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Regulations for calcium, magnesium or hardness in drinking water in the European Union member states

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ABSTRACT

Very low or very high concentrations of calcium (Ca) and magnesium (Mg) or total hardness in drinking water have been empirically recognized as the cause of the problems with corrosion, scaling, or taste of water. A large body of scientific evidence over the last 60 years has also attributed health problems to both extremes of these minerals in water. For example, drinking water low in Mg significantly increases the likelihood of cardiovascular mortality. This knowledge is not properly considered in the drinking water quality regulations, especially as more and more water is now produced by desalination disturbing its natural mineral composition. Although the current EU Drinking Water Directive does not include limits for hardness, Ca or Mg, most member states regulate these parameters either through law (12 countries) or technical guidance (7 countries), and several countries have issued educational information for the public. However, the regulations in most countries are not based on current research and not comparable because some provide a recommended range while others provide mandatory minimum or maximum limit values. This summary of the situation in 28 European Union countries is intended to provide information that can contribute to the implementation of the revised EU Directive.

1. Introduction

Drinking water is not and cannot be pure H_2O like distilled or osmotic water. The presence of certain amounts of total dissolved solids (TDS) and some essential elements are needed not only to prevent pipe corrosion and ensure an acceptable taste but also to prevent subacute and chronic adverse health effects from the long-term consumption of water (Rosborg and Kozisek, 2020). Thus, the focus on current microbiological and toxicological limits is inadequate and should be extended to include certain minerals.

Subacute health effects, which may appear within weeks to months after starting regular consumption of distilled or demineralized water, comprise signs of profound deficiency of calcium, magnesium or sodium: extreme fatigue, malaise, nausea, headache, brittleness of nails and hairs, leg and abdominal cramps, preeclampsia, twitch, metabolic acidosis, cardiovascular disorders (arrhythmia), or higher diuresis (Kozisek, 2005). These symptoms are mostly independent of the nutritional status of ill person.

Epidemiologic studies completed in different countries by different teams of researchers since 1960 have consistently reported chronic health effects of naturally occurring low mineral water or artificially softened water (specifically water low in magnesium (Mg), calcium (Ca) or bicarbonates). The most comprehensive review of about two thousand papers, including more than 100 studies with primary data, was ordered by the Drinking Water Inspectorate (England and Wales) and completed by the University of East Anglia in Norwich in 2005 (UoEA and DWI, 2005). A meta-analysis of 14 analytical observational studies (i.e. the most valid epidemiological studies) that investigated the association between cardiovascular disease and drinking water hardness found convincing evidence of the protective role of Mg in drinking water. The pooled odds ratio showed a statistically significant inverse association between Mg and cardiovascular mortality (OR 0.75; 95%CI 0.68, 0.82; $p = 0.001$). The highest exposure category (people consuming drinking water with Mg content of 8.3–19.4 mg/l) was significantly associated with a decreased likelihood of cardiovascular mortality by 25% compared with people consuming water with Mg content of 2.5–8.2 mg/l (Catling et al., 2008). Two recent and independent meta-analyses that considered several more recent studies (Jiang et al., 2016; Gianfredi et al., 2017) reported similar results. Gianfredi et al. also found a statistically significant protective effect of water calcium on cardiovascular diseases. The current position of the World Health Organization (WHO, 2011, 2017a) is that the strength of evidence is insufficient to propose guidelines for Ca, Mg or water hardness. However, in another WHO publication on the public health significance of Ca and Mg, Calderon and Hunter (2009) concluded *"There is a growing consensus among epidemiologists that the*

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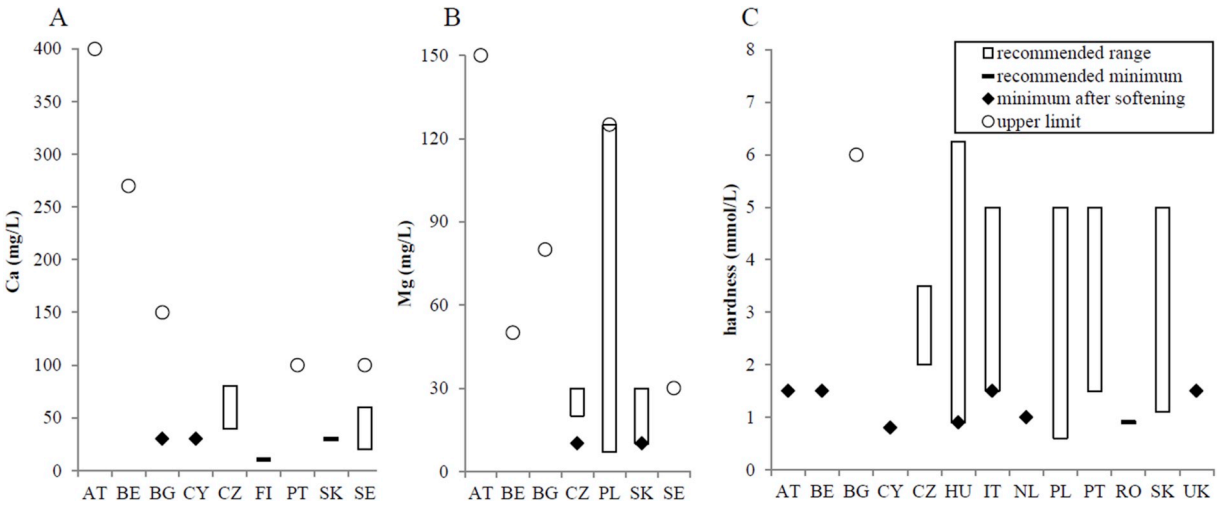

Fig. 1. Comparisons of limit values or recommended ranges for drinking water calcium (A), magnesium (B) and hardness (C) in different EU member states. Data include both legal regulations and technical guidelines.

Disclaimer

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Declaration of competing interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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