PHYSICAL AND CHEMICAL CHARACTERISTICS FACT SHEET

Silicon

(Public consultation draft July 2024)

Guideline

Based on health considerations, the concentration of silicon in drinking water should not exceed 100 mg/L.

General description

Silicon is an ubiquitous element present in the environment and occurs naturally in foods as silicon dioxide (SiO_2, commonly known as silica) and silicates. High levels of silicon are found in foods derived from plants, particularly cereals, whereas silicon levels are lower in foods from animal sources.

Silicon is mainly found as insoluble silicates (silica), but small amounts of soluble silicon are naturally present in water, chiefly as orthosilicic acid ($Si(OH)_4$), which is the most bioavailable source of silicon. Amorphous silica is used as a food additive, in particular as an anticaking agent, but also to clarify beverages, control viscosity and as an antifoaming agent and dough modifier. It is also used as an anti-caking agent and as an excipient in pharmaceuticals for various drug and vitamin preparations.

Silicon copper alloys with various compositions have also been developed to induce grain refining and strength increase in alloys or to produce lead- and arsenic-free copper alloys with good machinability for plumbing product purposes (SLR 2023). Silicon copper alloys have been identified as a potential replacement for lead copper alloys in plumbing products. In the United States of America, silicon copper alloys are one of the most common substitutes for lead in copper alloys available on the market (ABCB 2021). Further information on lead replacements in plumbing products (such as silicon copper alloys) is available in Information Sheet 4.1 – Chemicals leaching from plumbing.

A review found that a drinking water guideline value for silicon has not been set by international agencies such as the World Health Organization (SLR 2023).

Typical values in Australian drinking water

Concentrations of silicon measured by water suppliers in reticulated drinking water supplies around Australia are usually reported as silica (SiO_2). However, concentrations of silicon can be calculated from the concentration of silica reported (through dividing the atomic mass of silicon by the atomic mass of silica and multiplying by the concentration of silica detected). For example, in 2019-2020, the Northern Territory reported average concentrations of silica of 11 to 104 mg silica/L (equating to approximately 5.2 – 49 mg silicon/L). In Western Australia in 2019-2020, mean concentrations of silica ranged from 0.6 to 90 mg/L (equating to approximately 0.28 – 42 mg silicon/L) (SLR 2023).

Treatment of Drinking Water

Limited data were available on the treatment of drinking water source waters to minimise silicon concentrations.

The removal of silicon (as silica) has been achieved using a strongly basic anion exchange resin in the deionisation process by distillation or reverse osmosis (Dayanand *et al.* 2019). Reverse osmosis has also been found to reduce tap water silicon concentrations by about 55% (from 2.2 to 0.95 mg/L) (Dobbie and Smith 1986).

Measurement

Silicon is commonly measured in drinking water by inductively coupled plasma mass spectrometry, inductively coupled plasma optical emission spectroscopy or inductively coupled plasma atomic emission spectroscopy, according to USEPA Methods SW-846, 3005A, 3010A, 3015A, 3051A, 6010, 6020, 6020A and 29. The standard limit of reporting ranges from 0.05 to 0.5 mg/L depending on the test method used (SLR 2023).

Health considerations

There is limited evidence of adverse effects from oral exposure to silicon in humans. Some reports suggest a possible association of renal stones in humans following long-term use of magnesium trisilicate-containing antacids (EFSA 2010, FAO/WHO 1974), which can result in a dose of up to 4 mg/day of magnesium trisilicate (EFSA 2018).

A review found that sub-chronic studies in rats identified no treatment-related adverse effects from dietary administration of about 370 mg silicon/kg bw/day as different forms of silicon. However, in dogs this dose of silicon when administered orally as sodium silicate or magnesium trisilicate resulted in renal lesions (Newberne and Wilson 1970). Renal effects have also been reported in guinea pigs exposed orally to 16-32 mg silicon/kg bw/day as magnesium trisilicate in drinking water (Dobbie and Smith 1982). These species are considered to have a higher sensitivity than humans due to differences in kidney function (EFSA 2018).

The review also found that other toxicological studies conducted in rats with micronised synthetic amorphous silica have found no treatment-related adverse effects in these animals (SLR 2023).

Derivation of guideline

The health-based guideline value of 100 mg/L (rounded) for silicon in drinking water was derived as follows:

$$100 \text{ mg/L} = \frac{1{,}175 \text{ mg/kg bodyweight/day} \times 70 \text{ kg} \times 0.3}{2 \text{ L/day} \times 100}$$

where:

- 1,175 mg/kg bw/day is the no observed adverse effect level (NOAEL) based on a long-term (2 year) dietary study of micronized silica in rats (Takizawa et al. 1988).
- 70 kg is taken as the average weight of an adult.
- 0.3 is the proportion of total daily intake attributable to the consumption of water. European data suggests that adults may ingest up to 50 mg of silicon per day from food and up to 500 mg of silicon per day from supplements, amounting to a daily intake of up to approximately 8 mg/kg bw (UK EVM 2003). The tolerable daily intake is calculated to be approximately 12 mg/kg bw per day based on a NOAEL of 1,175 mg/kg bw per day. 30% of the tolerable daily intake has been calculated as the relative contribution of drinking water to the total daily intake of silicon.
- 2 L/day is the average amount of water consumed by an adult.
- 100 is the safety factor in using results of an animal study as a basis for human exposure (10 for interspecies extrapolation, 10 for intraspecies variations).
- The calculated value of 123 mg/L is rounded to a final health-based guideline value of 100 mg/L as per the rounding conventions described in Chapter 6.

Review history

This fact sheet was developed based on a review of the available evidence completed in 2023 (SLR 2023; see Administrative Report for more information).

References

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