Uranium Activity to Mass Conversion Factor Guideline for Use in Drinking Water Compliance Monitoring and Risk Assessment

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Regulatory Background

Uranium is a naturally occurring radioactive element and is a concern in drinking water because of its potential toxicity to humans. The Safe Drinking Water Act (SDWA) requires water suppliers to monitor for the presence of uranium in drinking water. The United States Environmental Protection Agency (USEPA) issued a final Maximum Contaminant Level (MCL) of 30 ug/l in the Federal Register on December 7, 2000 based on an MCLG of 20 ug/l that was derived using data from rat experiments. In these experiments, rats were administered uranyl nitrate by gavage and No Observed Adverse Effects Level (NOAEL) and Lowest Observed Adverse Effects Level (LOAEL) were calculated on a mass basis. This MCL is based on kidney effects observed in rats and is assumed to be protective of potential kidney and cancer effects in humans.

Activity to Mass Conversion Factors

Testing for the presence of uranium in drinking water can be done using several methods approved by USEPA. Depending on the analytical method, uranium can be measured either as the activity of the radionuclide where the results are reported in units of picocuries per liter (pCi/l), or uranium can be measured as the mass of the isotope and the results are reported in mg/l or ug/l. Uranium has two radioactive isotopes, uranium-234 and uranium-238 that have potential adverse health effects on humans exposed to elevated levels of uranium for an extended period of time. The toxicity of uranium is due to the alpha radiation associated with the decay of the uranium nucleus. The mass to activity ratio for uranium in a water sample varies depending on the isotopic ratio in that water supply. The nature of radioactivity in drinking water is such that there can be a significant difference in the activity due to the mixtures of isotopes in different water supplies. Most of the mass of uranium is contributed by the uranium-238 isotope, while uranium-234 is the major contributor to total activity.

The regulatory level for uranium in drinking water is reported in mass units (ug/l) and results that are reported in activity units (picocuries per liter or pCi/l), must be converted to the appropriate mass units to make the appropriate determination of whether or not the system is in compliance. Activity to mass conversion factors range from 0.67 to 1.5 pCi/ug (USEPA 2000) and the major challenge is to determine which factor is most appropriate to use to calculate an exposure point concentration for compliance monitoring or to use in a human health risk assessment. Ideally the activity to mass ratio should be calculated for each water supply but if this is not possible, there is a health protective approach to evaluate compliance with the regulatory level.

Recommended Evaluation Approach

A two-tiered approach can be used to initially screen for compliance with the regulatory level. The first tier involves using a conservative activity to mass ratio of 0.67 pCi/ug to convert activity units in pCi to mass units in ug. The second tier would be to determine the actual activity to mass ratio for a particular water supply.

Tier I

Tier I is a screening level compliance option that uses an activity to mass conversion factor of 0.67 pCi/L to convert activity data to mass units in ug. Using this conversion factor results in the most conservative estimate of an exposure point concentration because it is the lowest in the range of the identified conversion factors. Therefore, the concentration calculated using the default activity to mass ratio is likely to be an overestimate of the true concentration and it is therefore appropriate to compare to the MCL as a screening evaluation. If the estimated concentration in pCi/L is below the MCL, then would be no need to go to Tier II, and compliance with the MCL would be determined as for any other chemical. If the concentration is greater than the MCL, then the water supplier can choose to either characterize the actual mass to activity ratio of their particular water supply (Tier II evaluation) and recalculate the mass concentration or, the water supplier can decide to take appropriate action to decrease the level of uranium in the drinking water supply.

Tier II

Tier II evaluation involves the characterization of the actual activity to mass relationship for a particular water supply. This approach provides a water supplier with a much more accurate activity to mass estimate based upon the actual relative composition of isotopes present, thereby decreasing the uncertainty associated with calculating risks to human health from exposure to uranium in drinking water. This option should be emphasized as the preferred evaluation approach because the true activity to mass ratio is measured instead of being estimated using default values.

These alternatives are summarized in Table 1.

Reference

USEPA 2000. National Primary Drinking Water Regulations; Final Rule 65 FR 236; December 7, 2000.

Table 1. Alternative Evaluation Sequence for Performing MCL Comparisons with Reported Uranium Activity Results in pCi/L

Alternative Evaluation Options	**Activity to Mass Conversion Factor to Use, pCi/ug**	**Outcome of Comparison of Uranium concentration, ug/L to MCL**	**Possible Actions**
Tier I	0.67	< MCL	no need for Tier II compliance with MCL determined as for other chemicals
		< or = MCL	go to Tier II or, decrease level of uranium in water supply
Tier II	Determine site-specific value	< MCL	compliance with MCL determined as for other chemicals
		< or = MCL	decrease level of uranium in water supply

ERRATA:
Correction made 7/15/08 to units in second column of Table 1 from pCi/mg to pCi/ug.