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# Aluminum Concentrations in Water of Elderly People's Houses and Retirement Homes and Its Relation with Elderly Health

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**Abstract** The purpose of this study was to determine the concentrations of aluminum (Al) and other metals in water samples from elderly people's houses and retirement homes. Forty-six duplicate water samples from kitchen taps were collected in Ribeirão Preto/SP, Brazil. Metal levels were measured by atomic absorption spectrophotometer. Aluminum concentration exceeded the maximum allowed values in 26% of samples according to the Decree 518/2004 of the Brazilian Health Ministry. It was noted that 11% of elderly living at monitored houses, as well as 19% living at retirement homes presented Alzheimer disease diagnostic. These results suggest taking into account Al risks among vulnerable elderly population groups.

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Aging is a phase of life in which metal homeostasis is affected, causing progressive vulnerability to a physiological overload, which in turn leads to different problems for elderly people's health (Mocchegiani et al. 2007). This condition is associated with the vulnerability of the immunological system and with exposure time to risk factors that predispose to an increase of health problems (Kovaiou et al. 2007). During the senescence, in addition to biological factors, external factors can also impair elderly health. External factors predisposing to health problems in the population include exposure to heavy metals (Farzin et al. 2008). Although people of all ages can develop health damage caused by metals, the elderly can be more susceptible to the development of these problems, as the duration of their exposure to metals is longer across the whole life (Navas-Acien et al. 2004; Tellez-Plaza et al. 2008).

In the twentieth century, the rise in the population's life expectancy disclosed the aging of the world population. Although in Brazil, this demographic transition process is recent, the consequent epidemiological transition can be already noted, revealing an enormous growth in chronic-degenerative diseases (Schramm et al. 2004). In this context, the advancement of knowledge about the risks of exposure to heavy metals evidences the importance of assessing water quality and problems for human health, particularly addressing vulnerable population groups. In recent years, a number of studies on the effects of heavy metals in human and animal health have been carried out (Tsuji and Karagatzides 2001; Jadhav et al. 2007; Islam et al. 2007; Wigle et al. 2008).

In the present investigation, we analyzed the concentrations of Al, Cd, Cr, Cu, Fe, Hg, Mn, Pb and Zn in water samples collected at elderly people's houses and retirement homes of Ribeirão Preto, Brazil. The main purpose of the study was to assess if these levels could be altered by water storage, channeling, and/or treatment in the city. It was mainly focused on understanding if metal levels could be a significant risk on elderly health.

## Materials and Methods

Ribeirão Preto is a city located at the Northeast of São Paulo State, Brazil. Between January and December 2006, 46 water samples were collected from kitchen taps in houses and retirement homes located at different points of the city. Before collection, water circulated for 2 min (Segura-Muñoz et al. 2003). The houses selected for water sample collection accomplished with the following criteria: having at least one person aged 60 years or older, having lived at the same house for at least 10 years, and using public network water for consumption. Water samples were fixed with 0.5 mL of highly pure 65% nitric acid (Suprapur, E. Merck, Darmstadt, Germany) up to a pH $< 2$ and kept at $-18$°C until analysis. They were centrifuged (CT-500 – Cientec) at 2,500 rpm, and the supernatants were separated for future reading of metals (APHA 1998). The pH of water was read in situ by applying the potentiometric method, using a portable pH meter (Model 206-LUTRON) previously calibrated with 4.0 and 7.0 pH buffer solutions.

The concentrations of metals were determined by atomic absorption spectrophotometer (AAS) at the Metals Sector of the Pediatric Laboratory at the HCFMRP/USP. Aluminum, Cd, Cr, Pb and Mn concentrations were determined by graphite furnace AAS (VARIAN-ZEEMAN 640-Z). Mercury levels were measured by hydride generation AAS (VARIAN AA-200), while the concentrations of Cu, Fe and Zn were determined through flame AAS (VARIAN AA-55). Results with a systematic error margin of up to 20% were considered as valid. Detection limits were the following: 0.00001 mg/L for Cd and Hg; 0.001 mg/L for Al, Mn, Pb and Zn; 0.002 mg/L for Cr; and 0.005 mg/L for Fe and Cu. The quality control of the instrumental methods and analytical procedures was checked using certified potable water samples (PW-373, PW-388), from Quality Control Technologies Pty. Ltd. (Queensland, Australia). The mean recovery percentages ($n = 6$) for PW-373 and PW-388 were the following: Al 94.3/94.1; Cd 96.7/96.2; Cr 93.8/92.2; Cu 94.7/95.0; Fe 92.1/91.8; Hg 95.7/95.3; Mn 95.6/95.4; Pb 102.0/100.5, and Zn 93.1/92.4.

Data were analyzed according to the parameters recommended in the Decree 518/2004 of the Brazilian Health Ministry (Brazilian Health Ministry 2004) and the values regulated by the World Health Organization (WHO) in its Guidelines for Drinking-Water Quality (WHO 2006). For statistical analysis of the results, the Statistical Program Graph Pad Prism (Version 3.02 for Windows, Graph Pad Software, San Diego, CA, USA) was used. The Mann–Whitney U-test, the Kruskal–Wallis non-parametric test, and the Dunn's test for multiple comparisons were used. The level of significance was set at $p < 0.05$.

**Table 1** Concentrations (mg/L) of a number of metals in water samples collected from retirement homes and houses at Ribeirão Preto, São Paulo, Brazil

| | Al | Cd | Cu | Cr | Fe | Hg | Mn | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|
| Retirement homes | | | | | | | | | |
| Mean | 0.186 | 0.00004 | 0.009 | 0.0012 | 0.008 | – | 0.0006 | – | 0.035 |
| SD | 0.378 | 0.00002 | 0.006 | 0.0019 | 0.010 | – | 0.0008 | – | 0.080 |
| Minimum | 0.005 | 0.00002 | 0.001 | 0.0002 | 0.002 | <0.0001 | 0.0001 | <0.001 | 0.007 |
| Maximum | 1.467 | 0.00014 | 0.028 | 0.0035 | 0.040 | 0.0010 | 0.0025 | <0.001 | 0.400 |
| Elderly people's houses | | | | | | | | | |
| Mean | 0.295 | 0.00004 | 0.020 | 0.0016 | 0.031 | – | 0.0006 | – | 0.065 |
| SD | 0.638 | 0.00002 | 0.019 | 0.0008 | 0.025 | – | 0.0004 | – | 0.092 |
| Minimum | 0.004 | 0.00003 | 0.004 | 0.0003 | 0.012 | <0.0001 | 0.0002 | <0.001 | 0.016 |
| Maximum | 2.672 | 0.00350 | 0.062 | 0.0031 | 0.092 | 0.0017 | 0.0018 | <0.001 | 0.389 |
| Maximum recommended parameters | | | | | | | | | |
| BHM[a] | 0.2 | 0.005 | 2 | 0.05 | 0.3 | 0.001 | 0.1 | 0.01 | 5 |
| WHO[b] | 0.2 | 0.003 | 2 | 0.05 | 0.3 | 0.001 | 0.1 | 0.01 | 3 |

[a] Decree 518/2004 of the Brazilian health ministry (Brazilian Health Ministry 2004)

[b] Guidelines for drinking-water quality world health organization (WHO 2006)

## Results and Discussion

The current metal concentrations analyzed in water samples collected in houses and retirement homes in Ribeirão Preto are summarized in Table 1. Aluminum, Cd, Cr, Cu, Mn, Pb and Zn were detected in 100% of the analyzed samples, while Fe and Hg were detected in 68% and 58% of the samples, respectively. The mean pH value was 6.5 ± 0.52, and the mean temperature 27.8 ± 1.9°C. All collected water samples tended towards neutrality. This is an important issue, as waters with low pH levels can contribute to the complexation of metals, generating an increase in metal levels in water.

According to the Decree 518/2004 and WHO guidelines, the analyzed Al concentrations exceeded the maximum values allowed (0.2 mg/L) in 26% of the samples belonging to 11 sampling points distributed across different neighborhoods of the city (Fig. 1). Aluminum concentrations in samples collected from houses did not show significant differences with those obtained in samples collected in retirement homes ($p > 0.05$). Aluminum was the only metal exceeding the maximum levels allowed by municipal standards. In order to check the potential existence of spatial differences in Al concentrations in the city, Al levels were grouped according to three regions of Ribeirão Preto defined as Central/West, North, and South

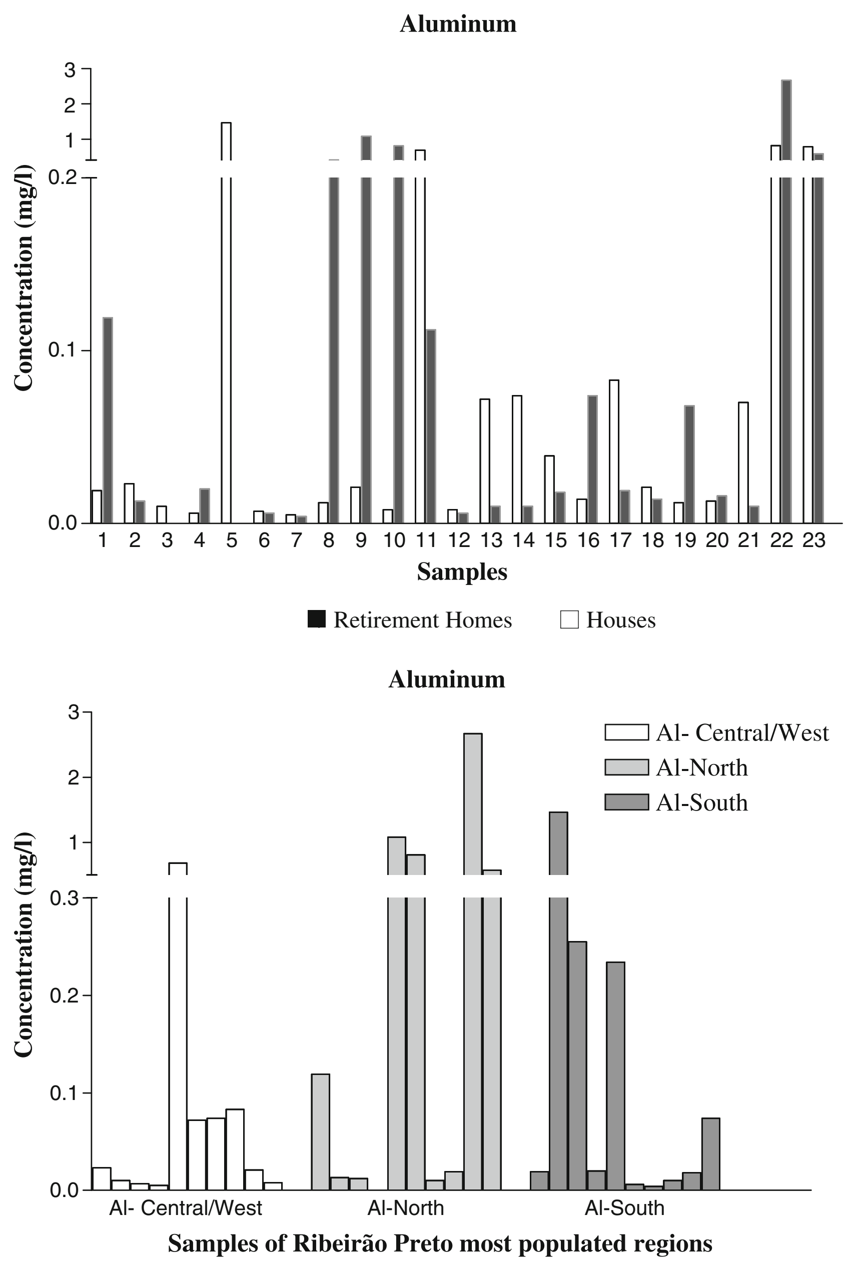


**Fig. 1** Aluminum concentrations in drinking water samples collected in retirement homes and houses and grouped according to regions in Ribeirão Preto, São Paulo, Brazil

(Fig. 1). No significant differences in Al concentrations for the regions established in this study were found.

In recent decades, a number of studies have involved Al as a potential etiological agent in Alzheimer's disease (AD). In accordance with scientific evidence, it has been shown that Al plays a role in different neurophysiological processes responsible for neuronal degeneration, which is characteristic of AD (Ferreira et al. 2008; Rodella et al. 2008). In the present study, it was noted that 11% of elderly living at monitored houses, and 19% living at retirement houses presented diagnostic of AD. Other psychiatric disorders were also observed in the records of the retirement homes.

In recent years, human Al exposure has notably increased due to its numerous industrial uses (pans, anti-acid medicines, milk and juice packs, deodorants, antiperspirants, dental prosthesis, among others). Thus, the residues generated and disposed in open air landfills and toilets can already start to favor a greater potential of soil contamination by this element. The concentration of heavy metals, including Al, present in soils can suffer percolation processes or infiltrations in its different layers, reaching the freatic water layer, and subsequently, contaminating subterranean waters (Segura-Muñoz et al. 2003). Water supplies in Ribeirão Preto come from the Guarani aquifer, with 100% of the city receiving subterranean water. Although the Guarani aquifer system is considered free of metal contamination, it is being monitored taking into account the permanent risk of metal infiltrations (Hirata et al. 2007).

The current Cd and Pb concentrations were below standardized levels. Cadmium and Pb concentrations in water samples collected from houses and retirement homes did not show significant differences among the sampling points. In turn, Cu, Fe and Mn levels remained below the limit established by the two standards here used. It was found that Cu, Fe, Mn and Zn concentrations in samples collected from houses were significantly higher than in those from retirement homes ($p < 0.05$). Chromium and Hg concentrations in water remained below the maximum values allowed. No significant differences in Cr and Hg levels were noted in samples collected from houses and retirement homes. Mercury was only detected in 58% of the samples, all showing concentrations below standardized values.

Exposure to metals is a real event, which can cause irreparable damage mainly in the elderly, who have a deficient immunological system. The results of the current study show Al concentrations above recommended values in 28% of the collected samples. It increases the possibility that elderly people may develop neurological diseases due to this higher exposure level. According to the current assessment, although the water in Ribeirão Preto is appropriate for consumption, Al concentration is high in some regions with a general average level of 0.218 mg/L.

In summary, we recommend that exposure to metals (especially focused on Al) through water consumption should be included in the agenda of public entities. It must cover aspects aimed at reducing elderly people's exposure to these elements, with a comprehensive assessment of possible problems for the health of this important group of population. The continuous monitoring of metals in drinking/tap water is an extremely important measure to assess the risk of exposure to these elements by vulnerable population groups such as the elderly.

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