PHYSICAL AND CHEMICAL CHARACTERISTICS FACT SHEET

Lead

(Public consultation draft July 2024)

Guideline

Based on health considerations, the concentration of lead in drinking water should not exceed 0.005 mg/L.

General description

Lead is one of the most common of the heavy metals and is mined widely throughout the world. It is used in the production of lead acid batteries, solder, alloys, cable sheathing, paint pigments, rust inhibitors, ammunition, glazes and plastic stabilisers.

Lead can be present in drinking water, most commonly due to leaching from household plumbing systems containing lead. These may include lead in copper alloys, lead in pipes, or in solder used to seal joints. The amount of lead dissolved will depend on several factors including pH, water hardness, temperature and the standing time of the water. There is an increasing availability of alternative plumbing products in Australia such as Lead Free plumbing products, which are defined by the Australian Building Codes Board as a plumbing product or material in contact with drinking water with a weighted average lead content of not more than 0.25% (ABCB 2023).

Approximately 80% of the daily intake of lead is from the ingestion of food, dirt and dust. Lead may be found as a contaminant in a wide range of foods however dietary exposures are considered to be lower than levels found to be of negligible risk of causing adverse health effects (FSANZ 2019).

Typical values in Australian drinking water

In major Australian reticulated drinking water supplies, total lead concentrations can vary in range, with typical concentrations less than 0.005 mg/L. A review found that mean levels in reticulated supplies in Australia appear to be lower than or similar to those in other developed countries (SLR 2023).

The concentration of lead in water within premises may be higher, especially in older buildings, due to exposure of the water to lead-containing plumbing products. A review found several Australian and international studies that detected up to 0.162 mg/L of lead in drinking water due to leaching from lead-containing plumbing materials including taps and lead service lines, suggesting that leaching of lead from lead-containing plumbing materials can be substantial (SLR 2023).

Treatment of Drinking Water

Lead concentrations in drinking water source waters can be reduced by conventional methods of water treatment using coagulants or lime softening. However, exposure to lead in drinking water is likely to occur past the point of water supply (i.e. the water meter) as leaching of lead from plumbing products most likely occurs within premises (see Section 9.6; Information Sheet 4.1).

There are a number of regulatory measures already in place in Australia to preventatively manage health risks from plumbing and to ensure water at the tap is safe. For example, all repairs or installations of plumbing products in Australia should be undertaken by a licenced plumber having regard to materials in contact with drinking water being certified against relevant Australian standards, such as the WaterMark Certification Scheme, *AS/NZS 4020:2018 Testing of products for use in contact with drinking water*.

The introduction of Lead Free regulations for plumbing products that come into contact with drinking water aims to reduce the potential health risks from lead leaching from plumbing products (ABCB 2023). In most circumstances, it will also reduce the need for additional measures to reduce exposure to lead within a building, such as preventative flushing regimes or in-premise water treatment.

In instances where there is uncertainty about the water quality within a building (e.g. after drinking water has been sitting stagnant in a school plumbing system during a holiday break), additional measures can be taken to reduce potential risks to health. See Information Sheet 4.1 – Chemicals leaching from plumbing products for more information.

Measurement

The concentration of lead in drinking water is commonly measured by inductively coupled plasma mass spectrometry (USEPA 6010, 6020, APHA 3010 and 3030). The limit of reporting typically ranges from 0.0002 to 0.05 mg/L depending on the laboratory test method.

Health Considerations

Lead can be absorbed by the body through inhalation, ingestion or placental transfer. In adults, approximately 10% of ingested lead is absorbed but in children this figure can be 4 to 5 times higher. After absorption, the lead is distributed in soft tissue such as the kidney, liver, and bone marrow where it has a biological half-life in adults of less than 40 days, and in skeletal bone where it can persist for 20 to 30 years.

In humans, lead is a cumulative poison that can severely affect the central nervous system and is associated with numerous adverse effects. Infants, foetuses and pregnant women are most susceptible. Placental transfer of lead occurs in humans as early as the 12th week of gestation and continues throughout development.

Several epidemiological studies have been carried out on the effects of lead exposure on neurodevelopmental and behavioural outcomes in children, suggesting that blood lead levels between 5 µg/dL and 10 µg/dL can adversely affect intelligence in children (NHMRC 2015b). In adults, a review found that there is jurisdictional agreement that key adverse effects associated with exposure to high amounts of lead include increased blood pressure and cardiovascular effects (SLR 2022). Recent studies have suggested that there is also moderate confidence in an association between lead exposure and increased fasting plasma glucose and incidence of fatty liver disease (Wan *et al.* 2021, 2022). The doses at which these effects occur are uncertain but appear to be at blood lead levels >5 µg/dL (SLR 2022, 2023).

Studies have investigated a wide range of other adverse effects associated with exposure to high amounts of lead in drinking water including hip fractures (Dahl *et al*. 2014), kidney damage, interference with the production of red blood cells and measures of iron deficiency (Danziger *et al*. 2021, 2022). A number of studies have also investigated possible associations between lead exposure from drinking water and incidence of miscarriages and foetal death (Edwards *et al.* 2014), and incidence of low birth weight and preterm births in American children (Dave and Yang 2022). However, the overall data for these studies is limited and no clear dose response relationships have been established (SLR 2023).

A review found that most jurisdictions agree that it is unclear whether lead is an oral genotoxic carcinogen in humans due to mixed results in genotoxicity assays (SLR 2022). Damage to DNA has been observed in several *in vivo* parenteral studies in rodents (ATSDR 2020). Kidney tumours have been reported in rats, mice and hamsters fed lead salts in their diet, but only at doses above 27 mg/kg bw per day. Gliomas (brain tumours) have also been reported in rats. In addition, lead salts given orally to rats have increased the carcinogenic activity of known carcinogens. The International Agency for Research on Cancer has concluded that inorganic lead compounds are probably carcinogenic to humans (Group 2A - limited human data but sufficient evidence in animals) and organic lead compounds are not classifiable as to their carcinogenicity to humans (Group 3) (IARC 2006).

Derivation of Guideline

Few jurisdictions have derived a health-based guideline value for lead in drinking water due to the uncertainty in the health evidence at low concentrations. The World Health Organization (WHO) has set a provisional drinking water guideline value of 0.01 mg/L based on treatment performance and analytical achievability (WHO 2016, 2022). The European Union has recently issued a revised drinking water limit for lead of 0.005 mg/L to be implemented by 2036 (EU 2020). A review found a public health goal of 0.0002 mg/L for lead in drinking water set by the California Office of Environmental Health Hazard Assessment (OEHHA) based on developmental effects was not considered feasible or appropriate for the Australian context (SLR 2022).

In the absence of clear no or lowest observed adverse effect level, it is reasonable to derive a health-based guideline value for lead in drinking water with the aim of overall reduction of exposure to lead. This approach is consistent with current Australian science policy to minimise exposure to lead in the most sensitive populations (infants, children, and pregnant women) (NHMRC 2015a,b).

Dose-response analysis of lead is typically conducted using blood lead levels to describe exposure, which is then converted back to an intake using physiologically based pharmacokinetic modelling. As per current NHMRC advice on blood lead levels (NHMRC 2015b), and a relative source contribution that assumes that 20% of the total lead intake can be attributable to water consumption, this translates to a blood lead level assigned to exposure from lead in drinking water of 1 µg/dL (i.e. 5 µg/dL x 0.2 = 1 µg/dL).

The concentration of lead in drinking water that results in a child's blood lead level reaching 1 µg/dL can be estimated using a predictive model such as the US EPA Integrated Exposure Uptake Biokinetic (IEUBK) model (USEPA 2021), which has been validated for use in health risk assessments. Model inputs assume a drinking water intake of 0.75 L/day for 0-1 year olds and 1 L/day for 1-7 year olds. The model also assumes that if 50% of ingested lead is absorbed by the gastrointestinal tract, a blood lead level of 1 µg/dL would be attained in children between 6 months and 2 years if the concentration of lead in drinking water was 0.005 mg/L.

As the same biokinetic factors are likely to be applicable for converting lead uptake to a blood lead concentration in infants (1 to 7 year olds) as in 0.5 to 1 year olds, it suggests that a similar blood lead concentration would be expected to be estimated in the 0.5 to 1 year olds. Since bottle-fed infants would likely receive up to 100% of their lead from formula made up with drinking water as opposed to only 20% used for young children, the exposure modelling for young children who have a much higher overall exposure to lead through other exposure pathways is protective for bottle-fed infant exposures.

Based on attaining a blood lead concentration attributable to drinking water of up to 1 µg/dL in children between 6 months and 2 years, IEUBK modelled data indicates that the health-based guideline value of 0.005 mg/L should not be exceeded in drinking water. This value has therefore been determined as an appropriate health-based guideline value for lead in drinking water that would help keep blood lead levels for the most sensitive population group (i.e. younger children) under levels that cause concern.

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).

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