



Preliminary Regulation of Strontium in Drinking Water

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Key Words

Strontium Regulation, Strontium Analysis, CCL3, UCMR 3, U.S. EPA Method 200.8, Drinking Water Regulation, Health Reference Level, Frequency and Levels of Occurrence, Safe Drinking Water Act

Executive Summary

In October 2014, the United States Environmental Protection Agency (U.S. EPA) made a preliminary determination to regulate strontium in drinking water based on data generated from their third Unregulated Contaminant Monitoring Rule (UCMR 3). The EPA will make the final decision on whether to regulate strontium in 2016. If regulation is approved, a Maximum Contaminant Level Goal (MCLG) and Maximum Contaminant Level (MCL) will be determined, and analytical methods will be approved for the analysis.



Introduction

The 1996 amendments to the U.S. Safe Drinking Water Act (SDWA) require the U.S. EPA to evaluate unregulated drinking water contaminants under the UCMR program every five years. In the most recent UCMR 3 (2012 to 2016) program that monitored 32 unregulated contaminants, the U.S. EPA made a preliminary determination on October 20, 2014 for regulation of strontium in drinking water. The U.S. EPA collected public comments on the preliminary determination through 2014 and is now collecting data to finally decide whether strontium will be regulated in drinking water in 2016. If strontium is approved for regulation, the U.S. EPA will come up with the MCLG for strontium in drinking water within 24 months and finalize the regulation standard 18 months thereafter.



Strontium and its Health Effect

Strontium (atomic number 38) is a member of the alkaline earth metals family. It has four stable isotopes and 16 radioactive isotopes. Since radioactive strontium, especially strontium-90, is separately regulated as a radionuclide in both air and drinking water,¹ the strontium referred to here is stable strontium.



Among the four stable isotopes (⁸⁴Sr, ⁸⁶Sr, ⁸⁷Sr and ⁸⁸Sr), ⁸⁸Sr is the most common, accounting for 83% of the total. In nature, stable forms of strontium are found mainly in the form of celestite (SrSO₄) and strontianite (SrCO₃). Since the US has stopped strontium mineral mining, strontium is imported for making pyrotechnic and signal products (fireworks and flares), ferrite ceramic magnets, master alloys, pigments and fillers, electrolytic production of zinc, fluorescent lights, toothpaste and medicine.

Strontium accumulates in the human body via number of exposure pathways: inhaled through the air, ingested in water and food, and absorbed through the skin.

Similar to calcium, strontium is easily taken from water and food, and is mainly (99%) deposited in bones. Excessive absorption of strontium negatively affects skeletal development and leads to thickened bones, which are prone to fracture. Infants, children, and adolescents are especially sensitive to strontium. Since strontium is excreted primarily in the urine, strontium also adds burden to patients with kidney disease.

Unregulated Contaminants Monitoring Rule 3 (UCMR 3) in Drinking Water

Under the SDWA, the U.S. EPA regulates more than 90 contaminants in drinking water through National Primary Drinking Water Regulations (enforceable standards) and National Secondary Drinking Water Regulations (unenforceable guidelines). These contaminants are reviewed by the U.S. EPA every six years (Figure 1). In addition, according to amendments made to the SDWA in 1996, the U.S. EPA is required to:

- Generate the contaminant candidate list (CCL) for unregulated drinking water contaminants every five years. (CCL1, CCL2 and CCL3 were developed in 1998, 2005 and 2009, respectively. A new CCL4 draft was released in January 2015 for public comment before April 6, 2015.)

- Collect data on health effects, and the frequency and levels of occurrence of selected contaminants through UCMR. A health reference level will be set based on health effect studies. Information on the frequency and levels of occurrence of the contaminants in public water systems is collected based on analysis using the designated approved regulatory analytical methods.
- Review and evaluate collected data, and decide whether to regulate at least five contaminants of the 30 contaminants studied in the UCMR.

Figure 1 illustrates the U.S. EPA process used to evaluate regulated and unregulated contaminants in drinking water. Recently, the U.S. EPA evaluated 32 contaminants on the UCMR 3 list, out of the 116 contaminants listed on CCL3. The data collection for UCMR 3 runs through December 31, 2015. All the data will be deposited into the National Contaminant Occurrence Database (NCOD) system for public review.

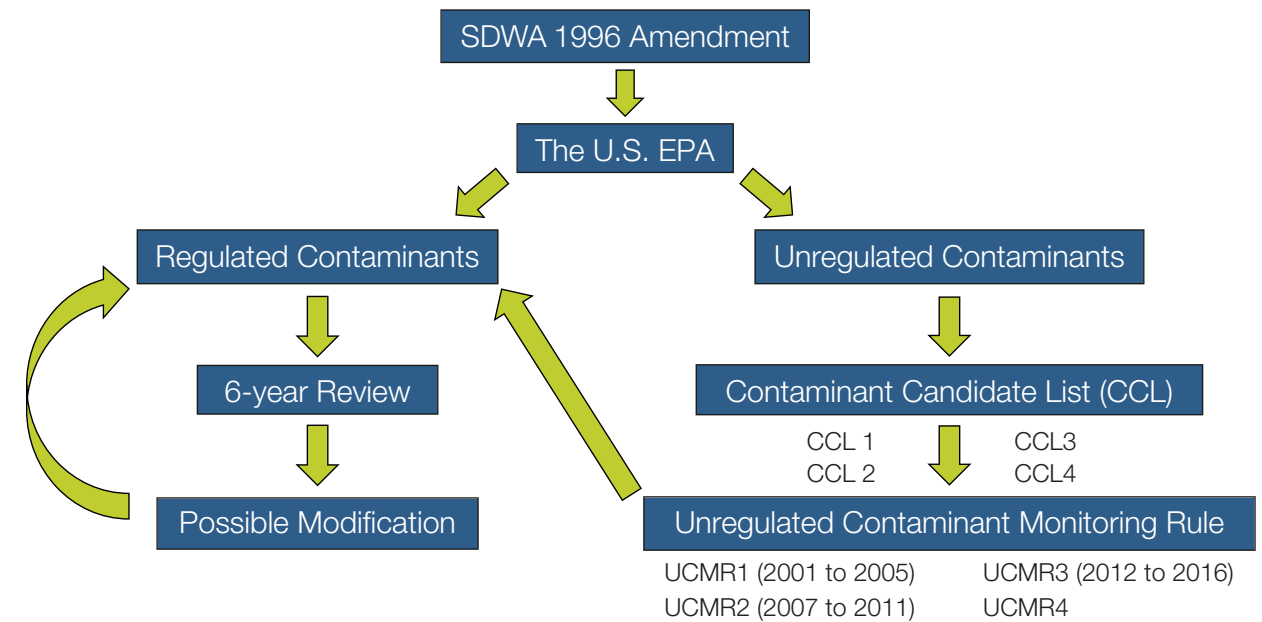


Figure 1. The flowchart for the U.S. EPA evaluation of regulated and unregulated contaminants in drinking water.

The 32 contaminants listed in UCMR 3 include five metals: cobalt, molybdenum, vanadium, strontium, total chromium, and chromium (VI). Total chromium is already regulated by the U.S. EPA, while chromium (VI) is regulated only in the state of California in the U.S. Total chromium and chromium (VI) fall under UCMR 3 because the U.S. EPA is considering whether a new regulation needs to be approved. Such approval requires convincing frequency and level occurrence data as well as the health effect data from toxicology studies. This is the first time the U.S. EPA is asking for both total chromium and chromium (VI) to be monitored using specific methods under low minimum reporting levels (MRL) to obtain more accurate testing results. Detailed total chromium and chromium (VI) information can be found on the web page for Association of California Water Agencies.²

Cobalt, molybdenum, and vanadium, monitored under UCMR 3, will continue to be monitored and appear on the CCL4 draft list. The UCMR 3 results for these metals and their occurrence data detected at MRL have been summarized in an EPA report.³

In contrast, a preliminary decision was made to regulate strontium in drinking water through the UCMR 3 study.



Preliminary Determination of a Regulatory Decision for Strontium

The U.S. EPA uses three criteria to decide or make a preliminary decision whether a particular contaminant needs to be regulated: health effect data, the frequency and levels of the occurrence, and the meaningful opportunity to reduce any health risk if regulated. After UCMR 3 data review, the U.S. EPA made a preliminary decision to regulate strontium in drinking water.⁴

The UCMR 3 data review on strontium supports all three criteria required for approval of regulations for new contaminants:

- **Strong health effects.** As described above, although stable strontium has not been found to be a carcinogen, strontium lowers the quality of bone if taken in the low-calcium diet. The effect is pronounced in children because their bones are fast growing.

- **Occurrence at levels and frequencies of public health concern.** According to data from the National Inorganics and Radionuclides Survey (NIRS), 99% of randomly selected public water systems tested from 1984 to 1986 had detectable strontium, ranging from 1.53 to 43,550 µg/L. More than 7% had a detected strontium at a level of health concern (a new health reference level for strontium has been changed from 4200 µg/L to 1500 µg/L). Adapted data from the Federal Register on UCMR is shown in Table 1.⁴
- **Meaningful opportunity for the reduction of a future health risk if regulated.** Strontium at the level of concern affects 26 states and more than 10 million people, suggesting that there is a large at-risk population across the U.S. that would benefit from strontium regulation.

Analysis of Strontium

Environmental strontium samples can be analyzed by multiple techniques such as spectrophotometry, fluorescence spectrometry, inductively coupled plasma optical emission spectrometry (ICP-OES) and inductively coupled plasma mass spectrometry (ICP-MS). However, UCMR 3 approves the use of

ICP-MS as outlined in Method 200.8 Rev. 5.4 for strontium analysis at an MRL of 0.3 µg/L. Other methods also approved for strontium analysis include SM3125 and ASTM 5763-10.⁵

Multiple spectroscopy methods have the capability to analyze strontium per the U.S. EPA guidelines, such as 200.5 (axial ICP-OES), 200.7 (ICP-OES), 200.8 (ICP-MS) and 200.9 (graphite furnace atomic absorption, GFAA). However, EPA 200.8 is the only feasible option for analysis as the detection limits required to meet minimum detection and reporting levels can be achieved only on an ICP-MS instrument. An ICP-OES and an AA would struggle to meet the required minimum reporting limits under UCMR 3. Method 200.8, version 5.4, approved in 1994, is used for strontium analysis with the requirement of field blanks at an MRL of 1/3 of the sample MRL (Table 2). In addition, recovery for laboratory fortified blank using the U.S. EPA 200.8 method specifies 85 to 115% range.⁶ However, it is important to note that, although the Collision/Reaction cell technology can be used for metal testing in other types of waters under the Clean Water Act, the technology has not been approved for drinking water analysis.

Table 1. Estimates of public water systems and population influenced by strontium from National Inorganics and Radionuclides Survey (NIRS).

	NIRS		Extrapolation of NIRS Data to Groundwater Systems Nationwide	
	Public Water Systems	Population Influenced	Public Water Systems	Population Influenced
Systems with Detectable Concentrations	980 of 989	1.481 M of 1.482 M	39.7 K of 40.1 K	93.0 M of 93.1 M
Systems with Strontium Detected Above One Half the HRL (>750 µg/L)	141 of 989	246 K of 1.5 M	5.7 K of 40.1 K	15.4 M of 93.1 M
Systems with Strontium Detected Above the HRL (>1500 µg/L)	69 of 989	159 K of 1.5 M	2.8 K of 40.1 K	10.0 M of 93.1 M

Table 2. MRL (Minimum Reporting Level) for five metals analyzed using EPA 200.8 in UCMR3.

Contaminants	Sample MRL (µg/L)	Field Blank Requirement (µg/mL)
Strontium	0.3	0.1
Cobalt	1	0.33
Molybdenum	1	0.33
Vanadium	0.2	0.06
Chromium (Total)	0.2	0.06

Conclusion

The U.S. EPA made a preliminary determination to regulate strontium in drinking water in 2014. After reviewing public comments and the data collected in 2015, the EPA will make a final decision in 2016. It is a 50/50 chance if strontium will get finally approved for regulation; more extensive studies on the health effect of strontium are needed to understand in-depth how significant the negative effect is on human health.⁷ If strontium goes on the drinking water regulatory list, a MCLG and MCL will be determined as the standards for public water systems to analyze strontium in drinking water. Since U.S. EPA Method 200.8 was used for evaluation of the frequency and level of occurrence, that method will very likely be approved as the regulatory method for strontium testing in drinking water as well as other metal detection methods depending on the final MCLG and MCL.

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