



## PHYSICAL AND CHEMICAL CHARACTERISTICS FACT SHEET

# Bismuth

(Public consultation draft July 2024)

## Guideline

*Based on health considerations, the concentration of bismuth in drinking water should not exceed 10 mg/L.*

## General description

Numerous bismuth salts and complexes have been used in cosmetics and medicinally for over two centuries for a range of clinical conditions, including common treatments for indigestion. As a result of its broad medical use, bismuth has been found in low concentrations in biological and environmental samples including blood, urine, food and water.

Bismuth copper alloys have been identified as a potential replacement for lead copper alloys in plumbing products. In the United States of America, bismuth copper alloys are one of the most common substitutes for lead copper alloy available on the market (ABCB 2021). Further information on lead replacements in plumbing products (such as bismuth copper alloys) is available in Information Sheet 4.1 - Chemicals leaching from plumbing.

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

## Typical values in Australian drinking water

Limited data is available on the concentration of bismuth in Australian reticulated drinking water supplies. Data available for areas of Queensland and Western Australia indicate that bismuth concentrations in reticulated water are likely to be considerably lower than the level that may cause health effects. For example, bismuth was not detected ( $<0.005 \mu\text{g/L}$ ) in 172 drinking water samples taken in Western Australia (Hinwood *et al.* 2015).

## Treatment of drinking water

No data were available on the treatment of drinking water source waters to minimise bismuth concentrations (SLR 2023).

## Measurement

The concentration of bismuth in drinking water can be determined through inductively coupled plasma mass spectrometry according to USEPA Methods 6010 and 6020; however, other spectrophotometric techniques have also been employed. The standard limit of reporting ranges between 0.001 and 0.01 µg/L depending on the test method used (SLR 2023).

## Health considerations

Bismuth medications have been used to treat a number of clinical conditions, including oral and upper respiratory tract infections, syphilis, diarrhoea, heartburn (pyrosis), dyspepsia (indigestion), gastroesophageal reflux, and peptic ulcer disease (SLR 2023). Bismuth substances also have broad anti-microbial, anti-leishmanial and anti-cancer properties.

The most commonly used forms of bismuth include bismuth subsalicylate and bismuth subcitrate for the treatment of diarrhoea and peptic ulcer disease. These medicinal products contain high concentrations of bismuth.

The toxicology database for bismuth is limited; however, a review of the evidence found case reports of neurotoxicity (encephalopathy) and nephrotoxicity from oral exposure to large amounts of bismuth salts from overdose of medications (SLR 2023).

Nephrotoxicity and mortality have been observed in rats after a bismuth dose of 157 mg/kg bw (Leussink *et al.* 2001).

Bismuth toxicity is likely influenced by the chemical form of bismuth, and it is noted that the lower toxic doses observed in some animal studies may be due to the used of highly soluble/bioavailable complexes of bismuth that are used in medicinal preparations (SLR 2023). Any potential exposure to bismuth that might leach into drinking water from plumbing products is likely to be due to solubilised bismuth salts or bismuth metal, rather than the complex forms used in medicinal preparations.

## Derivation of guideline

The health-based guideline value of 10 mg/L (rounded) for bismuth in drinking water was derived as follows:

$$10 \text{ mg/L} = \frac{1,000 \text{ mg/kg bodyweight/day} \times 70 \text{ kg} \times 0.1}{2 \text{ L/day} \times 300}$$

where:

- 1,000 mg/kg bw/day is the no observed adverse effect level (NOAEL) based on a short-term (28 day) study in rats orally administered bismuth powder (Sano *et al.* 2005) and supported by a long-term (2 year) dietary study in rats (Preussman and Ivankovic 1975).
- 70 kg is taken as the average weight of an adult.
- 0.1 is the proportion of total daily intake attributable to the consumption of water.
- 2 L/day is the average amount of water consumed by an adult.
- 300 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 and an additional safety factor of 3 for limitations in the current toxicological database). No additional safety factor was applied for use of a short-term study, as the NOAEL corresponded to the assumed NOAEL observed in a 2-year chronic study (noting there is some uncertainty in the reporting of the chronic study).
- The calculated value of 11.67 mg/L is rounded to a final health-based guideline value of 10 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

ABCB (2021). Lead in plumbing products in contact with drinking water. Final Regulation Impact Statement 2021. Australian Building Codes Board, July 2021.

Hinwood AL, Stasinska A, Callan AC, Heyworth J, Ramalingam M, Boyce M, McCafferty P, Odland J (2015). Maternal exposure to alkali, alkali earth, transition and other metals: Concentrations and predictors of exposure. *Environmental Pollution*, 204:256–263.

Leussink BT, Slikkerveer A, Engelbrecht MR, van der Voet GB, Nouwen EJ, de Heer E, de Broe ME, de Wolff FA, Bruijn JA (2001). Bismuth overdosing-induced reversible nephropathy in rats. *Archives of Toxicology*, 74(12):745–754.

Preussmann R, Ivankovic S (1975). Absence of carcinogenic activity in BD rats after oral administration of high doses of bismuth oxychloride. *Food and Cosmetics Toxicology*, 13(5):543–544.

Sano Y, Satoh H, Chiba M, Okamoto M, Serizawa K, Nakashima H, Omae K (2005). Oral toxicity of bismuth in rat: single and 28-day repeated administration studies. *Journal of Occupational Health*, 47(4):293–298.



SLR (2023). Evidence Evaluations for Australia Drinking Water Guidelines Chemical Fact Sheets – Lead Replacements in Plumbing – Bismuth Evaluation Report. SLR Consulting Australia Pty Ltd. Report prepared for the National Health and Medical Research Council, December 2023.

WHO (2022). Guidelines for drinking-water quality: fourth edition incorporating the first and second addenda. Geneva: World Health Organization.

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

DRAFT