Evaluation of Uranium and Radium in a Private Well

PITTSYLVANIA, VIRGINIA

<u>Letter Health Consultation</u>

April 16, 2014

Virginia Department of Health
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April 16, 2014

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Dear Jim,

Thank you for providing the necessary data needed to evaluate the radium and uranium levels in a private drinking water well in Pittsylvania County, VA. This letter describes the possible health implications that may result from exposure to elevated radium and uranium levels in well water. If you have any questions or concerns regarding this letter, please contact the Division of Environmental Epidemiology at (804) 864 8182.

BACKGROUND

The Virginia Department of Health (VDH)'s Division of Environmental Epidemiology was asked to determine if the concentrations of radium and uranium in well water at a residence (RW-1) in Pittsylvania County could be harmful to any consumers, particularly to any large groups of people who might consume the water for a brief period of time.

Pittsylvania County has the largest deposit of underdeveloped uranium in the United States and it is the seventh largest in the world. RW-1 is a private well located on a residential property for a single family. Residential wells in Virginia are governed by the State Board of Health's Private Well Regulations, which were enacted under the authority granted by the Code of Virginia §32.1-176.1 *et seq.* Neither the Code of Virginia nor the Private Well Regulations establish water quality standards for private wells, with the exception that a newly constructed well must test free of bacterial contamination before VDH can approve the well for use. In most cases, residential/private wells in the U.S. are largely exempt from state and federal drinking water regulations; therefore, they are not subject to the compulsory tests that are required of public water supplies.

Uranium

Uranium is a ubiquitous radioactive metal and chemical toxin. It can be found in water, food and air. Natural uranium is a mixture of three isotopes: ^{234}U, ^{235}U and ^{238}U. The most common isotope ^{238}U makes up about 99% of natural uranium by mass. Uranium decays very slowly. The half life of uranium-238 is about 4.47 billion years and that of uranium-235 is 704 million years, making them suitable for dating the age of the earth.

Uranium can be released into the environment from various activities such as mining and combustion from coal and other fuels. Uranium decays very slowly into radium and radon gas. Recent studies have focused on the toxic environmental effects of depleted uranium in military ammunition and other uses, but less focus has been given to the increasing consumption of ground water containing uranium.[1] Exposure to uranium from drinking water is increasing as more people are relying on ground water as their primary source of drinking water. In the U.S., groundwater is the main source of drinking water for 14–15 million (14%) of the 105.5 million homes and for approximately 42 million people.[2]

Health effects associated with uranium exposure are mostly due to the chemical properties of uranium, not radioactive effects. Natural uranium produces very little radioactivity. Humans' exposure to high levels of uranium in drinking water over many years has been associated with kidney damage. Studies have supported the fact that uranium has adverse effects on kidney functions with the proximal tubule as the site of toxic impact.[3] Damages to the proximal tubule in the kidney can cause decreased ability to reabsorb water and small molecules. The presence of elevated levels of the low-molecular-weight protein beta-2-microglobulin in the urine is an indicator for kidney damage.[4] If inhaled, uranium can cause damage to the respiratory tract. Although uranium could be a potential carcinogen since it emits alpha radiation, no evidence has shown that uranium in ground water induces cancer in humans. The National Toxicology Program (NTP), the International Agency for Research on Cancer (IARC), and the Environmental Protection Agency (EPA) have not classified uranium as a carcinogen.[5]

Radium

Radium is a naturally occurring radioactive metal which is formed from the decay of uranium and thorium in the environment. It is a slivery white metal that is present in several forms called isotopes. There are three main isotopes of radium found in the environment: ^{224}Ra with a half life of 3.6 days, ^{226}Ra with a half life of 1620 years and ^{228}Ra with a half life of 5.8 years.

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[1] Agency for Toxic Substances and Disease Registry. Toxicological profile for uranium – An Update. U.S. Department of health and human services. Public Health Service; Atlanta, Georgia: 2011. [August 2011]. Accessed at http://www.atsdr.cdc.gov/toxprofiles/tp150.html.

[2] Center for Disease control and Prevention (CDC), 2003. Drinking Water: Private Well Resources. Atlanta, GA. [[accessed 28 August 2006]]. Available: http://www.cdc.gov/ncidod/dpd/healthywater/privatewell.htm.

[3] Zamora ML, Tracy BL, Zielinski JM, Meyerhof DP, Moss MA (1998). Chronic ingestion of uranium in drinking water: a study of kidney bioeffects in humans. Toxicol Sci. 43(1):68-77.

[4] Kurttio P, Auvinen A, Salonen L, Saha H, Pekkanen J, Mäkeläinen I, Väisänen SB, Penttilä IM, Komulainen H, (2002). Environ Health Perspect. 110(4):337-42.

Radium was widely used as a luminous paint for watches, clock dials, instrument panels in airplanes, military instruments, and compasses until the 1960s. Radiation therapy from radium is used for the treatment of some cancers. Radium is also used in research and in the calibration of radiation instruments. In general, people are only exposed to low levels of radium that is naturally present in the environment. Exposure to higher concentrations of radium can occur near industries that burn coal and other fuels.

Radium is also present in soil, food and ground water. Exposure to radium may occur from ingestion of food and water, where it is then stored in the bones, similar to how calcium is stored. Unborn babies can be exposed to radium through the placenta. The level of radium in a baby is directly proportional to the level in the mother's blood. Radium in the body is excreted very efficiently and the amount in the body is equal to the amount a person was exposed to in the past 25 days. Exposure to radium increases the likelihood of developing teeth decay, broken teeth, anemia, and cataract. The incidence of bone, liver and breast cancer increases with exposure to high levels of radium.

Radon, a radioactive, colorless, odorless, tasteless noble gas is produced by the radioactive decay of radium-226. Radon exposure has been linked to lung cancer in numerous case-control studies performed in the United States, Europe and China. The greatest risk of radon exposure exists in homes and buildings that are airtight, insufficiently ventilated, and has foundation leaks that allow air from the soil into basements and dwelling rooms. Water from underground sources may contain significant amounts of radon depending on the surrounding rock and soil conditions, whereas surface sources generally do not. Besides being ingested through drinking water, radon is also released from water when temperature is increased, pressure is decreased and when water is aerated. Optimum conditions for radon release and exposure occur during showering. Water with a radon concentration of 10^4pCi/L can increase the indoor airborne radon concentration by 1pCi/L under normal conditions of water use. The EPA's action level for mitigating indoor radon levels is 4pCi/L.

Drinking water standards for uranium and radium

The Safe Drinking Water Act (SDWA) was passed by congress in 1976 and later amended in 1986 and 1996. The law was implemented to protect the U.S. population by regulating the public water supply. The SDWA allows the EPA to set standards that protect the public against natural and anthropogenic contaminants that may be present in drinking water.[6] The goals set by the EPA are levels at which contaminants can be present and no adverse health effect is likely to occur.[7] These non-enforceable levels with adequate safety margin, which are based entirely on exposure and possible health risk over a life time, are called maximum contaminant level goals (MCLGs). Apart from the non-enforceable limit, the EPA sets enforceable levels as close to the MCLG as possible, called the maximum contaminant level (MCL). These limits are set after considering costs, treatment technology, regulatory and economic impacts.[8] The MCLs for

[6] www.water.epa.gov

[7] http://water.epa.gov/drink/contaminants/basicinformation/radionuclides.cfm

[8] U. S. Environmental Protection Agency (EPA) (2009). Six-Year Review 2 Health Effects Assessment: Summary Report, Office of Water

uranium and radium in public drinking water are 30 µg/L and 5pCi/L, respectively. These levels are considered protective against adverse health effects.[9]

Monitoring and Results

The Commonwealth of Virginia has had a long-standing mining moratorium on uranium. In 2007, the Virginia Department of Mines, Minerals and Energy (DMME) issued a permit to Virginia Uranium to begin exploratory drilling in Pittsylvania County. Exploratory drilling is required to meet water quality protection standards and full reclamation plans for all disturbed areas is mandatory.[10] The permit allows research but prohibits mining. As part of the uranium exploration permit, residential wells in Pittsylvania County were sampled for baseline water quality measurements. RW-1 was one of the wells sampled for uranium and radium, and the results are presented in Table 1.

Table 1. Levels of uranium and radium in residential well water (RW-1)

Year	Sampling Quarter	Uranium (µg/L)	Radium (pCi/L)
2008	1	86	3.8
	2	166	10
	3	179	
	4	193	
2009	3	312	6.5
	4	168	6.7
2010	4	208	3.8
2011	4	132	13.3
2012	4	121	7.8
Drinking water standard		MCL= 30 µg/L	MCL = 5 pCi/L

(Source: Virginia Department of Mines Mineral and Energy) **pCi/L**=Picocuries/liter. **µg/L**=microgram/liter. **MCL**=Maximum Contaminant Level. **Shaded boxes**=data not available

DISCUSSION

For health effects to be evaluated, VDH first determines if an exposure pathway exists at a sufficient concentration and duration. This requires five elements: (1) a source of exposure - aquifers, (2) an environmental transport medium - ground water, (3) a route of exposure - ingestion, (4) point of exposure - private well, and (5) a receptor population - family members drinking form the well.

A pathway is complete if all its components are present and exposure of people occurred in the past, is occurring, or will occur in the future. If parts of a pathway are absent, if data are insufficient to decide whether the pathway is complete, or if exposure may have occurred at

[9] U.S. Environmental Protection Agency (EPA) (2013b) Basic Information about Radionuclides in Drinking Water. Accessed July 2013.

[10] http://www.dmme.virginia.gov/dmm/uraniumpermit.shtml

some time in the past, may be occurring in the present, or may occur in the future, then it is considered to be a potential pathway. If part of a pathway is not present and will never exist, the pathway is considered to be incomplete and is given no further consideration. A completed pathway exists for exposure to uranium and radium in RW-1.

The concentrations of uranium in RW-1 samples collected from 2008 to 2012 exceeded the MCL (Table 1). Similarly, the concentrations of radium exceeded the EPA's MCL in all but two samplings: quarter 1 in 2008 and quarter 4 in 2010 (Table 1). Consuming water with concentrations of uranium and radium above the MCL for an extended period of time may induce adverse health effects. The MCLs established by EPA are based on an individual consuming two liters of water daily over a period of 70 years. Therefore, it is unlikely that any adverse health effects would occur from a onetime exposure to water contaminated with these levels of uranium and radium.

CHILD HEALTH CONSIDERATIONS

VDH recognizes that children are at a greater risk of developing illness from exposure to hazardous chemical contaminants in drinking water. This is because children eat, drink, and breathe more per pound of body weight than adults. That means that in proportion to body weight, children are more exposed than adults to contaminants in air, food, water, and soil. Although, it is hypothesized that exposure to uranium would yield the same effects in children as in adults, no data describes the effects of uranium in children[11]. On the other hand, children are at greater risk of developing bone cancer when exposed to high levels of radium because they are still growing. Radium is able to mimic calcium and significant amounts can be accumulated in the bone due to chronic ingestion of radium contaminated water.[12]

CONCLUSIONS

Long-term use of well water from RW-1 is a health concern for users because of high concentrations of uranium and radium.

A one-time use of the well is unlikely to result in any adverse health effects.

RECOMMENDATIONS

VDH recommends that residents who have been using RW-1 as their primary drinking water source be informed of the adverse health effects that may occur.

VDH recommends that residents use an alternate drinking water source until the concentration of uranium and radium are reduced to below their respective MCL either naturally or through using water treatment technology.

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[11] http://www.atsdr.cdc.gov/phs/phs.asp?id=438&tid=77

[12] http://www.epa.gov/Region5/water/gwdw/ransomil/index.htm

VDH encourages private well water users to regularly test their water regardless of their location; however, for residents in this area, it is recommended to include uranium and radium on the analyte list.

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This report was supported by funds from a Cooperative Agreement with the Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. This document has not been reviewed and cleared by ATSDR.