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August 29, 2007

The Wisconsin Department of Health and Family Services (DHFS) is announcing the public comment period for the Health Consultation report on Manganese in City of Madison Drinking Water.

The 30-day public comment period for this Health Consultation begins on August 29, 2007, and ends on September 29, 2007.

Copies of the Health Consultation report can be obtained from the DHFS web site:
http://dhfs.wisconsin.gov/eh/WISites/index.htm

or at,

Public Health Madison – Dane County
210 Martin Luther King Blvd, Room.507
Madison, WI 53702

or at,

City of Madison Water Utility
119 East Olin Avenue,
Madison WI 53713

or by contacting,
Henry Nehls-Lowe, with the Division of Public Health.

Send written comments on the Health Consultation Report to:
Henry Nehls-Lowe
Division of Public Health
Department of Health & Family Services
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Or email: nehlshl@dhfs.state.wi.us

Health Consultation

PUBLIC COMMENT RELEASE

MANGANESE IN PUBLIC DRINKING WATER - 2006

CITY OF MADISON, DANE COUNTY, WISCONSIN

AUGUST 29, 2007

COMMENT PERIOD END DATE: SEPTEMBER 29, 2007

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

Health Consultation: A Note of Explanation

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

PUBLIC COMMENT RELEASE

MANGANESE IN PUBLIC DRINKING WATER - 2006

CITY OF MADISON, DANE COUNTY, WISCONSIN

Prepared By:

Wisconsin Department of Health and Family Services
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Summary

During 2006, 17 of about 1,119 Madison properties that were sampled had municipal drinking water with manganese levels exceeding the U.S. Environmental Protection Agency (EPA) Lifetime Health Advisory (HA) level of 300 µg/L (micrograms per liter). The manganese levels in these water samples were not at levels likely to result in adverse health effects for residents. Madison residents should not drink or cook with discolored tap water to avoid increased exposures to manganese. When tap water is discolored, residents should run the water until it clears. The City of Madison should continue to notify the public about discolored drinking water, monitor drinking water quality at taps when flushing city water mains, and notify residents about the results.

Introduction

This health consultation was prepared in response to a request from Dane County and the City of Madison, Wisconsin. In 2005, a number of Madison citizens expressed concerns about discolored drinking water and whether it was a health concern, particularly when the Madison Water Utility found elevated levels of manganese in a few water samples. In 2006, more extensive water testing indicated a relationship between discolored drinking water and elevated manganese levels. On August 15, 2006, Dane County and the City of Madison requested assistance from the Agency for Toxic Substances and Disease Registry (ATSDR) to evaluate the human health implications of elevated levels of naturally occurring manganese in the City of Madison municipal drinking water system. ATSDR has a cooperative agreement with the Wisconsin Department of Health and Family Services (DHFS) to perform health consultations and public health assessments within the State of Wisconsin, and as a result DHFS prepared this report. The purpose of this health consultation is to evaluate the manganese exposures experienced by Madison residents during 2006, review the current literature of health effects associated with manganese in drinking water, and address the health questions and concerns raised by the public.

Background

Each year the City of Madison obtains 12 billion gallons of drinking water from 24 wells drilled deep into surrounding groundwater aquifers. Established in 1880, the City of Madison Water Utility provides drinking water, through 840 miles of water mains, to an estimated 220,000 residents at 62,000 homes and commercial properties within the City of Madison, Town of Madison, Village of Maple Bluff, Village of Shorewood Hills, Town of Blooming Grove, and the Town of Burke.

Naturally occurring manganese is common in groundwater drawn for drinking water by the Madison Water Utility. Madison municipal wells draw groundwater with manganese levels

that typically range between 0.1 to 190 µg/L (micrograms per liter). The manganese levels in 16 public wells are typically less than 30 µg/L, with levels in 5 other public wells ranging from 30 to 50 µg/L. There are another 3 public wells with manganese levels that exceed 50 µg/L, but levels do not reach 300 µg/L. The Water Utility only operates these 3 wells between June and September to ensure adequate water flow for fire protection during high water demand summer months, but also to minimize discolored tap water due to the accumulation of manganese in water mains.

Manganese found in groundwater at Madison wellheads is predominantly in a dissolved, water-soluble form. As the water is pumped from the ground and comes into contact with an oxygen rich environment or a strong oxidant such as chlorine, dissolved manganese, iron and other inorganics precipitate out from solution in the water mains. Under normal flow conditions, these mineral precipitates typically remain attached to pipe walls or form as solids that settle on the bottom of the water mains. Over time, significant amounts of mineral accumulation may occur in the water mains.

Manganese in Madison tap water can briefly jump to higher levels than what is found at the wellhead. This has been attributed to several issues, including the flushing of sediments and scaling from the main water supply lines, which also has resulted in discolored and turbid tap water of many homes. However, disturbances in water flow caused by a water main break, a valve being opened or closed, flushing of sediments and scaling from main water supply lines, hydrant flushing, or other disruptions can stir up manganese and other mineral precipitates in sediments, result in discolored water, and temporary water quality problems.

To address this accumulation of sediments, in 2005, the City of Madison initiated the unidirectional flushing of water mains on a limited basis. 3000-foot sections of water pipe are isolated by closing select valves, and high velocity water is used to scour the pipes and remove accumulated sediments that discolor tap water. The flushing program has been used to clean pipes and minimize discolored water at drinking water taps. In 2006, about 50% of the City's 840 miles of water mains were cleaned using uni-directional flushing; the remaining 50% of mains was conventionally flushed. Priority was given to conduct unidirectional flushing in service areas historically served by wells with higher levels of manganese and neighborhoods in which discolored tap water appears more frequently.

Discolored water events may occur even with an effective water main flushing program in place. Mineral deposition in water mains is a cumulative process that depends on the concentration of metals in the source water and time since the previous flush. Discolored water events not associated with flushing water mains are usually random, temporary, and infrequent; water typically clears in 15-30 minutes without additional action. The City of Madison recommends that people avoid drinking, cooking or preparing infant formula with discolored water. Running a cold-water tap at full force can usually flush out the sediments and discoloration in a few minutes. If the color persists, customers are urged to report the problem to the Madison Water Utility.

To better understand the relationship between discolored water and manganese levels, the City of Madison Health Department examined lab analytical data and instrument turbidity[1] measurements of 234 water main samples collected in 2005 and 2006 from fire hydrants (2006). Analysis of the data showed that as turbidity increased manganese concentrations also increased. The data estimated that when turbidity reached 2 NTU (nephelometric turbidity units), manganese levels would typically be close to 300 µg/L, and at 5 NTU, manganese would likely be around 980 µg/L. The City of Madison concluded that "visibly dirty water may have excess levels of manganese and should not be used for drinking or cooking."

Madison residents are likely to see their tap water as discolored when turbidity is above 5 NTU. However, people are less likely to notice discoloration when the turbidity ranges between 1 and 5 NTU. As a result, it is possible to have slightly discolored tap water with manganese above 300 µg/L and ranging up to 980 µg/L. Therefore, it is important that the Madison Water Utility notify the public when there is a potential or evidence of discolored tap water.

Data

Prior to 2005, each year the Madison Water Utility received several complaints from residents about discolored tap water, which was associated with the flushing of water mains. The frequency of these complaints increased in 2005 and 2006, but these complaints may not be associated with flushing. Some calls about discolored tap water raised concerns about drinking water quality and safety. Limited sampling of discolored tap water by the City of Madison in 2005 found elevated concentrations of manganese, occasionally above 300 µg/L, the U.S. EPA Lifetime HA level. A more widespread sampling program instituted in 2006 by the City of Madison found similar results.

There were two situations in 2006 when tap water was tested for manganese by the City of Madison. First, the Madison Water Utility, in collaboration with the City of Madison Health Department, collected 2,075 water samples from 1,113 Madison properties to better understand potential manganese exposures encountered by residents. This investigation encountered 11 properties with a manganese level above 300 µg/L. Second, when a property owner contacted the Madison Water Utility with questions or concerns about discolored tap water, on occasion the utility collected a water sample from the property[2]. When responding to customer concerns and sampling tap water in 2006, the Madison Water Utility encountered 6 private properties with a manganese level above 300 µg/L. While the City of Madison found elevated manganese

[1] Turbidity: Small, suspended solids or particles in water that cause discoloration or cloudiness. Turbidity measures how much suspended solids in water scatter light: water with little scattering of light and high clarity has very low turbidity; the higher the cloudiness and intensity of scattered light, the higher the turbidity.

[2] Currently, when a property owner contacts the Madison Water Utility about discolored tap water, the utility does not collect a water sample, but advises the property owner to not drink the discolored water and recommends running the tap until discolored water disappears.

levels at these 17 properties, it is likely there were other, unidentified properties served by the Madison Water Utility that also had elevated manganese levels in drinking water.

Table 1: Manganese Levels Above 300 µg/L in Tap Water
May to October 2006
City of Madison, Dane County, Wisconsin
All Concentrations in Micrograms per Liter (µg/L)

Service Well	Property	Block Location	Number of Samples	Manganese Concentration		
				Average	Median	Maximum
Random Sampling Program						
Well No. 3	A	2000 Eastwood Dr.	5	773	89	3,450
Well No. 3	B	1200 Elizabeth St.	3	128	39	343
Well No. 3	C	2400 Pennsylvania Ave.	5	95	39	336
Well No. 8	D	2100 Atwood Ave.	5	621	335	1,530
Well No. 10	E	4300 Hillcrest Dr.	6	146	105	368
Well No. 10	F	1300 Whenona Dr.	5	164	11	747
Well No. 29	G	700 Pulley Dr.	5	2,031	19	10,100
Well No. 29	H	700 Redland Dr.	5	98	19	441
Well No. 12	I	5000 Coney Weston Pl.	4	218	11	847
Well No. 25	J	800 Amnicon Tr.	4	79	4	306
Well No. 27	K	1200 Capitol Ct.	4	184	26	672
Sampling in Response to Customer Concerns						
Well No. 3	L	2200 E. Washington Ave	4	188	26	>700
Well No. 3	M	1400 E. Washington Ave	4	212	66	>700
Well No. 3	N	1100 Dayton St.	3	112	8	323
Well No. 10	O	4100 Manitou Way	2	365	365	719
Well No. 11	P	200 Corporate Dr.	4	118	4	461
Well No. 3	Q	1200 E. Johnson St.	4	279	38	1,030

For a short time during 2006, these 17 Madison properties had municipal drinking water with manganese level above the EPA Lifetime HA level of 300 µg/L, with the highest level measured in a tap sample at 10,100 µg/L. These elevated manganese levels occurred within several days

of the routine flushing of nearby city water mains. Water sample data shows that for 15 of the 17 properties with manganese above 300 µg/L, the manganese level in the follow-up sample was well below 300 µg/L. At the other 2 properties with manganese above 300 µg/L, the level increased in the follow-up sample, but dropped below the Lifetime HA level with the second or third follow-up sample (Table 1). In Table 1, properties are referred to by the block within which they are located, for confidentiality reasons.

While the manganese levels in water samples from these 17 properties were above 300 µg/L, the exceedances occurred only once or for a very short time. At 13 properties, the highest manganese level was detected in the 1st sample and levels substantially decreased in all subsequent follow-up water samples. At 3 other properties (A, B, & E) the manganese level in the 1st sample were below the Lifetime HA, then exceeded 300 µg/L in a single follow-up sample, but then dropped and remained below the Lifetime HA in all subsequent water samples. For example, at property G (700 Pulley Drive Block), the first water sample had manganese at 10,100 µg/L, but when resampled 8 days later the level dropped to 19 µg/L, with 9 and 3 µg/L in samples collected over the next 4 days. Finally, at another property (D) the level of manganese in the first 3 samples all exceeded the Lifetime HA level (335, 1,530, and 768 µg/L), and then below 300 µg/L in the last two samples, which were collected 20 and 23 days after the initial water sample. The samples collected at property D (2100 Atwood Avenue Block) were from a commercial building's basement tap that had not been used for 3 years prior to the sampling.

Discussion

In 2006, 17 of 1,119 Madison properties that were sampled received municipal drinking water that had manganese levels exceeding the EPA Lifetime HA level of 300 µg/L. Current studies indicate that the highest levels of manganese found in the City of Madison drinking water are not expected to cause adverse health effects for residents. A limited number of human studies examined long-term, multi-year exposures to elevated levels of manganese in drinking water and suggest children have an increased association with adverse neurological health effects when they drank water for many years with manganese at levels similar to the highest observed in Madison water. However, sampling data shows that during 2006, elevated manganese levels in Madison drinking water occurred only briefly, and the public was not continuously exposed to levels above EPA's health advisory levels for manganese. The manganese levels intermittently found in these water samples are not likely to result in adverse health effects for residents, including children.

Toxicological Implications of Manganese

Evaluating what levels of manganese can be harmful to people is difficult because small amounts of the element is also essential for normal physiological functioning in both humans and animals. Among humans, adverse health effects have been linked to both manganese dietary deficiencies and excess exposures. There also can be a wide variability among humans for an individual's manganese requirements and when adverse reactions occur related to elevated exposures.

Manganese is a naturally occurring element found in many types of rocks and soils, as well as groundwater. Manganese is also found in many foods, and is essential for good health. A normal constituent in human tissue and fluids, manganese is important in the formation of bones, and in the metabolism of amino acids, cholesterol, and carbohydrates (NAS 2001). For adolescents and adults, the National Academy of Sciences (NAS 2004a) recommends a daily intake of manganese between 1.6 and 2.3 mg/day[1], with 2.6 mg/day for women who are breast-feeding. For children between 1 and 8 years old, the recommended daily intake for manganese is between 1.2 and 1.5 mg/day. The recommended daily intake for infants is much lower, at 0.6 mg/day for ages 7 to 12 months, and 0.003 mg/day for ages 0 to 6 months.

Human diet obtains manganese from a variety of sources, including food and drinking water. Table 2 summarizes levels of manganese typically found in food. When ingested, manganese is absorbed into the blood from the small intestine, with greater absorption from water than food. Manganese is removed from the blood by the liver, and is ultimately excreted from the body via feces. The dose of manganese that adults and children obtain in their daily diet is usually well above the U.S. EPA Lifetime HA level for drinking water, which is set at 300 µg/L (how the Lifetime HA was derived is described on page 10).

While manganese is an essential nutrient, at higher doses it can be harmful, particularly for infants. The NAS set the "Tolerable Upper Intake" for manganese by adolescents and adults between 6 to 11 mg/day, and children aged 1 to 8 years between 2 to 3 mg/day (NAS 2004b). For infants, NAS was unable to establish an acceptable upper level of manganese because of infant's inability to handle excess amounts of the element and, consequently, NAS recommends that for infants the source of manganese should only be from food.

[1] One milligram (mg) is equivalent to 1,000 micrograms (µg). Therefore, the recommended daily manganese intake of 1.6 and 2.3 mg/day is equivalent to 1,600 and 2,300 µg/day.

Table 2: Manganese Levels in Common Foods

Types of Food	Range of Mean Manganese Concentrations	
	Milligrams per Kilogram (mg/kg)	Micrograms per Kilogram (µg/kg)
Nuts & nut products	18.21 – 46.83	18,210 – 46,830
Grains & grain products	0.42 – 40.70	420 – 40,700
Legumes	2.24 – 6.73	2,240 – 6,730
Fruits	0.20 – 10.38	200 – 10,380
Fruit juices & drinks	0.05 – 11.47	50 – 11,470
Vegetables & vegetable products	0.42 – 6.64	420 – 6,640
Desserts	0.04 – 7.98	40 – 7,980
Infant Foods	0.17 – 4.83	170 – 4,830
Infant formula (soy based)	0.31 – 2.87	310 – 2,870
Infant formula (cow-milk based)	0.03 – 0.075	30 – 75
Meat: poultry, fish & eggs	0.10 – 3.99	100 – 3,990
Mixed dishes	0.69 – 2.98	690 – 2,980
Condiments, fats & sweeteners	0.04 – 1.45	40 – 1,450
Beverages (including tea)	0.00 – 2.09	0.0 – 2,090
Soups	0.19 – 0.65	190 – 650
Milk & milk products	0.02 – 0.49	20 – 490

(Source: ATSDR 2000, page 362)

Studies indicate people develop adverse health effects when they have long-term exposures to high levels of manganese. The central nervous system is the primary target of excess manganese levels. Most human studies have demonstrated notable adverse health effects as a result of manganese inhalation exposures. Occupational studies of workers who inhaled dust with very high amounts of manganese found higher rates of neurological effects than in other workers who inhaled less manganese. There is limited information available about oral manganese exposures and its toxic effects on humans. Studies of animals exposed short and long-term to manganese also confirm that the central nervous system is the primary target of toxicity (U.S. EPA 2004), and that the liver can be adversely affected by high manganese concentrations. However, laboratory animals may not provide good experimental models for understanding the toxicity of manganese in humans.

There is little evidence to indicate that manganese causes cancer in animals and no evidence it causes cancer in humans. Human studies have not reported an association between manganese and cancers, and no firm conclusions about carcinogenicity have been drawn from animal studies (ATSDR 2000). The U.S. EPA has categorized manganese as a Class "D" carcinogen, which is "not classifiable as to human carcinogenicity" (U.S. EPA 2007).

When ingested, manganese is apparently less toxic to people than many other trace metals, and excess manganese is excreted, primarily by the liver. Despite this, a limited number of studies suggest that humans can develop adverse health effects resulting from long term ingestion of food or water with high amounts of manganese. Kondakis (1989) studied older adults (>50 yrs) from a Greece village who, for a number of years, drank well water with manganese levels between 1,800 and 2,300 µg/L. When compared with similar adults from two other villages with lower manganese levels in their drinking water (<252 µg/L), the villagers with the higher manganese levels performed more poorly on neurological evaluations. Contrary to Kondakis' findings, Vieregge (1995) reported no significant differences in neurological measures between two rural German communities, one with manganese levels in private well water ranging between 300 to 2,600 µg/L, and the other without elevated manganese levels in drinking water.

Very young children's bodies appear to be less capable than adults of metabolizing and excreting elevated levels of manganese, possibly because they have immature and developing organs, as well as a longer retention of manganese in their bodies than adults. As a result, children are more likely to develop adverse health effects, primarily neurological, at manganese exposure levels that do not result in similar effects in adults. However, only a few studies have examined the health consequences in young children who had long term exposures to elevated levels of manganese in drinking water. A case study of a 10 year-old child who drank well water for 5 years containing 1,200 µg/L manganese reported the child had poor verbal and visual memory (Woolf 2002). Another study of 142, 10 year-old children from Bangladesh, who regularly drank groundwater with an average manganese concentration of 795 µg/L (ranging between 4 to 3,908 µg/L), found a relationship between elevated manganese exposures and lower test scores on the Welscher Intelligence Scale for Children (Wasserman 2006). In a pilot study of 46 school-aged children (6-15 years old) from a Quebec community, Bouchard et al. (2007) quantified higher manganese hair levels in children whose homes received water from a well with an average manganese level of 500 µg/L compared to other children whose homes were served by a well with an average manganese level of 160 µg/L. The elevated hair manganese levels in children were associated with increased hyperactive and oppositional behaviors in the classroom.

There are very few studies that examined the human health consequences from short term exposure to high levels of manganese in drinking water. Kawamura et al. (1941) reported on neurological effects (muscle tonus, tremors, and mental disturbances) observed in six Japanese families who for 2 to 3 months drank groundwater with manganese levels as high as to 14,000 µg/L. The most severe health effects were reported in the elderly, with younger adults less affected and no symptoms observed in young children. The absence of health effects in young children is contrary to other studies that found children are more sensitive to manganese than adolescents and adults. However, some elderly may be at greater risk of health effects than middle-aged adults, possibly because of declining function of the gastrointestinal tract and liver in excreting manganese. People with liver disease appear to be less efficient in removing excess amounts of manganese from their bodies than healthy adults.

Despite the findings of these studies, each has a number of limitations, such as they did not measure manganese levels in foods, soil, or air, and could not estimate total manganese exposures that subjects had from all other sources. Kondakis (1989) only studied adults 50 years of age and older, and did not include younger adults and children. The Quebec pilot study (Bouchard 2007) reported that tap water was directly consumed in only 9% of homes, but many homes used tap water in cooking, and 89% of all children in the study drank water from dispensers at a school that received water from the well with the higher manganese level. Additionally, researchers did not consider other potential sources of manganese than drinking water, which could greatly affect participant hair concentrations. Participants in the Quebec pilot study were also self-selected, which might have inclined parents to participate if their children had more notable behavioral problems. Both the Quebec (Wasserman 2006) and Bangladesh (Bouchard 2007) studies did not include pre-school and younger children (less than 6 years-old), who may be even more susceptible than school-aged children. Only Kawamura (1941) reported the health effects with manganese exposure duration less than one or more years, though the drinking water levels were very high. There are no studies that have examined the human health consequences from exposure durations of 30 days or less with manganese similar to the levels found in Madison drinking water during 2006.

Health-Based Comparison Values

Health-based comparison guidelines and drinking water standards are set up to protect the health of the general public, including the more sensitive portion of the population. The purpose of this section is to summarize how the comparison values[2] were established for manganese, including the U.S. EPA Lifetime Health Advisory level of 300 µg/L, and the assumptions and safety factors used to be protective of all people, particularly children.

The U.S. EPA has established an oral Reference Dose (RfD) for elemental manganese at 140 µg/kg/day (U.S. EPA 2007). A RfD is "estimated to be an intake for the general population that is not associated with adverse health effects." The RfD for manganese is set at 140 µg per kilogram of body weight per day (µg/kg/day), which is equivalent to 10,000 µg (micrograms) per day for an adult (70 kg) and 1,400 µg per day for a child (10 kg). In developing this RfD, U.S. EPA weighed both its toxicity and essential nature for human diet, and based their decision on the findings of the Food and Nutrition Board of the national Research Council (NRC), which set the "estimated safe and adequate daily dietary intake" of manganese at 2,000 to 5,000 µg per day for an adult.

The U.S. EPA has not issued a maximum contaminant level (MCL) for manganese, which is the maximum allowable level of a chemical in U.S. public drinking water systems. However, U.S. EPA has issued a non-enforceable, secondary MCL for manganese of 50 µg/L. This secondary

[2] A comparison value is the level of a substance in air, water, food, and soil that are unlikely, upon exposure, to cause adverse health effects.

MCL is based on aesthetic factors such as discoloration of plumbing fixtures and staining of laundry.

Lifetime Health Advisory for Manganese

In the absence of U.S. EPA issuing an MCL for manganese in drinking water, it has developed a Lifetime Health Advisory of 300 µg/L. A Lifetime Health Advisory, or Lifetime HA, is a "portion of an individual's total exposure that is attributed to drinking and is considered protective of noncarcinogenic adverse health effects over a lifetime of exposure" (U.S. EPA 2004).

In deriving the Lifetime HA of 300 µg/L, U.S. EPA first calculated a Drinking Water Equivalent Level (DWEL) of 1,600 µg/L, which assumes an adult, who weighs 70 kg, will drink 2 liters of water per day. This DWEL used a modified RfD that was adjusted by a factor of 3, based on:

1. There is no difference between adsorption of manganese from food versus water.
2. The study by Kondakis (1989) that described possible adverse health effects from drinking water for a lifetime with manganese at or above 2,000 µg/L.
3. Infants absorb more manganese from their gastrointestinal tract and excrete less than adults.
4. Soy-based infant formula contains much higher levels of manganese than human or cow milk.

U.S. EPA has concluded that the current information known about manganese is not adequate to quantitatively determine the how much more susceptible children are to manganese than adults (EPA 2004). Despite this uncertainty, U.S. EPA took into account the above factors when modifying the RfD to provide a Lifetime HA that is more protective of children.

U.S. EPA assumed that people get four-fifths of their manganese from other sources, such as food, and one-fifth from drinking water. As a result, the Lifetime HA for adults and children was derived from one-fifth of 1,600 µg/L, which is 300 µg/L.

For short-term exposures, U.S. EPA also developed a Ten-Day HA level for manganese in drinking water for adults and children older than 6-months, which is 1,000 µg/L. For children younger than 6-months, U.S. EPA developed a Ten-Day HA level of 300 µg/L, which takes into account the four factors listed above that were used in deriving the Lifetime HA from the RfD.

For a single exposure to manganese in drinking water by adults and children older than 6-months, U.S. EPA recommended a One-Day HA level of 1,000 µg/L, which is the same level as the Ten-Day HA. U.S. EPA has not provided a One-Day HA level for children younger than 6-months.

<u>Child Health Considerations</u>

DHFS recognizes that children can be especially sensitive to contaminants. Children are often at greater risk than adults to certain kinds of exposure from toxic or hazardous chemicals in the environment. Children engage in activities, such as playing outdoors and hand-to-mouth behaviors, which increases their exposure to hazardous substances. Being much smaller than adults and playing on their hands and knees, children breathe air close to the ground that can have more dust, soil particles, and vapors. Children have a lower body weight, but a higher intake rate which results in a greater dose to chemicals per unit body weight. Also, children's bodies are developing and have a greater risk for permanent damage if toxic exposures are high enough during critical growth stages. For that reason, DHFS considers children as one of the most sensitive populations evaluated in this health consultation, and always takes into account children when evaluating exposures to contaminants.

The few available studies suggest that when very young children are continuously exposed to the highest manganese levels found in City of Madison drinking water, later in life they may have an increased risk of neurological and developmental problems. However, the Madison sampling data indicates that during 2006 the elevated manganese levels occurred only briefly and children were not continuously exposed to levels above the health advisory level, and not likely to result in adverse health effects.

Due to child sensitivity, elevated manganese levels in infant formula, and the association between discolored Madison water and elevated manganese levels, DHFS recommends that residents, particularly families with young children, avoid drinking, mixing infant formula, or cooking with discolored tap water.

Conclusions

1. For a short time in 2006, 17 of 1,119 Madison properties that were sampled had municipal drinking water with manganese levels exceeding the EPA Lifetime HA level of 300 µg/L.

2. Manganese levels in water samples collected from the City of Madison drinking water system during 2006 were not at levels that are likely to cause adverse health effects for residents. This poses a *No Apparent Public Health Hazard*[3].

Recommendations

1. Madison residents, should not drink, cook, or prepare infant formula with discolored tap water to avoid elevated exposures to manganese.

[3] "Exposure to…chemicals…is occurring, but the exposures are not at levels likely to cause adverse health effects" ATSDR 2005.

2. When tap water is discolored, Madison residents should run the tap water until discoloration goes away and the water is clear.

3. The City of Madison should continue to notify the public about discolored drinking water, monitor drinking water quality at taps when flushing city water mains, and notify residents about the results.

Public Health Action Plan

DHFS will address comments received from the public on this Public Comment Release and compile in the Final Release of this health consultation.

DHFS will continue to consult and collaborate with the City of Madison Health Department, and interested community members on manganese in municipal drinking water and related environmental health issues that might arise as new information becomes available.

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