Draft Interim Specific Ground Water Quality Criterion

for

Strontium

by

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Introduction

In response to a Site Remediation program request in March 2015 for an Interim Ground Water Quality Criterion for strontium (Sr), the Office of Science evaluated the relevant information available from the USEPA and the scientific literature. Based on this review, a draft Interim Specific Ground Water Quality Criterion of 1500 µg/L for strontium is recommended. Derivation of the criterion is described below.

Selection of a Reference Dose

USEPA IRIS Reference Dose (1992)

The USEPA IRIS database currently contains a Reference Dose (RfD) for strontium (Sr) of 0.6 mg/kg/day (http://www.epa.gov/iris/subst/0550.htm). This value was entered into IRIS in 1992.

USEPA Office of Water Draft Reference Dose (2014)

In 2011, in anticipation of evaluating strontium under the Drinking Water Contaminant Candidate List, the USEPA Office of Water published a Draft Health Effects Support Document for Strontium. I served as one of three external peer-reviewers for that document. My review (and those of the other reviewers) contained several substantive comments regarding the quality of the USEPA strontium document. In 2014, the USEPA published a revised Draft Health Effects Support Document for Strontium (available at: http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OW-2012-0155-0008). In part, this document represents the USEPA's revisions in response to peer reviewers' comments on the 2011 document. I have reviewed the 2014 document in detail along with my original comments on the 2011 document, and I am satisfied that the USEPA has adequately and appropriately addressed my comments and concerns.

The RfD derived in the USEPA's 2014 document is 0.3 mg Sr/kg/day. It is based on adverse alterations in bone calcification during post-natal bone growth (Marie et al., 1985)[1]. The 2014 value differs from the 1992 IRIS RfD by the relatively small (in the context of risk assessment) factor of two. Although the Marie et al. (1985) study was available and reviewed by USEPA in the 1992 IRIS assessment, a study by Storey (1961)[2] was the principal basis for the RfD and Marie et al. (1985) was used as supporting information. However, the 2014 USEPA strontium document makes the reasonable case that the Marie et al. (1985) study is a better basis for the derivation of an RfD for strontium than Storey (1961) for several reasons including: clear reporting of doses; a longer duration of exposure; better quantitative reporting of effects; and ability to apply benchmark dose modeling to the dose-response data in order to more accurately assess a point of departure.

Review of more recent literature

At the request of the Office of Science, the NJDEP's Environmental Research Library (ERL) conducted a literature search from 2014 forward in order to determine whether there were any publications in the scientific literature that have the potential to substantively and quantitatively alter the RfD for strontium that the USEPA proposed in its 2014 document. ERL conducted a search for

[1] Marie PJ, Garba MT, Hott M, Miravet L. Effect of low doses of stable strontium on bone metabolism in rats. Miner Electrolyte Metab. 1985;11(1):5-13.

[2] Strontium "rickets": bone, calcium and strontium changes. Storey E. Australas Ann Med. 1961 Aug;10:213-22.

strontium in PubMed, Toxnet, and Google Scholar using the following search terms, limiting from 2014 onward:

- **For PubMed:**
  (strontium[Title/Abstract]) NOT "strontium-90" NOT "strontium-89"
  Filters: Publication date from 2014/04/01; Toxicology (for details on the "Toxicology" subject filter, see this page: http://www.nlm.nih.gov/bsd/pubmed_subsets/tox_strategy.html.)
- **For TOXLINE:**
  Strontium (all fields)
  Checked: Add chemical synonyms and CAS numbers to search, Include PubMed records
  Only search documents added in the last 12 months.
- **For Google Scholar:**
  Strontium AND (*toxicity OR toxicology OR "adverse effects" OR "health effects" OR "human health") –"strontium-90" –"radioactive strontium"

I reviewed this search, and determined that there were no publications that had the potential to alter the value of the RfD in the USEPA's 2014 document.

Recommended Reference Dose
Based on my detailed review of the 1992 IRIS evaluation, the 2011 and 2014 USEPA Office of Water documents, and the results of the forward literature search, I recommend that the value of 0.3 mg/kg/day (300 µg/kg/day) developed by USEPA Office of Water (2014) be applied to the derivation of an Interim Specific Ground Water Quality Criterion (ISGWQC) for Strontium.

Assumptions for Drinking Water Consumption

The default NJDEP assumptions for drinking water consumption for derivation of an ISGWQC are:

- Daily drinking water intake (I) - 2 L/day
- Body weight (BW) – 70 kg

The standard approach for calculation of the ISGWQC is:

ISGWQC = [RfD/(I/bw)] x RSC

Where RSC is the relative source contribution.

These default values for BW (70 kg) and water intake (I = 2 L/day) are intended to reflect adult exposure parameters.

The RfD derived by USEPA (2014) is based on adverse effects of strontium on bone calcification during the sensitive period of bone growth during the post-natal through adolescent period of development. Thus, while this RfD is anticipated to be protective of the adverse effects of strontium during adulthood, the adverse effects addressed by this RfD are specific to these earlier life stages. The daily drinking water intake on a body weight basis (L/kg/day) is greater during these earlier stages than during adulthood. In recognition of this difference, EPA (2014, Appendix B) applied an age-specific calculation of the 90th percentile of the US population-based body-weight adjusted drinking water

intake based on a time weighted average for birth to 21 years old based on data in the EPA's 2011 Exposure Factors Handbook[3]. This resulted in an age adjusted time-weighted average drinking water intake during this period of 0.040 L/kg/day. For comparison, the corresponding value based on the standard default adult parameters (2 L/day/70 kg) is 0.029 L/kg/day. The age-specific value is thus 38% higher and will result in a correspondingly lower ISGWQC.

Given the age-specific nature of the RfD, this approach is both reasonable and protective. Future derivations of ISGWQC and MCL values by the NJDEP should consider similar age-specific approaches when the health-based criterion is based on an age-specific RfD

Relative source contribution

As detailed in EPA's 2014 document, there are significant sources of strontium in the diet relative to the RfD. These sources vary significantly by food and beverage type. Strontium intake from sources other than drinking water is, therefore likely to be significant and variable within the population. For these reasons, the standard default RSC of 0.2 is appropriate.

Derivation of the Draft Interim Specific Ground Water Quality Criterion

The draft ISGWQC is derived as follows:

Draft ISGWQC = [(RfD/(I/BW)] x RSC

Draft ISGWQC = [300 µg//kg/day]/(0.040 L/kg/day) x 0.2 = **1500 µg/L**

[3] http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252