PHYSICAL AND CHEMICAL CHARACTERISTICS
FACT SHEETS

Nickel

(Public consultation draft - April 2026)

GUIDELINE

Based on health considerations, the concentration of nickel in drinking water should not exceed 0.05 mg/L.

GENERAL DESCRIPTION

Nickel (Ni) (CAS 7440-02-0) is used in the electroplating industry and in the manufacture of stainless steel alloys used in the chemical, marine, nuclear and aerospace industries, and in many consumer products. It is used as a catalyst in industrial processes, and in oil refining. Main releases to the environment are from the burning of fossil fuels and in waste discharges from electroplating industries. Nickel can enter surface waters and groundwaters through nickel-containing particulate matter carried by rainwater and through the degradation or dissolution of nickel-containing rocks and soils (WHO 2021).

Drinking water generally contains very low concentrations of nickel. Concentrations reported internationally are usually less than 0.01 milligram per litre (mg/L) (SLR 2022a,b). Drinking water can become a significant source of nickel if the source water is contaminated (e.g. located in an industrial area) or if nickel leaches from nickel-containing plumbing products past the point of supply, such as nickel-plated tap fittings which are in contact with drinking water (see Section 9.6, Information Sheet 4.1 and enHealth 2021). Exceedances of nickel have been detected following testing of some drinking water fountains (ABCB 2021). Concentrations up to 1 mg/L have been reported in first flush drinking water that has been in prolonged contact with nickel-containing plumbing products (OEHHA 2001). However, these higher concentrations are unusual.

The diet is the main exposure source for nickel in the general population. Mean daily dietary intakes in Australian adults have been estimated at 0.15 mg for men and 0.115 mg for women. Major contributions to dietary intake include bread, cake, peanut butter, cereal, chocolate and tea (FSANZ 2008).

TYPICAL VALUES IN AUSTRALIAN DRINKING WATER

In major Australian reticulated drinking water supplies, concentrations of nickel range from 0.001 mg/L to 0.01 mg/L (SLR 2022a,b).

TREATMENT OF DRINKING WATER

Nickel concentrations in drinking water supplies can be reduced using chemical coagulation, sedimentation, filtration or co-precipitation with iron and manganese oxides (WHO 2021).

MEASUREMENT

Australian laboratories can determine nickel concentrations in drinking water supplies using inductively coupled plasma atomic emission spectroscopy (ICP-AES) or mass spectrometry (MS), according to US EPA Method 6010D (2018), US EPA Method 6020B (2014), US EPA Method 3010A (1992a), US EPA Method 3015A (1992b) and APHA 21st Edition (2005).

The standard limit of determination is 0.001 mg/L. A trace level of determination of 0.0001 mg/L is achievable by some commercial laboratories (SLR 2022b).

HEALTH CONSIDERATIONS

Intestinal absorption of soluble nickel in drinking water can be as high as 25-27% in the absence of food, or under a fasted state, compared with only 0.7-2.5% from food (EFSA 2020). After absorption, nickel appears to be distributed to most organs, with higher amounts in the kidneys, lungs and liver. Absorbed nickel is eliminated mainly in the faeces and to a lesser extent in urine (WHO 2021).

An extensive review and summary of the human and animal toxicity data for nickel compounds is available (NICNAS 2014).

In humans, oral exposure to nickel was associated with effects on the gastrointestinal, haematological, neurological and immune systems (WHO 2021).

Nickel is known to be a common skin allergen that can induce skin sensitisation (NICNAS 2014). Allergic contact dermatitis (type IV hypersensitivity) is the most prevalent effect of nickel exposure in the general population. EFSA (2020) identified a lowest-observed-adverse-effect-level (LOAEL) of 0.3 mg per person, corresponding to 0.0043 mg per kilogram body weight per day (mg/kg bw/day) assuming a body weight of 70 kg, for systemic contact dermatitis in nickel sensitised individuals after acute oral exposure to nickel in drinking water (Jensen et al. 2003). The health outcomes for nickel sensitive individuals should be considered on a case-by-case basis, and those affected are advised to seek medical advice.

Experimental animal studies show consistent evidence of developmental toxicity in rats following oral exposure to soluble nickel compounds at doses $\geq$ 1.3 mg/kg bw/day (SLR 2022a). Developmental toxicity has also been observed in mice, but at higher doses than for rats. Nickel is able to cross the placenta and affect the developing embryo or foetus (EFSA 2020).

Results of an initial one-generation dose-range finding study, and a follow up two-generation reproduction study, showed an increase in the incidence of post-implantation loss in rats exposed to nickel sulfate hexahydrate by oral gavage (SLI 2000a,b). Similar adverse effects have been observed in multi-generation reproductive toxicity studies in rats exposed to nickel chloride (Smith et al. 1993; RTI 1988a,b). EFSA (2020) identified a benchmark dose ($BMDL_{10}$) of 1.3 mg/kg bw/day for developmental effects (post-implantation loss in rats) using data from SLI (2000a,b). WHO (2021) adopted this endpoint in their determination of a drinking water guideline for nickel of 0.07 mg/L.

Nickel has been classified as a substance suspected of causing cancer and organ damage from prolonged or repeated exposure (SWA 2016). Recent data from human studies also suggest possible associations between nickel exposure and adverse reproductive and developmental outcomes (WHO 2021).

Epidemiological studies have demonstrated that inhalation of nickel can cause lung, sinus and nasal cancer. The International Agency for Research on Cancer (IARC) has concluded that based on inhalation exposure, nickel compounds are carcinogenic to humans (Group 1, sufficient evidence of carcinogenicity in humans), and metallic nickel is possibly carcinogenic to humans (Group 2B, possibly carcinogenic to humans). There is a lack of evidence of a carcinogenic risk from oral exposure to nickel compounds and metallic nickel (IARC 2012).

DERIVATION OF GUIDELINE

The guideline value for nickel in drinking water of 0.05 mg/L (rounded) was derived as follows:

$$0.05 \text{ mg/L} = \frac{1.3 \text{ mg/kg body weight per day} \times 70 \text{ kg} \times 0.1}{2 \text{ L/day} \times 100}$$

where:

- 1.3 mg/ kg bw/day is the benchmark dose lower confidence limit for an extra 10% of risk compared with the background risk ($BMDL_{10}$), derived on the basis of developmental effects (post-implantation loss in rats) from a dose-range finding reproductive toxicity study and a 2-generation reproductive toxicity study (EFSA 2020; SLI 2000a,b).
- 70 kg is taken as the average weight of an adult.
- 0.1 is a proportionality factor based on the assumption that drinking water accounts for 10% of the total daily intake of nickel.
- 2 L/day is the average amount of water consumed by an adult.
- 100 is the uncertainty factor applied to the $BMDL_{10}$ derived from animal studies (10 for interspecies variations, 10 for intraspecies variations).
- The calculated value of 0.0455 mg/L is rounded to a final health-based guideline value of 0.05 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 2021 (SLR 2022a,b) (refer to the relevant Administrative Report for more information).

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