PHYSICAL AND CHEMICAL CHARACTERISTICS FACT SHEET

Selenium

(Public consultation draft July 2024)

Guideline

Based on health considerations, the concentration of selenium in drinking water should not exceed 0.004 mg/L.

General description

Selenium and selenium salts are widespread in the environment. Selenium is released from natural and human-made sources (such as the burning of coal). Selenium is also a by-product of the processing of sulfide ores, chiefly in the copper refining industry.

The major use of selenium is in the manufacture of electronic components. It is used in several other industries, and selenium compounds are used in some insecticides, in hair shampoos as an antidandruff agent, and as a nutritional feed additive for poultry and livestock.

Selenium copper alloys have also been identified as a potential replacement for lead brasses in plumbing products. Further information on lead replacements in plumbing products (such as selenium brasses) is available in Information Sheet 4.1 – Chemicals leaching from plumbing.

Selenium concentrations in drinking water source waters are generally very low and depend on local geochemistry, climatic conditions (e.g. drought), pH and the presence of iron salts. Selenium in water is mainly present as inorganic compounds, predominantly selenate.

Weathering of rocks and soil may result in low levels of selenium in water, which may be taken up by plants (SLR 2022). Food is the major source of intake for Australians. Cereal and grain products contribute most to intake, while fish and liver contain the highest selenium concentrations.

Typical values in Australian drinking water

In major Australian reticulated drinking water supplies, mean selenium concentrations are less than 0.0025 mg/L (SLR 2022). Some remote areas of Australia have recorded higher concentrations. For example, in 2004 mean selenium concentrations in the Northern Territory ranged from 0.0002 – 0.012

mg/L, with exceedances recorded in Kings Canyon and Daly Waters (PWNT 2004).

Treatment of Drinking Water

Selenium concentrations in drinking water source waters can be reduced by coagulation with ferric chloride and by lime softening. Coagulation with alum is much less effective. Activated alumina adsorption is an effective means of treatment, but only at low pH. Removal of selenium in water can also be achieved through chemical clarification with ferric sulfate at a pH below 7 (WHO 2011).

Measurement

Selenium can be measured in drinking water through inductively coupled plasma mass spectrometry (US EPA Method 200.8), inductively coupled plasma atomic emission spectroscopy (SLR 2022) or hydride generation followed by atomic absorption spectroscopy (APHA Method 3500-Se). The limit of reporting ranges from 0.0001 mg/L to 0.001 mg/L.

Health Considerations

Selenium is an essential element for many species, including humans. Signs of selenium deficiency in humans are not well established but may include effects on the cardiovascular system, immune system, endocrine system and male reproductive system.

Selenium compounds are readily absorbed in humans. Selenium is metabolised in the liver then distributed to other organs and tissues such as the pancreas, nervous system, skin and hair, bone, muscle, lungs and kidneys. The toxicity of selenium may vary among the different selenium compounds and additional research may be required to clarify the importance of the chemical form on overall toxicity (SLR 2023).

There have been a number of reports of ill effects attributed to short- and long-term exposure to high levels of selenium; most of these have resulted from occupational exposure or accidental poisoning; acute or chronic nutritional toxicity is comparatively rare.

Selenosis is known to occur in humans from supplemental intakes of selenium of 0.2 - 40.8 mg/day (Aldosary *et al.* 2012, Lippman *et al.* 2009, MacFarquhar *et al.* 2010). A large study (over 34,000 men) investigated the effects of selenium supplementation (0.2 mg selenium per day) and/or Vitamin E supplementation over a 4 to 7-year period on the development of certain cancers (Lippman *et al.* 2009). The study identified a marginally statistically significant increase in the rate

of mild dermatitis and alopecia (an early indication of selenosis) in patients taking selenium. This study was also used by the European Food Safety Authority (EFSA) to establish a tolerable upper intake level for selenium of 0.255 mg/day for adults from total dietary sources (EFSA 2023). This level was defined by EFSA as the maximum level of total chronic daily intake of a nutrient (from all sources) which is not expected to pose a risk of adverse health effects to humans.

Studies in humans suggest that there is no association between exposure to selenium and mortality from cardiovascular disease, coronary heart disease or stroke. There is limited evidence around an association between selenium and an increase in prostate cancer at supplemental doses of 0.2 - 0.4 mg/day, and a possible association with Type 2 diabetes at supplemental selenium doses from 0.055 - 0.2 mg/day. A review found that there is insufficient evidence to indicate an association between selenium and several other health outcomes, such as mortality from Parkinson's disease, increased cholesterol, amyotrophic lateral sclerosis, melanoma, urinary tract tumours, or multiple myeloma (SLR 2023).

A review found that selenium compounds may be genotoxic at doses that cause other adverse health effects (SLR 2022). Except for selenium sulfide, experiments with laboratory animals indicate that selenium compounds are not carcinogenic, with some selenium compounds potentially displaying an anticarcinogenic effect. Results for selenium sulfide indicate that it causes liver and lung tumours in mice. The International Agency for Research on Cancer has concluded that selenium is not classifiable as to its carcinogenicity in humans (Group 3, inadequate evidence in humans and in animals) (IARC 1987).

Derivation of Guideline

The health-based guideline value of 0.004 mg/L (rounded) for selenium in drinking water was derived as follows:

$$0.004 \text{ mg/L} = \frac{0.255 \text{ mg/day} \times 0.1}{2 \text{ L/day} \times 3}$$

where:

- 0.255 mg/day is the adjusted minimal lowest observed adverse effect level (LOAEL) for mild selenosis (alopecia and dermatitis) in adult males receiving supplementary selenium in the diet (Lippman *et al*. 2009). The minimal LOAEL for mild selenosis of 0.2 mg/day as added selenium was adjusted by adding this to the dietary selenium intake likely to have been ingested by the adult male participants in the study (i.e. 0.055 mg/day, which is the normal recommended amount of selenium in the North American diet to prevent selenium deficiency as reported in NIH (2021) (SLR 2023).

- 0.1 is the proportion of daily intake attributable to the consumption of water.
- 2 L/day is the average amount of water consumed by an adult.
- 3 is the safety factor applied as the effect was mild and the LOAEL is a minimal LOAEL. Consideration was given to balancing the essentiality of selenium with the potential for adverse effects. An uncertainty factor for human variability was not included as the study included a large population of 8,752 adult males and there is no indication that females or children are more susceptible to the effects of selenium.
- The calculated value of 0.00425 mg/L is rounded to a final health-based guideline value of 0.004 mg/L as per the rounding conventions described in Chapter 6.

Review History

The fact sheet was initially endorsed in 1996. This update of the fact sheet was based on reviews of the available evidence completed in 2022 and 2023 (SLR 2022, 2023; see Administrative Report for more information).

References

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NOTE: Important general information is contained in PART II, Chapter 6