Drinking Water Quality: Uranium Contaminant Levels

Type of EPHT Indicator	Hazard, Exposure
Measures	Level of Contaminant in Finished Water 1. Yearly distribution of number of Community Water Systems (CWS) by maximum Uranium concentration (cut-points: <5, <10, <20, <30 >30 µg/L Uranium). 2. Yearly distribution of number of CWS by mean Uranium concentration (cut-points: cut-points: <5, <10, <20, <30 >30 µg/L Uranium). 3. Average Concentration of Uranium, by Year. Potential Population Exposure to Contaminants in Finished Water 4. Yearly distribution of number of people served by CWS by maximum Uranium concentration (cut-points: <5, <10, <20, <30 >30 µg/L Uranium). 5. Yearly distribution of number of people served by CWS by mean Uranium concentration (cut- points: <5, <10, <20, <30 >30 µg/L Uranium).
Derivation of Measures	Uranium measures will be developed from water system attribute and water quality data stored in state Safe Drinking Water Act (SDWA) databases such as the Safe Drinking Water Information System (SDWIS/State). Data will be cleaned and transformed to a standard format. Analytical results of drinking water samples (usually taken at entry points to the distribution system or representative sampling points after treatment) will be used in conjunction with information about each CWS (such as service population and latitude and longitude of representative location of the CWS service area) to generate the measures.
Units	Uranium, µg/L
Geographic Scope	State and Community Water System
Geographic Scale	The finest detail will be approximate point location of the community water distribution system represented by water withdrawal point, water distribution extents, principal county served, or principal city served.
Time Period	2000 – Most Recent Year Available
Time Scale	Calendar year
Rationale	Uranium (U) and Public Health Uranium is a silver-white metal that is extremely dense and weakly radioactive. It usually occurs as an oxide and is extracted from ores containing less than 1% natural uranium. Natural uranium is a mixture of three isotopes: 238U (greater than 99%), 235U (about 0.72%), and 234U (about 0.01%). Uranium has many commercial uses, including nuclear weapons, nuclear fuel, in some ceramics, and as an aid in electron microscopy and photography. Depleted uranium (DU) refers to uranium in which the proportions of 235U and 234U isotopes have been reduced compared with the proportion in natural uranium. Since the 1990's, DU

	has been used by the military in armor-piercing ammunition and as a component of protective armor for tanks. Natural and depleted uranium are primarily chemical toxicants, with radiation playing a minor role or no role at all (ATSDR, 2009). Everyone is exposed to uranium in food, air, and water as part of the natural environment. (ATSDR, 2009). Variable concentrations of uranium occur naturally in drinking water sources. In some locations the natural concentrations may have increased due to mining and milling of uranium. Thus, the primary exposure sources for non-occupationally exposed persons are likely dietary and drinking water. Populations most heavily exposed to uranium are those employed in mining and milling operations, or in uranium enrichment and processing activities (ATSDR, 2009). In workplaces that involve uranium mining, milling, or processing, human exposure occurs primarily by inhaling dust and other small particles. Exposure to DU may occur in military personnel from retention of internal shrapnel that contains DU or exposure to dust generated from ammunition impact. Absorption of uranium compounds is low by all routes of exposure (i.e., ingestion, inhalation, and skin contact). Depending upon the specific compound and solubility, 0.1%-6% of an ingested dose may be absorbed. Inhaled uranium-containing particles are retained in the lungs, where limited absorption occurs (less than 5%). After long term or repeated exposure, kidneys, liver, and bones can accumulate uranium with the largest amounts being stored in bones (Li et al., 2005). Uranium is eliminated in feces and urine; about 50% of the absorbed dose is eliminated in the urine within the first 24 hours. After exposure to soluble uranium salts, the initial half-life of uranium is about 15 days (Bhattacharyya et al., 1992), which represents distribution and excretion, with much slower elimination from bone. After inhalation, the half-life of insoluble uranium in the lungs is several years (Durakovic et al., 2003). Human health effects from uranium at low environmental doses or at biomonitored levels from low environmental exposures are unknown. Health outcomes that may occur with uranium overexposure, based on both observed human effects and animal studies, include non-malignant respiratory disease (fibrosis, emphysema) and nephrotoxicity. Studies of persons with chronic exposure to elevated uranium salts in drinking water have shown changes in urinary biomarkers potentially associated with impaired kidney function (Kurttio et al., 2006). IARC and NTP have no ratings for uranium human carcinogenicity. Radiation risks from exposure to natural uranium are very low. Alpha radiation (such as that from uranium) is classified as a human carcinogen. However, human studies have not found elevated rates of cancer from uranium exposure, and high-dose animal studies have not found cancer following inhalation, oral, or dermal exposure to uranium. Workplace air standards and guidelines for external exposure to soluble and insoluble uranium compounds have been established by OSHA and ACGIH, respectively. Drinking water and other environmental standards have been established by U.S. EPA. Information about external exposure (i.e., environmental levels) and health effects is available from ATSDR at: http://www.atsdr.cdc.gov/toxprofiles/index.asp. In an analysis of occurrence data from the EPA 6 Year Review of National Primary Drinking Water Regulations, uranium was detected in 4,101

systems serving close to 55 million people (EPA, 2009). Concentrations of uranium were greater than the MCL in 448 systems serving close to 8.4 million people (EPA, 2009).

Biomonitoring Information

Levels of urinary uranium reflect recent and ongoing or accumulated exposure. A previous nonrandom subsample from NHANES III (n = 499) (Ting et al., 1999) and other small populations have shown urinary concentrations that are similar to those in NHANES 1999-2000, 2001-2002, and 2003-2004 (Dang et al.,1992; Galletti, 2003; Karpas et al.,1996; Tolmachev et al., 2006). Older studies have demonstrated urinary uranium concentrations that are consistent with levels in the U.S. population, in that the levels were below their respective detection limits (Byrne et al., 1991; Hamilton et al., 1994; Komaromy-Hiller et al., 2000). In a study of 105 persons exposed to natural uranium in well water, urinary levels of uranium were as high as 9.55 µg/L (median 0.162 µg/L) (Orloff et al., 2004). Eighty-five percent of those levels were above the 95th percentile of the NHANES 1999-2000 population. The U.S. Nuclear Regulatory Commission (NRC) has set an action level of 15 µg/L urinary uranium to protect people who are occupationally exposed (NRC, 1978). Finding a measurable amount of uranium in urine does not mean that the level of uranium causes an adverse health effect. Biomonitoring studies on levels of uranium provide physicians and public health officials with reference values so that they can determine whether people have been exposed to higher levels of uranium than are found in the general population. Biomonitoring data can also help scientists plan and conduct research on exposure and health effects.

Sources of Uranium

Uranium is a naturally-occurring element found in the earth's crust. It is naturally abundant in rocks, soil and water. Significant concentrations of uranium can occur in phosphate rock deposits, and in minerals such as pitchblende and uraninite. The total amount of Uranium on earth stays virtually the same because it has such a long half-life (4.47x109 years for U-238) (EPA, 2010).

Uranium Regulation and Monitoring

The EPA limits the amount of uranium that may be present in drinking water to 30 ug/L (EPA, 2009). A gross alpha particle activity measurement may be substituted for the required uranium measurement provided that the measured gross alpha particle activity does not exceed 15 pCi/l.

Monitoring frequency

Once a CWS has satisfied initial monitoring requirements (4 quarterly samples at every entry point to the distribution system within the first quarter after initiating the source); the required frequency for Uranium monitoring is once every three years if the average of the initial monitoring results for the contaminant is greater than one-half the MCL but at or below the MCL. States may allow CWS to reduce the frequency of monitoring from once every three years to once every six or nine years at each sampling point, if the average of the initial monitoring results for

	each contaminant is below the detection limit. If a system has a monitoring result that exceeds the MCL while on reduced monitoring, the system must collect and analyze quarterly samples at that sampling point until the system has results from four consecutive quarters that are below the MCL, unless the system enters into another schedule as part of a formal compliance agreement with the State (CFR, 2002).
Use of Measure	These measures can assist by addressing the following surveillance functions: • Distribution measures provide information on the number of CWS and the number of people potentially exposed to Uranium at different concentrations. • Maximum concentrations provide information on the peak potential exposure to Uranium at the state level. • Mean concentrations at the CWS level provide information on potential exposure at a smaller geographic scale.
Limitations of The Measure	The current measures are derived for CWS only. Private wells may be another source of population exposure to Uranium. Transient non-community water systems, which are regulated by EPA, may also be an important source of Uranium exposure. Measures do not account for the variability in sampling, numbers of sampling repeats, and variability within systems. Concentrations in drinking water cannot be directly converted to exposure, because water consumption varies by climate, level of physical activity, and between people (EPA 2004). Due to errors in estimating populations, the measures may overestimate or underestimate the number of affected people.
Data Sources	Iowa Department of Natural Resources
Limitations of Data Sources	The required monitoring frequency for Uranium is infrequent (every 3 to 6 years) and may be as intermittent as every nine years; therefore most states will have very little data on this contaminant. Ground water systems may have multiple wells with different Uranium concentrations that serve different parts of the population. Compliance samples are taken at each entry point to the distribution system. In systems with separate wells serving some branches or sections of the distribution system, the system mean would tend to underestimate the Uranium concentrations of people served by wells with higher Uranium concentrations. Exposure may be higher or lower than estimated if data from multiple entry points for water with different Uranium levels are averaged to estimate levels for the PWS.
Related Indicators	Public Water Use; combined Radium-226 and -228
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