Manganese

(endorsed 2011)

GUIDELINE

Based on aesthetic considerations, the concentration of manganese in drinking water should not exceed 0.1 mg/L, measured at the customer's tap.

Manganese would not be a health consideration unless the concentration exceeded 0.5 mg/L.

GENERAL DESCRIPTION

Manganese is present in the environment in the divalent (Mn(II)), tetravalent (Mn(IV)), and heptavalent (Mn(VII)) states. Most of the divalent compounds are soluble in water. The most common tetravalent compound, manganese dioxide, is insoluble; however, the heptavalent permanganate is soluble.

Manganese is principally used in the manufacture of iron, steel and alloys.

Uncontaminated rivers and streams generally have low concentrations of manganese, ranging from 0.001 mg/L to 0.6 mg/L. High concentrations may occur in polluted rivers or under anoxic conditions such as at the bottom of deep reservoirs or lakes, or in groundwater.

At concentrations exceeding 0.1 mg/L, manganese imparts an undesirable taste to water and stains plumbing fixtures and laundry. Even at concentrations of 0.02 mg/L, manganese will form a coating on pipes that can slough off as a black ooze. Some nuisance microorganisms can concentrate manganese and give rise to taste, odour and turbidity problems in distribution systems. A discretionary target of 0.01 mg/L is suggested at the treatment plant.

Manganese interferes with the commonly used DPD method for determining chlorine residual, resulting in an overestimation of the residual so that chlorine appears to be present when it may not be.

Concentrations of manganese in food can vary considerably. The highest concentrations have been reported in grains, nuts and vegetables, while tea leaves can have extremely high concentrations.

It has been estimated that the average dietary intake of manganese is 2–4 mg per day.

TYPICAL VALUES IN AUSTRALIAN DRINKING WATER

In major Australian reticulated supplies, manganese concentrations can range up to 1.41 mg/L, with typical concentrations less than 0.01 mg/L. For regional NSW, for example, a median value of 0.005 mg/L was found over a nine-year period.

TREATMENT OF DRINKING WATER

Manganese concentrations in drinking water can be lowered by converting soluble forms to insoluble precipitates, followed by filtration. Manganese levels below 0.02 mg/L can be achieved with a well operated and optimised potassium permanganate system. Achieving <0.01 mg/L manganese in treated water is not possible with potassium permanganate alone, so high pH coagulation processes or a two-stage filtration process are employed at several plants; however, this process will not be suitable for all waters. Pre-filtration chlorination can help to achieve a target of 0.01 mg/L.

MEASUREMENT

The manganese concentration in drinking water can be determined using inductively coupled plasma emission spectroscopy or graphite furnace atomic absorption spectroscopy (APHA Method 3500-Mn Parts B or C, 1992). The limits of determination are 0.005 mg/L and 0.001 mg/L respectively.

HEALTH CONSIDERATIONS

Manganese is an essential element and is required by mammals and birds for normal growth. Manganese deficiency affects bone, the brain and reproduction in a number of animal species. Although no specific symptoms have been described in humans, it has been suggested that manganese deficiency may be associated with anaemia and, in children, with bone disorders.

Owing to the low solubility of manganese in gastric juices, only 3-8% of ingested manganese is absorbed by the gastrointestinal tract. After absorption, it is concentrated in the liver and eventually excreted in faeces. In humans it has a relatively short biological half-life of 13 to 37 days.

An extensive review and summary of the human and animal toxicity data for manganese is available (IPCS 1981).

In humans, manganese toxicity has occurred mainly as a result of inhalation of manganese dust over long periods. By the oral route, manganese is regarded as one of the least toxic elements.

In one case involving heavy consumption of highly contaminated well water, resulting symptoms included lethargy, increased muscle tone, tremor and mental disturbances. Concentrations of manganese were over 14 mg/L; however, concentrations of other metals were also high and the reported effects may not have been due solely to manganese.

Experiments with laboratory animals have shown no adverse effects other than a change in appetite and a reduction in the metabolism of iron in haemoglobin synthesis.

There is no firm evidence that manganese is carcinogenic. Some studies indicate that it may, in fact, have an anticarcinogenic effect. Some *in vitro* studies using mammalian and bacterial cells have reported that manganese acts as a mutagen.

DERIVATION OF GUIDELINES

The aesthetic guideline of 0.1 mg/L at the customer's tap is based on practical experience and has been reported by utilities to be acceptable to customers. The discretionary target of 0.01 mg/L at the treatment plant is also based on experience; that although manganese accumulates in distribution systems, a plant producing 0.01 mg/L generally does not generate customer complaints, while a concentration of 0.02 mg/L or more tends to lead to various problems.

The health-based guideline value for manganese in drinking water can be derived as follows:

$$0.5 \text{ mg/L} = \frac{10 \text{ mg/day} \times 0.1}{2 \text{ L/day}}$$

where:

- 10 mg/day is the amount of manganese that can be safely consumed from all sources (WHO 1973).
- 0.1 is a proportionality factor based on the assumption that 10% of daily intake is attributable to the consumption of water.
- 2 L/day is the estimated maximum amount of water consumed by an adult.

The maximum tolerable daily intake value includes adequate safety factors, so no additional safety factors are necessary. This value exceeds the concentration at which manganese can cause taste and odour problems.

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

REFERENCES

APHA Method 3500-Mn Part B (1992). Manganese: Atomic Absorption Spectrometric method. *Standard Methods for the Examination of Water and Wastewater*, 18th edition. American Public Health Association, Washington.

APHA Method 3500-Mn Part C (1992). Manganese: Inductively Coupled Plasma method. *Standard Methods for the Examination of Water and Wastewater*, 18th edition. American Public Health Association, Washington.

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WHO (World Health Organization) (1973). Trace elements in human nutrition: Manganese. Report of the WHO Expert Committee, Technical Report Service, 532, 34-36, Geneva, Switzerland.

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