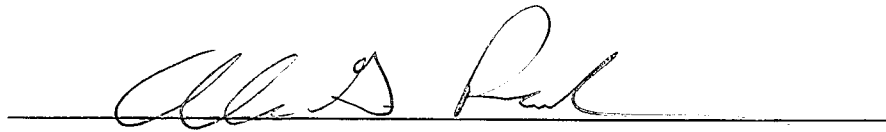
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CERTIFICATION

The Iowa Department of Public Health, Hazardous Waste Site Health Assessment Program, has prepared this health consultation for the Hills, Iowa, perchlorate groundwater contamination site under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). The document is in accordance with approved methodology and procedures existing when the health consultation was being prepared.



Technical Project Officer, SPS, SSAB, DHAC, ATSDR

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



Chief, SPS, SSAB, DHAC, ATSDR

Appendix A Fact Sheet



**Department of Public Health
Division of Health Protection
& Environmental Health**

PERCHLORATE FACT SHEET

“Promoting and Protecting the Health of Iowans”

The Iowa Department of Public Health (IDPH) Division of Health Protection and Environmental Health has prepared this fact sheet to answer some frequently asked questions and provide general information about perchlorate. For more information, call IDPH at 515-281-6881.

HIGHLIGHTS: Exposure to high levels of perchlorate can affect the thyroid gland. Women who are pregnant and their fetuses may be susceptible since pregnancy itself stresses thyroid function. The effects of exposure to any hazardous substance depends on the dose, duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

What is Perchlorate?

Perchlorate is a compound made up of chlorine and oxygen that can either be found in nature or made by man. It has been widely used in rocket fuel, fertilizers, fireworks, road flares, electronic tubes, ammunitions, and in paint and enamel production. Perchlorates are also used in tanning and leather finishing, electroplating, aluminum refining, and rubber manufacturing. Waste from production and improper disposal of perchlorate-containing chemicals are increasingly being discovered in soil and water.

What happens to perchlorate in the environment?

Perchlorate can get into the air and fall to the ground over time. Perchlorates can dissolve in water and remain for decades under typical groundwater and surface water conditions.

How might I be exposed to perchlorate?

- By drinking water that contains perchlorate
- By inhaling dust contaminated with perchlorate
- Perchlorate *is not* well absorbed through the skin

Are there any medical tests to determine if perchlorate exposure has occurred?

- Perchlorate quickly leaves the body in the urine.
- Most labs cannot test perchlorate in urine.
- Your doctor can do a blood test to determine if your thyroid gland is working properly.

How can perchlorate affect my health?

Perchlorate interferes with iodine uptake into the thyroid gland. Because iodine is needed to make thyroid hormones, it may affect how the thyroid functions.

In adults, the thyroid helps to regulate metabolism. When thyroid hormone is affected, thyroid hormone production may decrease which can negatively affect the metabolic rate. It may cause signs of hypothyroidism, such as enlargement of the thyroid gland.

Impaired thyroid function in pregnant women may impact the fetus or newborn resulting in changes in behavior, delayed development, and decreased learning capability. Thus, exposure to perchlorate in drinking water may be a greater concern for women and the developing fetus.

In children, the thyroid plays a major role in proper development and metabolism. Infants and small children have less reserve of iodine in their thyroid gland than adults, putting them at higher risk.

What recommendations has the federal government made to protect human health?

The Environmental Protection Agency (EPA), other federal agencies, states, and water suppliers are addressing perchlorate contamination through a number of activities. The EPA is monitoring perchlorate in drinking water through the Unregulated Contaminant Monitoring Program. Contact the EPA's Safe Drinking Water Hotline at 1-800-426-4791 for more information on drinking water issues.