

# Soft Water = Increased CVD Risk = *Poor Science!*

By Susan R. Feldman

For decades, nutritionists have been researching and reporting findings that the nutritional sources of the elements, calcium and magnesium, are the foods we eat. Surprisingly, the World Health Organization (WHO), along with International Life Sciences Institute (ILSI), will be examining the hypothesis that hard water—water containing the hardness minerals of calcium and magnesium—is a necessary source of nutrition for these two elements.

## Water hardness

Hardness refers to the amount of dissolved calcium or magnesium salts present in water. Usually, these are present as soluble salts of bicarbonate, chloride, sulfate and nitrate. The more dissolved substances present, the harder the water. While rainwater is very low in material content and contains no minerals attributed to hardness, it does contain total dissolved solids (TDS). A steady rain will have a TDS of about five ppm. Once the rainwater soaks into the ground, it begins to dissolve some hardness minerals and these minerals (calcium and magnesium) end up in underground water aquifers. Table 1 illustrates the classifications of various degrees of hard and soft water.<sup>1</sup>

Calcium carbonate is naturally present in soil, limestone deposits and caves and is the source of calcium deposits in water lines, coffee pots, scale in sinks and when mixed with soap or detergent, imparts a grey cast to laundered clothing and leaves rings on bathtubs. The result is not solely a matter of aesthetics, for these deposits can cause diminished water flow in piping as well, a costly fix for the hapless homeowner.

Hard and soft water areas are found

all over the world. There are many cities in the U.S. that have either soft or hard water. Table 2 illustrates a sampling of each type.

Many communities soften their municipal water, while others obtain it naturally. Before we draw conclusions as to what kind of health impact these communities experience with regard to the water they are exposed to and most likely drink, let us examine what we know about the functions of the elements, calcium and magnesium, in the human body.

**Table 1. Hard versus soft water**

Grains per gallon	Hardness
Less than 1	Soft
1 to 3.5	Slightly
3.5 to 7.0	Moderately hard
7.0 to 10.5	Hard
Greater than 10.5	Very hard water

## Calcium

Calcium (Ca) accounts for about one to two percent of adult human body weight, with over 99 percent of total body calcium being found in the teeth and bones. The remaining one percent of that amount is present in the blood, fluids, muscle and other body tissue. It is this one percent of body calcium that participates with the bone mineral calcium during formation and resorption.

Calcium's role in the body includes the mediation of vascular contractions and vasodilation. Calcium also plays an important role in muscle contraction, nerve

transmission and glandular secretion.<sup>2</sup> As a part of the bone mineral, hydroxyapatite,  $3\text{Ca}_3 \cdot (\text{PO}_4)_2 \text{Ca}(\text{OH})_2$  calcium makes up 40 percent of bone weight. Bone is dynamic tissue and constantly undergoes osteoclastic (bone resorption) and osteoblastic (bone formation) equilibria. In children, the rate is highest with bone formation exceeding bone resorption. In the elderly, formation lags behind resorption. We normally see a balance between the two in most adults. Childhood fractures heal quickly, while the bones in the aged break more easily. Yet the massive *Womens' Health Initiative* study of 36,282 postmenopausal women found no association between dietary intake of calcium and hip fracture incidence.<sup>4</sup>

## Nutritional importance of calcium

Most people are familiar with the fact that milk and milk products provide rich sources of calcium in the diet, but there are other good sources of calcium as well. Table 3 lists some excellent sources and their calcium content, while Table 4 lists some foods that contain high levels of calcium that are not well ab-

**Table 2. Examples of U.S. cities with hard/soft water**

Soft water	Hard water
Detroit, Mich.	Santa Ana, Calif.
New York, N.Y.	Cincinnati, Ohio
Boston, Mass.	Jacksonville, Fla.
Atlanta, Ga.	Indianapolis, Ind.
Seattle/Tacoma, Wash.	Phoenix/Scottsdale/Mesa, Ariz.
San Francisco, Calif.	Las Vegas, Nev.
Montgomery, Ala.	Salt Lake City, Utah
Sacramento, Calif.	Oklahoma City, Okla.
Savannah, Ga.	Los Angeles, Calif.

sorbed due to their oxalate content.

National Institutes of Health (NIH) recommends the calcium daily intake for men and women over 65 to be 1,500mg.<sup>4</sup> Currently, adults obtain the majority of their calcium intake from foods, both non-fortified and calcium-fortified and from calcium supplements.<sup>5</sup> For infants (up to six months of age), optimal calcium intake is estimated to be 400 mg/day and 600 mg/day for infants 6-12 months. The intake increases to 800 mg/day in young children (ages one to five years) and 800-1,200 mg/day for older children (6-10 years); 1,200-1,500 mg/day for adolescents and young adults (11-24 years); 1,000 mg/day for women between 25-50 years and 1,200-1,500 mg/day for pregnant or lactating women. Scientists believe that calcium intake below 2,000 mg/day is considered safe in most individuals. Recommended daily intake for men is 1,000 mg/day (25-65 years). But it must be noted again that the extensive *Women's Health Initiative* study of 36,282 older women found no association of dietary calcium and hip fracture incidence.<sup>6</sup>

Optimal calcium absorption requires adequate vitamin D in the diet. In addition to these guidelines, drugs, hormone and genetic factors (as well as age) influence the amount of calcium required for optimal skeletal health. NIH stated in 1994 that the preferred source of calcium is through calcium-rich food.

## Magnesium

Total body magnesium (Mg) is approximately 25 g. About 12.5-15 g resides in bone in normal adults. One third of skeletal magnesium is exchangeable. Functionally, magnesium serves as a reservoir to maintain normal extracellular magnesium concentration, which is about one percent of total body Mg, while normal serum magnesium is 0.75-0.95 mmol/L. Magnesium functions as a cofactor in over 300 separate enzyme systems. The element is required for both anaerobic and aerobic energy generation in the body, and required for the following body reactions: glycolysis, oxidative phosphorylation in the mitochondria and phosphate transfer reactions when chelated in MgATP and Mg ADP. Magnesium influx is linked to sodium

and bicarbonate transport and is necessary for sodium and potassium ATPase activity. Mg regulates outward potassium movement in myocardial cells, which is one reason it is known as nature's physiological calcium channel blocker.

The arrhythmogenic effect of Mg deficiency may be related to magnesium's role in maintaining intracellular potassium. During Mg depletion, intracellular calcium rises. Magnesium acts as gating for the Ca channels. In Mg depletion, one may experience muscle cramps, hypertension, coronary and cerebral vasospasms and is found in many diseases relating to cardiovascular and neuromuscular function, diabetes mellitus, renal wasting syndromes and in alcoholism.

Magnesium is the most important inorganic element in the production of food and fossil fuels. It forms the center of the chlorophyll molecule. Its absorption in the body is inversely proportional to ingestion.<sup>7</sup> For example, in healthy older men, 380 mg intake resulted in a net absorption of 40-60 percent. With a constant diet, Mg absorption was 50-60

percent for various foods. Net absorption dropped to 15-36 percent at higher magnesium intakes.

Magnesium intake decreased by half from 1950 to 2000 in the general population. Researchers attribute this decline to food processing and to acid rain depleting the soils of magnesium in exchange for aluminum combined with intensive farming.

## Causes of Mg deficiency

There are several conditions that can impact how much magnesium is absorbed by the body. Some can result in magnesium deficiency. Reduced dietary intake and poor gastrointestinal absorption, caused by diarrhea, vomiting or laxative use, are examples of such conditions. Increased renal losses as a result of congenital or acquired tubular defects, diabetes mellitus, alcoholism or even drug-induced conditions can cause a magnesium deficiency. Other known causes include excessive sweating and increased magnesium requirements, such as growth spurts or even pregnancy, which can impact the balance of magnesium in the body.

## Magnesium-rich foods

It is not difficult to find adequate sources of magnesium in a varied diet. Table 5 illustrates some excellent sources thereof. Magnesium is also found in foods such as avocado, barley, oysters, chocolate, sunflower seeds, buckwheat, quinoa (a grain) and almonds.

The U.S. Dept. of Agriculture lists the mean magnesium intakes as 323 mg/day for males over nine years of age and 228 mg/day for females over nine years of age. After age 70, for both sexes, the intake is decreased. Magnesium is ubiquitous in foods, but the content varies substantially. Chlorophyll is the magnesium chelate of porphyrin, the compound found in green leafy vegetables that give them their color. Refined foods have lower magnesium levels than less processed foods. Present day diets that are high in refined foods are suspect of being magnesium deficient, low in fiber and low in iodine. All three are essential for good health.

There is no routinely accepted mainstream test available to measure or accurately assess

**Table 3. Calcium-rich food items**

Food Item	Serving (oz.)	Ca content (mg)
Milkshake	1 cup (8 oz.)	415
Pizza, cheese	1/8 of 10 inch pizza	362
Low fat yogurt	1 cup	330
Sardines, canned	1/2 cup (3 1/2 oz.)	314
Skim milk	1 cup	302
Whole milk	1 cup	291
Swiss cheese	1 slice (1 oz.)	272
Salmon	1/2 cup	196-259
Ricotta	1 oz.	257
Soft serve ice milk	1 cup	236
Provolone	1 oz.	214
Broccoli, cooked	2 large stalks	176
Tomato soup/milk	1 cup	159
Mustard greens, cooked	1/2 cup	138
Cottage cheese, creamed	1 cup	136
Tofu	2 oz.	73
Flour tortillas	1 ea.	46
Corn tortillas	1 ea.	42

**Table 4. Foods containing both calcium and oxalate**

Food item	Serving size	Ca Content (mg)
Cocoa, mixed with milk	1 cup	298
Collard greens, cooked	1/2 cup	152
Turnip greens, cooked	1/2 cup	138
Spinach, cooked	1/2 cup	107
Beet greens, cooked	1/2 cup	99
Okra, cooked	8-9 pods	92
Kale, cooked	1/2 cup	89
Green beans	1/2 cup	31

a person's individual nutritional requirement for calcium or magnesium. In fact, just measuring the amount of magnesium in the body is a complex assessment. Older methods, such as serum magnesium, are now criticized as inaccurate. Only 0.3 percent of total body Mg is found in blood serum. Red blood cells have three times the magnesium level of serum alone. Urine Mg levels estimate the body throughput, but do not represent total body Mg. Serum Mg, however, is the most often quoted in the literature.

There is a magnesium retention test, which involves a 24-hr. baseline followed by a parental load of administered magnesium. One then measures how much magnesium is excreted into the urine over another 24-hr. period. Excretion greater than 60-79 percent magnesium suggests that Mg depletion is unlikely. However, there is no standardized testing method and it only quantifies the major exchangeable pool of magnesium. The newest method uses an ion selective electrode to measure the ionized Mg in serum, blood or plasma. Nuclear magnetic resonance has also been used as an assay method.

As was noted earlier, the net absorption of magnesium in a typical diet is 50 percent. Also, high levels of dietary fiber decrease magnesium absorption due to bioavailability<sup>8</sup> (see Table 6). Interestingly, the dietary level of calcium has no effect on magnesium absorption rates.

### Cardiovascular disease and magnesium

When we review the literature on the topic of cardiovascular disease (CVD) and magnesium, we find many epidemiological studies in which some declare that areas with hard water tend to have lower cardiovascular death rates. Epidemiologic studies look at the significance of data trends within a given population and try to determine statistical significance from them. In addition, problems have been identified in evaluating some of the studies.<sup>9</sup> Other studies have not found such an association involving hard water and lower CVD rates.<sup>10</sup> What are lacking are controlled human intervention

studies that support the relationship. A daily recommended intake (DRI) study indicates that only evidence from controlled diet experiments would provide substantiated information on Mg levels of food, water, supplements, etc. and the bioavailability of each may differ. Balance studies must be well designed, using no self-selected diets. Studies that are not carried out in a metabolic unit under close medical/nutritional supervision usually lack data on magnesium intake

from water and their sources. This omission precludes the use of many early studies, which were conducted in uncontrolled or free-living environments and also studies that calculated the data rather than actually analyzing them.

### Osteoporosis and magnesium

Hydroxyapatite crystal formation and ultimate growth is affected by the body's magnesium level.<sup>11</sup> A low magnesium level will yield a low bone mineral index (BMI). Supplementation with magnesium of post-menopausal women increased their BMI within one year. The amounts were 500 mg. magnesium and 600 mg. calcium with estrogen replacement therapy and daily multivitamins, resulting in increased calcineous bone mass density in less than one year. These observations suggest that dietary magnesium may be related to osteoporosis and indicate a need for further investigation of the role magnesium plays in bone metabolism.<sup>12</sup>

### Why are magnesium research values suspect?

Besides having uncontrolled and variable sources of magnesium intake, food and water storage affect the amount of magnesium that is viable when ingested. Most research data does not include the magnesium value of water, partly because magnesium levels in water are lumped into hardness values that are expressed as total calcium carbonate.

In addition, mobile cultures cannot depend upon consistent magnesium levels, especially when coupled with food sources. Since bioavailability depends upon amount, increasing the magnesium level in water may deplete the amount absorbed from food sources.

For the most part, calcium retention in bone is under strong homeostatic control that is regulated by genetics, hormones and weight-bearing exercise. There is a point at which added calcium in the diet does not significantly increase calcium retention. This point is known as the plateau intake.<sup>13</sup> Older adults will continue to lose calcium despite high intakes due to other causes, such as estrogen levels, smoking and sedentary lifestyles. Currently, there are no consistent as-

**Table 5. Magnesium-rich food items**

Food item	Serving (oz.)	Mg (mg)
Peanuts, raw/roasted	½ cup	123/131
Tofu, raw	¼cup	127
Broccoli, cooked	2 large stalks	120
Spinach, cooked	¼cup	79
Chard, Swiss, cooked	¼cup	76
Soybeans, cooked	¼cup	74
Tomato paste, canned	¼cup	67
White beans, cooked	¼cup	57
Sweet potato, canned	¼cup	61
Black beans, cooked	¼cup	60
Sorrel, cooked	¼cup	60
Nuts, seeds, all types	1 oz.	9-152 (60 avg.)
Pumpkin seeds	1 oz.	152
Chili with beans, canned	¼cup	58
Peanut butter	2 tbsp.	51
Succotash, cooked	¼cup	51
Beet greens, cooked	¼cup	49
Lima beans, all	¼cup	41-49
Milk, all types	1 cup	28-40 (35 avg.)

**Table 6. Factors affecting Mg requirement**

Magnesium requirement	Positive Mg balance	Negative Mg balance
Men, 355 g/day	Low fiber: 9 g/day	High fiber: 59 g/day
Young women, 243-252 g/day	Low fiber: 23 g/day	High fiber: 39 g/day

**Table 7. Dietary intake of magnesium, mg/day median (min.-max.)**

Source	West, n = 105		East, n = 102	
	Mg, mg/day, total intake	250 (67-725)	221 (74-703)	
Local water	2.5	(0.3-4)	3.8	(0-24)
Milk & cheese	61.7	(0-263)	54.7	(1-460)
Mineral water	3.0	(0-33)	2.0	(0-21)
Vegetables	13.3	(2-68)	12.8	(0.49)
Potatoes	16	(0-140)	16	(1-140)
Breads, cereals	70.4	(7-258)	68.8	(8-221)
Chocolate	8.6	(0-429)	2.8	(0-186)
Fruit, berries	11.4	(0-74)	11.5	(0-51)
Wine, beer	1.0	(0-23)	4.0	(0-39)
Meat, fish	14.0	(0-40)	17.9	(3-64)

sociations between calcium intake over a 10-year period and the risk of fracture in peri- and postmenopausal women. This is not surprising when one considers the complex factors of genetics, diet, environment and long latency period which are interrelated in osteoporosis.

A 2003 observational study in Sweden<sup>14</sup> examined the influence of Ca and Mg in drinking water and diet on CVD risk factors in individuals living in hard and soft water areas with differences in cardiovascular mortality. In Tables 7 and 8, the sources of magnesium and calcium are provided. While we need to keep in mind that correlation is not causation, this study showed a positive correlation between calcium content in household water and systolic blood pressure and negative correlations with calcium content and s-cholesterol and s-LDL-cholesterol. No correlation was seen with magnesium content in household water to any risk factors. The study was unable to conclude a definite causal relationship and urged the need for more research on the issue.

The magnesium and calcium amounts in drinking water are small in relation to dietary requirements and intake from food. Are they more bioavailable from water than from food? This bioavailability needs to be determined.

### World Health Organization Symposium (WHO)

So where does that leave us? WHO, along with ILSI and the National Sanitation Foundation (NSF), is holding an International Symposium on Health Aspects of Calcium and Magnesium in Drinking Water, April 24-26, 2006 in Baltimore, Md., to review the current status of research on this topic. The program outline is available on the ILSI website at <http://www.ilsf.org/Events/>. A special website has been created for the Symposium, <http://www.camgwater.org> which has schedules, registration forms and complete information.

WHO opined that the epidemiology points to a lower risk of certain types of CVD for populations that consume hard water containing calcium and magnesium, with magnesium being the point of most interest. All the evidence on this question to date has been observational and most of it from small studies of varying type and quality. The science is clear

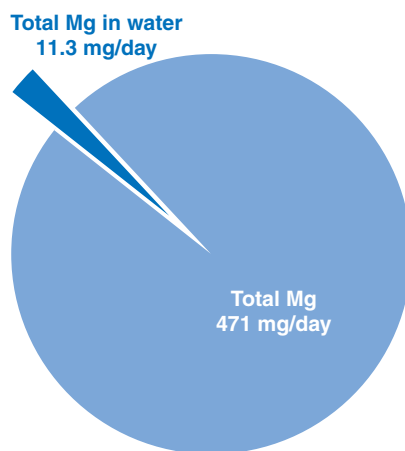
**Table 8. Dietary intake of calcium, mg/day median (min.-max.)**

Source	West, n = 105		East, n = 102	
	Ca, mg/day, total intake	(min.-max.)	Ca, mg/day, total intake	(min.-max.)
Local water	10	(0-126)	45.2	(0-297)
Milk & cheese	700	(0-2573)	610	(21-4306)
Mineral water	15	(0-171)	11	(0-129)
Vegetables	25	(4-123)	27	(0-128)
Potatoes	5	(0-40)	3	(0-40)
Breads, cereals	81	(7-246)	67	(10-221)
Chocolate	57	(0-2857)	13	(0-1142)
Fruit, berries	25	(0-119)	17	(0-128)
Wine, beer	2	(0-38)	11	(0-54)
Meat, fish	12	(0-53)	14	(3-41)

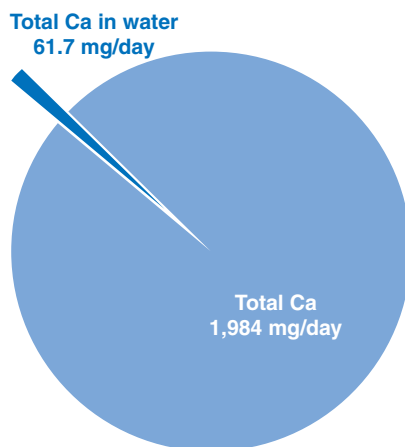
on one point: consensus recommendations are higher than current intakes.

Still, assembling experts and polling them, as the agenda for the Baltimore symposium appears to indicate is the plan, can only yield poor conclusions in the hierarchy of evidence-based science. If it adheres to standards of evidence-based medicine, the best the Symposium

**Figure 1. Median magnesium intake versus total median water intake**



**Figure 2. Median calcium intake versus total median water intake**



can do is find agreement on the need for a controlled trial and identify the questions that should guide it.

It is worrisome that WHO seems poised like a runner at the gate to pursue a strategy that smacks of 'ready, shoot, aim.' They admit they need more scientific evidence, then how they can they already draw such conclusions?

In April, the Codex Alimentarius Commission is scheduled to meet in Geneva, Switzerland to review water as a nutritional

source. Then, later this year, WHO has announced its intent to produce a *Guidance on Health and the Environmental Aspects of Desalination Processes*. The 4th edition of *Guidelines of Drinking Water Quality* is due to be printed in 2008. Proposals include the addition of calcium and magnesium to bottled water and possibly municipal waters to exceed an arbitrary calcium and magnesium lower limit. There will be no time for further research to inform the writers of these documents, yet by announcing the schedule, WHO has put enormous pressure on itself to act even if its only basis is scientifically inadequate.

Already, proposals are being considered that require calcium or magnesium fortification of bottled water. Possibly, if the rumblings we hear in the industry prove correct, there are plans to require municipal drinking water to meet or exceed minimum concentrations of calcium and magnesium.

Where is the science? Where is the evidence? What proves any of this will be beneficial, particularly in light of the facts regarding the nature of magnesium bioavailability? We lack any intervention data examining the health effects of fortifying drinking water, especially for high-risk individuals.

Although informed that scientific evidence is lacking, WHO reviewed relevant studies (published since 1979) and concluded, "there is little evidence that supports an association between water hardness or calcium concentration in deionized water and cardiovascular disease. However, the available information from experimental, clinical and epidemiological studies supports the hypothesis that lower-than-recommended intake of magnesium is a condition that increases the risk of dying from and possibly developing CVD, stroke or hypertension."

It must also be pointed out that many hard water supplies do not contain significant amounts of magnesium.

As part of the intervention trial, we should also question the assumption that the health effect comes from calcium and/or magnesium. A paper called, *Mineral elements related to cardiovascular health* addresses the question: hardness, good or softness, bad? There is the possibility that other beneficial trace elements frequently present in hard water may be responsible for the phenomenon. A recent Finnish study suggests that iron and copper in drinking water may be associated with increased risks of heart attack. It is apparent that there is a need for much good research to be done before a conclusion affecting global drinking water is reached.

The readers of this publication have a vested interest in the outcome of the symposium and should find the topic interesting from many standpoints. As an industry we should make our voices heard before any guidelines or mandates are written in stone, we need to demand that more scientific research is performed and completed.

## References

1. Harrison, Joseph F., P.E., *Water Treatment Fundamentals*, 7th ed., Water Quality Association, 2001.
2. Morris, Christopher, ed., *Academic Press Dictionary of Science and Technology*, Academic Press, 1992.
3. Women's Health Initiative, *NEJM*, February 16, 2006.
4. *Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D and Fluoride*, National Academy of Sciences, 1992. <http://www.nap.edu/catalog/5776.html>.
5. National Institutes of Health, *JAMA*, 1994.
6. Women's Health Initiative, *Ibid*.
7. National Academies Press, "Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D and Fluoride", Kayne and Lee, 1993, <http://www.mgwater.com/exhibitk.shtml>.
8. National Academies Press, *Ibid*, Siener and Hesse, 1995.
9. Comstock, G., "Water hardness and cardiovascular diseases," *Amer. J Epidemiol.* 1979, 110(4): 375-400.
10. Hammer and Heyden, 1980, <http://www.mgwater.com/exhibitk.shtml>.
11. National Academies Press, *Op. cit.*, Cohen, 1988.
12. *Ibid*, Sojka and Weaver, 1995.
13. *Ibid*, Matkovic & Heaney, 1992.
14. C. Nerbrand et al., "The influence of cal-

cium and magnesium in drinking water and diet on cardiovascular risk factors in individuals living in hard and soft water areas..." *BMC Public Health* 2003, 3:21.

## Additional bibliography

1. Fransson GB et al., *Acta Paediatr Scand.* 1984 Jul;73(4):471-6.
2. T. Crawford et al., *The Lancet*, 4 February, 1967.
3. U. of AZ Cooperative Extension, Calcium & Calorie Content of Selected Foods.
4. Watering Your Heart: How a Little Mg May Help. <http://www.wholehealthmd.com/news/>
5. J. Dorea, "Magnesium in Human Milk", *J Amer. Coll. Nutr.* 19(2):210-970.
6. Magnesium Content of Foods, *Composition of Foods Agriculture Handbook No. 8*, USDA, 1975. <http://www.mgwater.com/content/shtml>
7. T. Frost, *Hardness Minerals and Drinking Water, WC&P*, October 2005.
8. International Symposium on Health Aspects of Calcium and Magnesium in Drinking Water, ILSI website: <http://www.camgwater.org/>
9. W. J. Fawcett et al., "Magnesium: physiology and pharmacology", *Brit. J. Anaesthesia* 83 (2): 302-20 (1999).
10. "Hardness in Drinking Water," background document for WHO *Guidelines for Drinking-water Quality*, 2nd ed., vol. 2, Geneva, 1996.

11. R. Rylander et al., "Magnesium and calcium in drinking water and cardiovascular mortality", *Scand J Work Environ Health*. 1991;17(2): 91-4.

12. C. Yang, "Calcium and Magnesium in Drinking Water and Risk of Death From Cerebrovascular Disease", *Stroke*. 1998; 29:411-414.

13. P. Kendall, "Drinking water quality and health", Colorado State University Cooperative Extension, <http://www.ext.colostate.edu/pubs/foodnut/09307.html>.

14. L. Fabrizi, "Health risks from drinking demineralized water", <http://www.lenntech.com/health-risks-demineralized-water.html>.

15. Marx, R. Neutra, "Magnesium in drinking water and ischemic heart disease", *Epidemiol Rev*. 1997;19(2):258-72.

16. Y. Miyake, M. Iki, "Ecologic study of water hardness and cerebrovascular mortality in Japan", *Arch Environ Health*. 2003 Mar;58(3): 163-6.

17. M. Zerbini et al., "Drinking water hardness and chronic degenerative diseases. II. Cardiovascular diseases.", *Ann Ig*. 2003; Jan-Feb;15(1):41-56.

18. E. Rubenowitz et al., "Magnesium in drinking water in relation to morbidity and mortality from acute myocardial infarction", *Epid*. 2000 Jul;11(4):416-21.

19. R. Maheswaran et al., "Magnesium in drinking water supplies and mortality from acute myocardial infarction in north west England", *Heart* 1999 Oct;82(4):455-460.

20. C. Yang et al., "Magnesium in drinking

water and the risk of death from diabetes mellitus", *Magnes Res* 1999 Jun;12(2):131-7.

21. E. Rubenowitz et al., "Magnesium and calcium in drinking water and death from acute myocardial infarction in women", *Epidemiol* 1999 Jan;10(1):31-6.

22. E. Rubenowitz et al., "Magnesium in drinking water and body magnesium status measured using an oral loading test", *Scand J Clin Lab Invest* 1998 Aug;58(5):423-8.

23. C. Yang, "Calcium and magnesium in drinking water and risk of death from cerebrovascular disease", *Stroke* 1998 Feb;29(2):411-4.

### **About the author**

G Susan R. Feldman is Technical Director of the Salt Institute, the world's foremost source of authoritative information about salt and its more than 14,000 uses. The Institute is a nonprofit association of salt producers and manufacturers, founded in 1914. Contact her at Salt Institute, 700 North Fairfax Street, Fairfax Plaza, Suite 600, Alexandria, Va. 22314-2040; office telephone (703) 549-4648; cell phone: (571) 218-8764; fax (703) 548-2194; email: [susan@saltinstitute.org](mailto:susan@saltinstitute.org) or visit [www.saltinstitute.org](http://www.saltinstitute.org).

**Author's note:** For the "Women's Health Initiative Study", see the *New England Journal of Medicine*, 2/16/06, *Calcium plus Vitamin D Supplementation and the Risk of Fractures*.