Survey of Bottled Drinking Water Available in Manitoba, Canada

Eva Pip

Department of Biology, University of Winnipeg, Winnipeg, Manitoba, Canada

Forty domestic and imported brands of bottled water were purchased in Manitoba, Canada and examined for total dissolved solids (TDS), chloride, sulfate, nitrate-nitrogen, cadmium, lead, copper, and radioactivity. The samples showed great variation in quality, and some exceeded the Canadian Water Quality Guidelines for drinking water for TDS, chloride, and lead. Carbonation, ozonation, and type of packaging were not differences in metal levels, although carbonated samples tended to show higher TDS values. A number of deficiencies were found with respect to product labeling. Key words: bottled water, cadmium, chloride, copper, lead, nitrate, radioactivity, sulfate, total dissolved solids. Environ Health Perspect 108:863-866 (2000). [Online 1 August 2000] http://ehpnet1.niehs.nih.gov/docs/2000/108p863-866pip/abstract.html

Annual consumption of bottled water in North America and Europe is substantial (1,2). Many consumers choose this alternative because they dislike the taste of chlorinated tapwater, or because they believe that bottled water contains fewer contaminants and is a healthier choice (2,3). In Manitoba, consumers may be concerned about heavy metals such as lead, trihalomethanes, or asbestos from asbestos-cement pipe in their municipal water supply or, in some cases, from packaging. The addition of algal toxins such as microcystin have been detected in numerous raw and treated waters in the province (4,5).

The bewildering array of brands offered for sale includes various domestic and imported spring and mineral waters, tapwaters treated by filtration, reverse osmosis, or distillation, and miscellaneous waters supplemented by the addition of specific salts. To compound the confusion, labeling is extremely variable. Label designs can feature attractive pictures of blue mountains or glaciers that may bear no relationship to the actual provenance of the water. Descriptions of the product often contain terms that imply purity, such as “glacial,” “alpine,” “natural,” “crystal,” “premium,” or “pure.” Unfortunately, definitions of terms differ in various jurisdictions and in the understanding of individual bottlers. The water source is not always identified, and in the understanding of individual bottlers, the term “premium,” or “pure” implies something different from the term “natural.”

Consumer awareness of the content of bottled water is low (5). Many consumers may be unaware of the presence of a wide variety of contaminants in the water they consume. The majority of consumers do not understand the labeling requirements of bottled water and are unable to choose water that contains levels of contaminants to their satisfaction (6). The Canadian government has not published any guidelines for the improvement of consumer awareness of the quality of bottled water (7).

Bottling and packaging can contribute a variety of inadvertent chemical contaminants. Materials used in filtering and processing may contribute asbestos (21). Organic compounds such as toluene, cyclohexane, dichloromethane, pentane, benzene, phthalate esters, and others with tumor-inducing properties may leach from plastic packaging, polystyrene cap liners, or unknown sources (22,23). Leaching of volatile and semivolatile organic compounds from packaging materials into the water has been shown to increase with length of storage time, temperature, and exposure to sunlight (23). Glass containers may present the risk of leaching lead into the water. Because bottled water is usually stored at room temperature (24), and many consumers may buy large quantities at a time for later use or stockpile it for emergencies, this elevates the risk for leaching.

In Canada, bottled water comes under the purview of the Canadian Food and Drugs Act and Regulations (25). Those regulations

Radioactivity is measured only rarely in bottled water, even though some natural springs can contain leached radionuclides (15) from radioactive minerals in rocks and soil. Measurable amounts of radium have been reported in a number of imported and domestic bottled waters in both the United States (15) and Australia (16). Canadian Water Quality Guidelines (CWQG) (17,18) have itemized some selected elements, with the recommendation that maximum additive conditions should be considered for different radionuclides that target the same organ or tissue.

Even when water quality is good at the source, it may deteriorate through subsequent handling, transportation, and storage. Growth of microorganisms may occur via agencies such as introduced flakes of human skin, particularly in nonozonated, noncarbonated waters (19). Warburton et al. (20) found that Pseudomonas and Salmonella could survive for longer than 100 days in bottled water, with the former having a synergistic effect on survival of the latter. Isolates from bottled water may be resistant to antibiotics (20).

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Address correspondence to E. Pip, University of Winnipeg, Winnipeg, Manitoba, Canada R3B 2E9. Telephone: (204) 774-9319 Fax: (204) 774-4134 E-mail: eva.pip@uwinnipeg.ca

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applicable to bottled water are currently under review.

The objective of the present study was to examine bottled waters available in Manitoba retail stores for total dissolved solids (TDS), chloride, sulfate, nitrate-nitrogen (nitrate-N), cadmium, lead, copper, and total radioactivity and to determine whether these parameters could be correlated with labeling, packaging, and disinfection qualities.

Methods
Forty brands of bottled water were purchased in urban and rural stores in southern Manitoba. We analyzed chloride, nitrate, and sulfate using methods recommended by the American Public Health Association (26).

Total dissolved solids were measured directly using a TDSText 1 (Oaktok, Wards Natural Science, St. Catharines, Ontario). Total radioactivity was measured for a 1-cm deep sample from a freshly opened bottle using the RM-60 Radiation Counter (Aware Electronics, Wilmington, DE) calibrated against cesium-137, with a window area of 65.6 mm² and a distance of 1 cm from the sample surface. The sample was not evaporated to avoid the loss of volatile radionuclides. We made three replicate counts of 1 min each for each sample. We made background counts using empty counting dishes.

We determined cadmium, copper, and lead using a PDV2000 digital anodic stripping voltameter (Chemtronics Ltd, Bentley, Australia). Three 5-mL aliquots were analyzed for each sample. We made three replicate counts of 1 min each for each sample. We made background counts using empty counting dishes.

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The label analysis is normally for the water at the source, but the source may vary in quality over time, or some parameters may change by the time the water reaches the consumer. However, in certain instances the sum of the listed parameters on the label exceeded the listed TDS value.

The amount of information presented on the labels varied greatly, from no analytical data at all to numerous inorganic parameters, and occasionally, parameters such as osmotic pressure and source temperature. Trace elements were often listed as 0 mg/L or 0 ppm, which provided little information when the analytical detection threshold is unknown and guidelines for these parameters are specified in micrograms or parts per billion. Furthermore, the information on the label, particularly for low-level substances such as metals, did not always reflect what was actually in the bottle at the time of purchase.

The TDS in surface waters in Manitoba has been found to range from 18 to 5,333 mg/L (29), whereas in Canadian drinking water it has been reported as 20–3,800 mg/L for surface and groundwater sources (17). Bottled waters in this study therefore showed a range of TDS that was similar to that of Canadian tapwater. However, the designation of “mineral water” was not always correctly applied, nor was this label always found on waters with high TDS. Even when appropriately labeled, mineral waters are invariably sold intermixed with other types of bottled water, and the consumer is generally not aware of the difference between them. In some cases health claims were made on labels of brands which exceeded the CWQG of one European mineral water with 570 mg/L TDS, purporting to contain a calcium concentration of 20% of the TDS, claimed to be beneficial as a diuretic and to assist in the elimination of uric acid.

The mean chloride value was 24 mg/L for bottled waters, decreased to 15 mg/L when the single high sample from Quebec was removed. Chloride levels in Canadian drinking water are generally <10 mg/L (17), and, therefore, from the standpoint of this parameter, bottled water offers little advantage. However, the mean sulfate concentration of 27 mg/L in bottled waters compared favorably with some Canadian drinking waters, which may range to 1,795 mg/L (17), although in Winnipeg tapwater sulfate is negligible.

Nitrate is highly variable in drinking water, but may reach concentrations in excess of 1,000 mg/L in some groundwaters and >100 mg/L in surface waters, although in the latter nitrate rarely exceeds 5 mg/L (17). In Manitoba, nitrate may be encountered in waters impacted by intensive livestock production, fertilizer application, or septic effluent, and some private water supplies subject to such contamination can approach or exceed the CWQG (30,31). However, public water supplies in the province do not exceed, but may approach, the CWQG of 10 mg/L nitrate-N (32). In the present study, all of the bottled waters (except for one French brand) contained <2 mg/L nitrate-N.

Lead levels exceeded the CWQG of 10 µg/L in three of the samples. As a comparison, the lead concentration in Canadian tapwater has been reported as 7.6 µg/L (17); although lead in Winnipeg tapwater may range from 2 to 450 µg/L, depending on the type of distribution pipe, amount of older high-lead solder in the plumbing system, and length of contact time (30,33).

Cadmium concentrations in some brands were higher than the maximum of 0.27 µg/L in Canadian distributed waters (17), although the maximum of 1.1 µg/L in the present study was the same as the maximum in Canadian raw waters (17). Differences in handling and type of packaging (e.g., cap liners, and cadmium-based stabilizers in plastics) may contribute to differences in metal concentrations among brands, while length and conditions of storage time may lead to differences among individual bottles. For example, in the present study, three different brands that purported to come from the same British Columbia source showed a 3- and 2-fold variation in the cadmium and the lead concentrations respectively.

The greatest difference between bottled and tapwaters was in copper. In Canadian tapwaters, copper levels are consistently high-er (17) than the maximum observed for bottled waters in this study, and concentrations as high as 1.59 mg/L have been reported in Winnipeg first-draw tapwater (33), primarily as a result of leaching from copper pipe. Although water softness and pH influence the leaching rate of metals (e.g., 33), the present study showed no measurable association between metal content and carbonation, even though carbonation may decrease the pH to <5. Similarly, no significant differences for metal concentrations were found for ozonation or TDS, nor for waters labeled as spring or mineral, agreeing with a previous study (35) that found differences only for fluoride, but not for lead, arsenic, or aluminum between spring or mineral waters.

Carbonation has antibacterial properties (35). Bottled waters with higher TDS and sulfate concentrations showed a significantly higher tendency to be carbonated to improve taste. The adverse effects of carbonated beverages on tooth enamel wear have been investigated (36), but other physiological effects of the consumption of large volumes of carbonated fluids have not been well documented. Pouderoux et al. (37) found that carbonated water did not affect gastric emptying compared to still water, although it did affect intragastric meal distribution.

In the present study, although overall regional differences in radioactivity were not notable, two domestic samples were significantly higher than the background. Excessive radium levels have been reported in some bottled waters available in Australia (16), and of 22 imported and U.S. brands contained measurable radium activity (15). It is apparent that this issue requires further investigation, particularly with regard to total radioactivity of samples, as more than one radionuclide may be present.

In conclusion, this study demonstrates the need for more stringent standardization of the bottled water market, particularly with regard to quality control, labeling, and monitoring, as well as further study of the effects of packaging materials and storage conditions on final product quality.

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