

# Aluminium



March 2002

## INTRODUCTION

Aluminium is a ubiquitous element in the environment, comprising 8% of the earth's crust. It is a light weight, silvery white, soft, malleable metal, derived from the refining and smelting of cryolite and bauxite ore.

## USES

Aluminium has a myriad of uses in modern society and is a widespread part of modern life. It is alloyed with other metals and used in many industries, including the shipbuilding, electrical, building, motor vehicle and jewellery industries. It is widely used in the packaging of foodstuffs and drinks, in petroleum processing and in the rubber industry. Aluminium compounds are used in antacid medicines, antiperspirant products, in food processing and in the treatment of water for potable use.

## OCCUPATIONAL EXPOSURE

There are significant occupational hazards associated with the production of aluminium. These include exposures to heat, noise and fluorides. A form of airways disease known as 'potroom asthma' is associated with the smelting of aluminium oxide into aluminium. Aluminium powder is highly flammable. It is used in the pyrotechnic and paint industries. Long-term inhalation of aluminium powder has been associated with pulmonary fibrosis.

Impairment of cognitive function, motor dysfunction and peripheral neuropathy has been reported in workers exposed to aluminium in the workplace.

## ENVIRONMENTAL EXPOSURE

Environmental exposure to aluminium is inevitable. The principal routes of entry are:

- the ingestion of food or water containing aluminium
- the inhalation of aluminium as fine particles

The average amount of aluminium ingested by adults or children in a day from food and beverages is estimated to be 5-20 mg. Aluminium can be taken into the body from food (both as naturally occurring aluminium and as additives), from transfer of aluminium from cooking implements and containers (including aluminium drink cans), and aluminium in water, aerosols and dusts. Although little is known about the metabolism of aluminium, it is understood that less than 1% of ingested aluminium is absorbed. However, significant absorption can occur when the intake is very high, such as in high doses of aluminium-based antacids.

The amount of aluminium present in food varies. Animal products are relatively low in aluminium content while plant products are relatively high. The main sources of aluminium in the diet are grain and dairy products, desserts and beverages. There is sufficient evidence to indicate that cooking food of a salty or sufficiently acidic or alkaline nature in aluminium pots and pans, or storing the food in aluminium foil, results in an increased amount of aluminium in the food and increased dietary intake. However, there is no evidence that this is associated with a significantly increased uptake of aluminium into the body.

In addition to naturally occurring aluminium in water supplies, drinking water is often treated with an aluminium compound (alum) in a process known as flocculation. Most, but not all, of the aluminium is removed later in the water treatment process. The National Health and Medical Research Council (NHMRC)/Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) Australian Drinking Water Guidelines (1996) recommend a Guideline Value for aluminium in drinking water of 0.2 mg/litre. However, this value is not health-based but based on aesthetic considerations. Water authorities are encouraged to keep acid-soluble aluminium below 0.1 mg/litre.

Assuming an average intake of 2 litres a day, water at the Drinking Water Guideline Value of 0.2 mg/L would provide 0.4 mg of aluminium daily via this route. There is a suggestion that aluminium dissolved in water has greater bioavailability than other dietary forms of aluminium and that greater amounts of this form of aluminium could be absorbed. However, this aspect still requires further study. Other studies have identified high levels of aluminium in the contents of some aluminium-canned drinks and orange juices.

Aluminium can also occur as a dust, particularly during the refining process or in dusts arising from the soil from agricultural processes, and in cigarette smoke. However, inhalation of aluminium in the environment is thought to contribute only 0.01-0.02 mg of aluminium intake per day.

Although aluminium is used in antiperspirants, it is unlikely that there is significant absorption of aluminium through the skin.

### HEALTH EFFECTS

Aluminium is usually present only in trace amounts in living organisms. It has no recognised role of importance in biological processes. Overall, the body guards against aluminium by absorbing less than 1% of dietary aluminium and effectively excreting it via the kidneys.

Silicic acid and fluoride protect against absorption, but acidity promotes the absorption of aluminium. It is notable that aluminium accumulates with age in lung, bone and brain tissue, and this has led in part to the controversy about aluminium and a possible association with Alzheimer's Disease.

When aluminium accumulates acutely in tissues such as the brain, it has the potential to cause serious adverse neurological effects. Dialysis encephalopathy is a form of aluminium neurotoxicity characterised by speech difficulty, dementia and convulsions. It is attributed to the use of aluminium-treated water in dialysis. This source, when added to the aluminium present in medications used in the treatment of renal failure, and the poor renal excretion of aluminium by the diseased kidneys, leads to the acute accumulation and deposition of aluminium in body tissues, including the brain, with resultant neurotoxic effects. It should be emphasised that these acute effects arose in patients who were exposed to about 150 litres of aluminium-treated water per dialysis session. This resulted in an exposure to approximately 30 mg of aluminium per session, three times a week, with direct transfer into the bloodstream via the dialysis machine.

Water is now treated by a process called reverse osmosis prior to use in dialysis to bring the concentration of aluminium in the water below 0.01 mg/litre.

The main area of contention with regards to aluminium toxicity revolves around the possible role of aluminium in the aetiology of Alzheimer's Disease. The suggestion that chronic aluminium accumulation in brain tissue plays a causal role in Alzheimer's Disease was based on the finding of high aluminium content in the brains of patients with Alzheimer's Disease. However, it is not known whether this is a cause or effect of the disease, as aluminium tends to accumulate in normal subjects as they get older. A 1989 study established a small but statistically significant increase in the risk of Alzheimer's Disease in areas of high aluminium content (>0.1 mg/litre) in the drinking water. However, this study has been criticised for several methodological flaws which cast doubt upon the interpretation of the findings.

Other studies have looked at antiperspirants and antacids (with and without aluminium-based components) on an 'ever used' versus 'never used' basis. One of these studies was very small (5 cases and 15 controls), while another found an excess risk of Alzheimer's Disease in association with the use of aluminium-based antiperspirants.

Aluminium-based antacids posed no excess risk of Alzheimer's Disease, but there was a large risk associated with the use of any antacid, with or without aluminium. At this stage, given the flaws and weaknesses in the studies to date, there is no strong evidence to associate aluminium from normal daily environmental exposures with the occurrence of Alzheimer's Disease. The most well supported environmental association with Alzheimer's Disease is previous head injury.

The WHO International Programme on Chemical Safety review (1997) of aluminium reached the following conclusions in regard to risks from aluminium in various groups in the community:

#### *Healthy general population*

Aluminium has not been shown to pose a health risk to healthy, non-occupationally exposed humans. There is no evidence to support a primary causative role of aluminium in Alzheimer's Disease.

#### *Subpopulations at special risk*

In people of all ages with severe kidney failure being treated by haemodialysis, there is an increased risk of aluminium induced toxicity (renal encephalopathy, vitamin D resistant osteomalacia and microcytic anaemia). Every effort should be made to limit aluminium exposure in these people.

#### *Occupationally exposed populations*

Workers who have long-term, high-level exposure to fine aluminium particulates may be at increased risk of adverse health effects. Exposure to pyrotechnic aluminium powder has caused pulmonary fibrosis. Irritant-induced asthma has been associated with inhalation of aluminium sulfate, aluminium fluoride and potassium aluminium tetrafluoride. It has been found to occur in the complex environment of primary aluminium production, especially potrooms.

#### **CURRENT GUIDELINES**

The NHMRC/ARMCANZ Australian Drinking Water Guidelines (1996) recommend a Guideline Value of 0.2 mg/litre for aluminium. The Guidelines note that the level can be readily reduced with further treatment to less than 0.1 mg/litre. At concentrations above 0.2 mg/litre, there is a tendency to form a whitish precipitate of aluminium hydroxide resulting in visible discolouration of the water supply. This level is therefore established for aesthetic reasons rather than as a protective health measure.

The World Health Organization advises that the PTWI (Provisional Tolerable Weekly Intake) for aluminium is 7.0 mg/kg of body weight (FOA/WHO, 1989). This approximates to a maximum tolerable daily intake of 70 mg for a 70 kg adult.

The WHO International Programme on Chemical Safety (1997) recommendations for public health protection for aluminium are:

- Strategies should be developed to limit exposure in patients with severely impaired renal function who are exposed to aluminium from pharmaceutical products.
- For patients with end-stage renal failure treated by dialysis, exposure to aluminium should be limited by treatment of the water and elimination of aluminium contamination of the chemicals used to prepare dialysis fluid. It is suggested that dialysis fluids should contain less than 15 g aluminium/litre.

### SELECTED BIBLIOGRAPHY

Amaducci L, Lippi A. "Risk Factors for Alzheimer's Disease" (Editorial), *Int J Geriatric Psychiatry*, Vol. 7: 383-388 (1992).

Davenport A, Goodall R. (Letter), *Lancet*, 1992, Vol. 339, May 16, p 1236.

Duggan J, Dickeson J, Tynan P, Houghton A, Flynn J. "Aluminium beverage cans as a dietary source of Aluminium", *Med J Aust* 1992; 156: pp. 604-605.

Editorial: "Is aluminium a dementing ion?", *Lancet*, 1992, Vol. 339, March 21, pp. 713-714.

Graves AB, White E, Koepsell T, Reifler B, van Belle G, Larson E. "The association between aluminium containing products and Alzheimer's Disease", *J Clin Epidemiol*, 1990, Vol. 43, No. 1, pp. 35-44.

International Programme on Chemical Safety. *Environmental Health Criteria* number 194, Aluminium, WHO, Geneva, 1997.

Kawachi I, Pearce N. "Aluminium in the drinking water - is it safe?", *Australian Journal of Public Health*, 1991, Vol. 15, No. 2, pp 84-87.

National Health and Medical Research Council/Agriculture and Resource Management Council of Australia and New Zealand, *Guidelines for Drinking Water Quality in Australia 1996*, AGPS, Canberra, 1996.

Martyn C, Osmond C, Edwardson J, Barker D, Harris E, Lacey R. "Geographical relation between Alzheimer's Disease and Aluminium in drinking water", *Lancet*, 1989, 1; pp. 59-62.

Parmeggiani L. (ed) "Encyclopaedia of Occupational Health and Safety", 3rd Edition, International Labour Organisation, Geneva, 1983.

Sittig M. *Handbook of Toxic and Hazardous Chemicals*, 2nd Ed., Princeton, NJ, 1985.

U.S. Department of Health and Human Services, *Toxicological Profile for Aluminium*, Agency for Toxic Substances and Disease Registry, July 1992.

WHO Food Additives Series: 24, *Toxicological Evaluation of Certain Food Additives and Contaminants*, Cambridge University Press, 1989.

For more information, contact your local public health network



Click on the map or the links below to go to contact info

**Central Public Health Unit Network** servicing Brisbane northside, Longreach, Redcliffe, Rockhampton, Sunshine Coast, Wide Bay.

For contact details go to <http://www.health.qld.gov.au/phs/cphun/>

**Southern Public Health Unit Network** servicing Brisbane southside, Darling Downs, Roma, South Coast, South West Queensland, West Moreton

For contact details go to <http://www.health.qld.gov.au/phs/sphun/>

**Tropical Public Health Unit Network** servicing Cairns, Mackay, Mount Isa and Gulf, Townsville

For contact details go to <http://www.health.qld.gov.au/phs/tphun/>

For medical advice, contact your doctor, hospital or health clinic.

#### Published by:

Environmental Health Unit  
10<sup>th</sup> floor, Queensland Health Building  
147-163 Charlotte Street,  
BRISBANE 4000

GPO Box 48 BRISBANE 4001

Ph: +61 7 3234 0938

Fax: +61 7 3234 1480

<http://www.health.qld.gov.au/phs/ehu/>

This fact sheet may be reproduced in full, providing the source is acknowledged, but may not be reproduced in part without prior permission of Public Health Services, Queensland Health.