Letter Health Consultation

CALVARY PENTECOSTAL CAMP
ASHLAND, VIRGINIA
Elevated uranium in a non-transient non-community water system

Prepared by:
VIRGINIA DEPARTMENT OF HEALTH
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August 15, 2013

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Letter Health Consultation: A Note of Explanation

A letter health consultation is a verbal or written response from VDH 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 letter health consultation process for Calvary Pentecostal Camp, unless additional information is obtained by VDH which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

COMMONWEALTH of VIRGINIA

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August 15, 2013

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RE: Public health implications from exposure to elevated uranium concentration in potable water at Calvary Pentecostal Camp in Ashland, Virginia

Dear Mr. Aulbach,

Thank you for the opportunity to review the potable well water uranium concentrations you provided April 22, 2013. This letter describes possible public health implications from exposure to the water. Should you have additional questions or information to be considered, please contact me via phone at (804) 864-8127 or email: dwight.flammia@vdh.virginia.gov.

BACKGROUND

The Virginia Department of Health was asked if uranium concentrations in water samples collected from a private well at Calvary Pentecostal Camp Waterworks (and hereafter referred to as “Camp”) were a concern to the community it served. The water system at the Camp is a non-transient non-community water system; therefore, it is regulated but not required to monitor uranium concentrations in the system. On April 11, 2013, the Virginia Department of Consolidated Laboratory Services advised the Office of Drinking Water that an elevated uranium result was identified while processing routine “metals” analysis of a drinking water sample collected on March 3, 2013 by the Camp. The metals analysis yielded a uranium concentration result of 106 micrograms per liter (μg/L). In March 2010, elevated uranium concentrations (96 μg/L) were also reported. The laboratory analyzed the water samples using

> ***Non-transient non-community water systems*** *are a type of non-community system that serves the same users most days, but those people do not live there. Examples are office buildings, factories, or schools.* (VDH web site accessed July 2013)

approved Environmental Protection Agency (EPA) method 200.8 which measures total uranium (P. Ma, Personal Communication, 07/13/2013).

The Camp is located in Hanover County at 11352 Heflin Lane, Ashland, VA 23005. The Camp provides water to volunteer staff and those attending weekend and extended religious meetings at Calvary Pentecostal Campgrounds. During the summer, the campground hosts an Annual Summer Campmeeting that attracts people from outside the area. The meeting this year is being held June 28-September 1, 2013. The individuals attending the Summer Campmeeting are housed at the campgrounds. Other meetings last a few days, while some meetings such as the Women's Convention, require participants to stay at a nearby hotel.

URANIUM

Uranium (U) occurs naturally in soil, rock, and water. In nature, uranium is always found in combination with other elements particularly oxygen. Uranium has an unstable nucleus and emits energy in the form of subatomic particles and radiation. The release of subatomic particles results in a different uranium isotope. Depending on the stability of the isotope produced, called a daughter ion, this process known as radioactive decay will continue until a stable isotope is formed. There are three isotopes of uranium found in nature, U-238, U-235, and U-234. This isotopic mixture exists in nature as 99.284% U-238, 0.711% U-235, and 0.005% U-234 (ATSDR, 2013). Typical uranium soil concentration found in the United States is about three parts per million (ppm), with higher-than-average levels in the West (Bleise, 2003) (Regenspurg, 2009). Uranium occurs as a trace element in geological formations including granite, metamorphic rocks, monazite sands, and phosphate deposits.

Drilled wells that obtain their water from fractures of bedrock are more likely to have higher levels of uranium than dug wells. Other environmental factors that affect the amount of uranium in wells include the partial pressure of carbon dioxide, oxygen, pH, minerals, and the nature of contact between the water and uranium. These factors play a role in uranium's solubility and mobility in the well's source water (EPA, 2006).

Due to its natural abundance, uranium can be found anywhere including water, food, and air. Uranium is not an essential mineral for health and there are no known biological pathways requiring it. Absorption and distribution of uranium in the body is dependent on exposure pathway, particle size, and solubility. Only 0.1-6% of uranium ingested as food or water is absorbed into the blood stream and absorption through the skin is very small. Studies have consistently shown that ingesting soluble uranium (easily absorbed into the blood stream) predominantly affects the kidneys in humans (Vicente, 2010). Insoluble and sparingly soluble compounds (not readily absorbed into the blood stream) are believed to have little potential to cause renal toxicity but could cause pulmonary toxicity from inhalation exposure. Once in the blood stream, more than 50% of the uranium is filtered by the kidneys and leaves the body in the urine within one day. Bathing and showering in water with elevated concentrations of uranium is not a health concern.

There is limited data on the potential for uranium to induce damage to the muscle-skeletal system and liver in humans. Other potential targets of toxicity include the reproductive system although information supporting an association between uranium and reproductive effects in humans is limited. High levels of uranium have been shown to affect the growth and reproductive system in animals (ATSDR, 2013) (Vicente, 2010).

Naturally occurring uranium has very low levels of radioactivity and is the only radionuclide for which the chemical toxicity is equal to or greater than the radiotoxicity (Bleise, 2003) (ATSDR, 2013). Natural uranium has not been classified with respect to carcinogenicity by the National Toxicology Program, International Agency for Research on Cancer, or the EPA.

URANIUM DRINKING WATER STANDARD

In 1974, U.S. Congress passed the Safe Drinking Water Act. This law requires EPA to determine the level of contaminants in drinking water at which no adverse health effects are likely to occur. EPA uses a multi-step process to determine the *non-enforceable* maximum contaminant level goal (MCLG) (EPA, 1992) (EPA, 1993). The critical step in this process is the determination of the oral reference dose (RfD). This is the dose below which non-carcinogenic health effects should not occur from being exposed to the contaminant for a lifetime. The RfD is generally based on studies where animals are exposed to doses of a contaminant that does not produce any adverse effects (no-observed-adverse-affect-level (NOAEL)). In cases where all doses in a study produced adverse effects then the lowest dose (lowest-observed-adverse-affect-level (LOAEL)) is used. Next, uncertainty factors are applied to the dose to account for animal-to-human extrapolation, variability in population sensitivity, and inadequacies of the available data to yield the RfD (EPA, 2009).

The MCLG is calculated by applying water consumption rates, average adult body weight, and the contribution that consuming water with the contaminant adds to the overall daily intake to the RfD. The MCLG is used to derive the *enforceable* maximum contaminant level (MCL). This level is set as close as possible to the MCLG but takes the following factors into consideration: analytical methodology, treatment technology and costs, economic impact, and regulatory impact (EPA, 2009).

The MCL for uranium in public drinking water that is determined to be protective of cancer and kidney toxicity is 30 µg/L (EPA, 2013a) (EPA, 2013b). The amount found at Calvary Pentecostal Camp in March 2010 (96 µg/L) and in March 2013 (106 µg/L) exceeds the MCL.

DISCUSSION

Before evaluating the health effects, VDH first determines if an exposure pathway exists. An exposure pathway consists of five elements. All five elements must be present for an exposure to be occurring, have occurred in the past, or possibly occur in the future (ATSDR, 2005).

The five elements for the Camp are as follows:

1. Source – geological rock formation
2. Transport medium – groundwater
3. Exposure point – well water
4. Exposure route – ingestion
5. Exposed population – volunteers and attendees

A *completed pathway* exists at the Camp.

Minimal Risk Levels (MRLs) are an estimate of the daily human exposure to a substance that is likely to be without appreciable risk of adverse health effects during a specified duration of exposure. MRLs are based only on non-carcinogenic effects. The MRL for exposure to soluble uranium for an intermediate time period (15-364 days) is 0.0002 mg/kg/day.

The MCL is the daily dose of uranium in water that is protective for a lifetime exposure. The attendees and volunteers staying at the campgrounds during the Summer Campmeeting are exposed for less than a lifetime. Therefore, VDH calculates the daily dose for this population and compares it to the intermediate minimal risk level (MRL) developed by the Agency for Toxic Substances and Disease Registry (ATSDR) for soluble uranium. The daily dose of uranium for adults attending the Summer Campmeeting is calculated to be 0.00005 mg/kg/day and assumes an adult weighs 80 kilograms, consumes 2 liters of water containing 106 µg/L uranium for 67 days (number of days during the Summer Campmeeting), and assumes 10% of uranium ingested is absorbed by the body. This calculated daily dose does not exceed the intermediate MRL (0.0002 mg/kg/day). The daily dose of uranium for an adult volunteer working 251 days a year [365 days a year minus 114 days (weekends and two week vacation a year)] at the campgrounds and consuming one third of daily water intake from the camp (2L x 0.33 = .66 L), is calculated to be 0.00006 mg/kg/day. This calculated daily dose is also below the intermediate MRL. See attachment for derivation of soluble uranium MRL (ATSDR, 2013).

It is not known whether the water provided by the Camp is used daily for an extended period of time (more than one year) by any particular populations, such as permanent residents, groundskeeper, security staff, or other personnel. Also, the concentration of uranium in groundwater may change over time, which may put users at a higher risk of developing adverse health effects.

CHILD HEALTH CONSIDERATIONS

VDH recognizes that developing fetuses, infants, and children may be more sensitive to chemical hazards than adults. Children differ in their exposure and susceptibility to hazardous chemicals. Their physiology (body weight) and behavior (such as hand-to-mouth activity) can lead to higher daily doses than adults in the same environment. Children can consume seven times the amount of water per body weight than the average adult consumes (Magdo, 2007). The bodies of children are developing and growing more rapidly than adults, thus making them potentially more susceptible to most chemical hazards. However, in reviewing the toxicity of uranium, VDH did not identify specific information that suggests children are more susceptible to uranium than adults. A case report of a family exposed to extremely high uranium levels in water is described at the end of this section.

Since children are growing and have a higher rate of bone formation, it is possible that the amount of uranium deposited in their bone will be higher than adults. The tubular secretion and reabsorption in newborns is less inefficient than adolescents and adults. Whether or not this increases the susceptibility of newborns to uranium toxicity has not been fully characterized. Developmental effects have been observed in rodents following oral exposure to uranium in water.

A three year old child developed proximal renal tubule damage, as defined by elevated beta-2-microglobulin, from exposure to uranium in well water as high as 1,160 µg/L. The beta-2-micorglobulin excretion rate was initially 90 µg/mmol creatinine and decreased to 52 µg/mmol creatinine three months after the family ceased drinking the water (children reference range: < 40 µg/mmol creatinine). None of the other children aged five, seven, nine, and twelve years or any of the parents had elevated beta-2-microglobulin (Magdo, 2007).

URANIUM REMOVAL FROM DRINKING WATER TECHNOLOGY

Several methods are available for the removal of uranium from drinking-water, although some of these methods have been tested at laboratory or pilot scale only. Coagulation using ferric sulfate or aluminum sulfate at optimal pH and coagulant dosages can achieve 80–95% removal of uranium, whereas at least 99% removal can be achieved using lime softening, anion exchange resin or reverse osmosis processes (Aieta, 1987) (Lowry, 1988). In areas with high natural uranium levels, achieving acceptable uranium concentrations may be difficult with the treatment technology available (WHO, 2005).

CONCLUSIONS

Consuming uranium in drinking water at Calvary Pentecostal Camp Waterworks at the concentrations detected in March 2013 is not expected to adversely affect those attending the Campmeeting in 2013 or volunteers working at the campgrounds less than a year, because the daily dose does not exceed the intermediate MRL.

Consuming uranium in drinking water at Calvary Pentecostal Camp Waterworks at the concentrations detected in March 2013 for more than a year poses a potential public health hazard, because the concentration exceeds the MCL.

Technology is available that can reduce the concentration of uranium in well water at the Calvary Pentecostal Camp Waterworks to concentrations that do not pose a public health concern.

RECOMMENDATIONS

To protect those that may work or live at Calvary Pentecostal Campgrounds and use the water daily for drinking and cooking, VDH recommends that either Calvary Pentecostal Camp Waterworks install treatment technology that removes uranium from the drinking water or provide an alternative source of water for drinking and cooking.

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