Comparison of the Microbiological Quality of Water Coolers and That of Municipal Water Systems

BENOÎT LÉVESQUE,1* PIERRE SIMARD,2 DENIS GAUVIN,1 SUZANNE GINGRAS,1 ÉRIC DEWAILLY,1 AND ROBERT LETARTE2

Service Santé et Environnement, Centre de Santé Publique de Québec, Ste-Foy, Québec, Canada G1V 2K8,1 and Département de Microbiologie, Faculté de Médecine, Université Laval, Ste-Foy, Québec, Canada G1K 7P42

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The microbiological quality of tap water and that of water from 50 water coolers located in residences and workplaces were comparatively studied. In addition, different factors that might influence the bacteriological contamination of water dispensers were examined. Aerobic and facultative anaerobic heterotrophic bacteria, total coliforms, and two indicators for fecal contamination (fecal coliforms and fecal streptococci) as well as three types of pathogenic bacteria (Staphylococcus aureus, Pseudomonas aeruginosa, and Aeromonas spp.) were enumerated. It was found that 36 and 28% of the water dispenser samples from the residences and the workplaces, respectively, were contaminated by at least one coliform or indicator bacterium and/or at least one pathogenic bacterium. The respective proportions of tap water samples contaminated in a similar fashion were 18 and 22%, much less than those observed for water coolers ($\chi^2 = 3.71, P = 0.05$). We were unable to discern the dominant factors responsible for the contamination of water coolers, but cleaning the water dispenser every 2 months seemed to limit the extent of contamination.

In North America, the market for bottled water is in full expansion. Its annual growth rate is estimated to be 25% (27). The consumption of spring water (mineral salts, <500 mg/liter) accounts for most of this increase. In the Canadian province of Québec, 900,000 persons out of a population of 6,800,000 now drink bottled water (18).

Spring water contains a natural microflora composed mainly of species of the genera Achromobacter, Flavobacterium, Alcaligenes, Acinetobacter, Cytophaga, Moraxella, and Pseudomonas (12, 24). Initial populations are small but can evolve rapidly during bottling and storage (26). In the absence of treatment (i.e., chlorination and ozonation), bacterial multiplication may occur for 1 to 3 weeks after bottling, and the bacterial count can reach $10^9$ to $10^4$ bacteria per ml at 37°C (10).

In addition to natural contamination, the product can also be altered before it reaches the consumer. Contamination can occur at any time during processing. In Wales, Hunter and Burge (11) found Staphylococcus epidermidis and Staphylococcus humanus in 6 of 52 bottles of water, which was attributed to poor hygiene.

In Canada, Warburton et al. (27) reviewed the results of tests of all bottled water samples collected by Health and Welfare Canada between 1981 and 1989 and concluded that 2 to 3% of the samples contained coliform bacteria. Furthermore, Sekla et al. (25) analyzed 60 bottles of water from retail stores and processing plants and found coagulase-positive Staphylococcus aureus in two samples, coliforms in four samples, and Enterococcus spp. in one sample.

The aim of these studies was to determine if contamination had occurred in the time between collection of the water at the spring and its processing for commercial use. Such studies, however, do not account for consumer behavior regarding the preservation of the product.

In the province of Québec, 30 to 50% of all complaints about bottled water received by the Ministry of Environment were related to water coolers (18). There are some 50,000 dispensers in public places and workplaces all over the province (18), and there are possibly as many more in private residences. To our knowledge, almost no data on the bacteriological quality of the water in these dispensers exist. Moreover, the lack of hygiene standards adds to the uncertainty surrounding health risks that could be related to the use of water coolers.

The purposes of our study were to evaluate the microbiological quality of spring water dispensed by water coolers in residences and workplaces in the Québec City region; compare the microbiological quality of this water with that of municipal tap water; and evaluate the importance of handling factors, such as cleanliness and storage time, to the microbiological quality of water coolers.

MATERIALS AND METHODS

Between 1 June and 1 August 1992, we selected and visited residences and workplaces located in two municipalities of the Québec City region chosen on the basis of their similar sizes, i.e., they had populations of around 60,000 inhabitants, and the fact that they are served by different municipal water systems. City 1 uses raw water of low quality which undergoes treatment, whereas city 2 obtains its water from a less contaminated source, and the water is only filtered and disinfected. Residences and workplaces were randomly selected from the phone book and from the list of enterprises of the Commission on Health and Security at the Work Place of the Province of Québec. A phone call was made to verify that a water cooler was in use. To be included in the study, owners of water dispensers had to have water supplied by a recognized company. We then selected 50 residences and 50 workplaces divided equally between the two municipalities.

Each site was inspected, and the results were documented. A questionnaire regarding the age of the water dispenser, the amount of water consumed, the frequency and method of cleaning, and related matters was filled out. Samples were taken from the water cooler and from the most-often-used

* Corresponding author. Mailing address: Service Santé et Environnement, Centre de Santé Publique de Québec, 2051, boul. René-Lévesque Ouest, Ste-Foy, Québec, Canada G1V 2K8. Phone: (418) 687-1090, ext. 296. Fax: (418) 681-5635.
faucet. To make sure that the samples were representative of the water consumed, we did not flush before sampling and there was no attempt to sterilize the outer surfaces of the faucets. In conjunction, water samples were collected for bacterial analysis from 20 18-liter bottles of spring water (representing the five most important bottling companies in the region) before installation of the bottles on water dispensers.

The samples were collected in sterile 1-liter plastic bottles containing 5 ml of a sterile sodium thiosulfate solution (1%). They were kept at 4°C and analyzed within 24 h in a laboratory accredited by the Quebec Ministry of Environment. Since infectious diseases could be spread through drinking water mainly by contamination with material of fecal origin (26), we quantified three indicators of fecal contamination (total coliforms [TC], fecal coliforms [FC], and fecal streptococci [FS]). We also assayed the water for aerobic and facultative anaerobic heterotrophic bacteria, an indicator frequently used to verify the microbiological quality of bottled water (26, 27).

Finally, we quantified microorganisms known to be opportunistic human pathogens (Pseudomonas aeruginosa, S. aureus, and Aeromonas spp.), recognizing the concern of the World Health Organization about P. aeruginosa in bottled water (20) and the ubiquitous presence of S. aureus (3, 14) and Aeromonas spp. (19) in the water environment.

The heterotrophic plate count (HPC) was determined by the pour plate method at 35°C for 48 h in accordance with the technique described by the American Public Health Association (1). TC, FC, FS, S. aureus, and P. aeruginosa were quantified by membrane filtration (1). Aeromonas spp. were filtered (0.45-μm pore size) from 1- and 100-ml water dispenser samples and 100-ml tap water samples. Each membrane with filtered cells was placed directly on phenol red agar supplemented with 1% soluble starch and 10 μg of ampicillin per ml as suggested by Palumbo et al. (21).

The results were divided into two classes according to their degrees of contamination. A sample of 100 ml was put in class A if it was contaminated by one of the pathogens or one of the following indicators: TC, FC, or FS. Class B was similar to class A except that the number of TC had to be 10 or more, the level considered unacceptable by the Quebec Ministry of Environment for drinking water derived from a municipal water system (17).

The data were sorted according to their origin (residence or workplace). Tap water and the water dispensers were compared by using the proportions of contaminated samples in classes A and B. The various factors that could influence the quality of the water dispensed by water coolers were also examined. Finally, residences and workplaces were compared for each contamination class. To verify the statistical significance of all these comparisons, we used the chi-square test except when the conditions for that test were not met. In that case, we used Fisher’s bilateral test (4).

**RESULTS**

The participation rates were 92% for the residences and 90% for the workplaces. The results of microbiological analyses performed on samples from the water coolers and tap water of each of the residences and workplaces appear in Table 1. Water dispensers and faucets are compared for each class of contamination in Table 2. The results of the HPCs for the water coolers, tap water, and the 20 bottle samples are presented in Table 3. It should be noted that none of these bottles was contaminated by either TC, FC, FS, or pathogenic bacteria.

<table>
<thead>
<tr>
<th>TABLE 1. Proportions of contaminated water coolers and faucets in residences and workplaces</th>
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<tbody>
<tr>
<td>Indicator pathogen or disease</td>
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<td></td>
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<tr>
<td>--------------------------------</td>
</tr>
<tr>
<td>TC</td>
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<tr>
<td>FC</td>
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<tr>
<td>FS</td>
</tr>
<tr>
<td>S. aureus</td>
</tr>
<tr>
<td>P. aeruginosa</td>
</tr>
<tr>
<td>Aeromonas spp.</td>
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</table>

| A^a | 36  | 28 | 18  | 22  |
| B^b | 30  | 22 | 8   | 22  |
| B^c | 62  | 62 | 2   | 12  |
| B^d | 44  | 16 | 0   | 2   |

\* \* ≥1 TC and/or ≥1 FS and/or ≥1 pathogenic bacterium per 100 ml.
\* \* ≥1 FC and/or ≥1 FS and/or ≥10 TC and/or ≥1 pathogenic bacterium per 100 ml.
\* \* ≥1,000 aerobic and anaerobic heterotrophic bacteria per ml.
\* \* ≥10,000 aerobic and anaerobic heterotrophic bacteria per ml.

We also compared the proportions of contaminated water dispensers in the workplaces and in the residences. For our two classes of contamination, there was no statistical difference in the proportion of water coolers contaminated (class A, \( X^2 = 0.74, P = 0.39 \); class B, \( X^2 = 0.83, P = 0.36 \)). As for tap water, the proportion of class B samples was higher for the workplaces than for the residences (\( X^2 = 3.84, P = 0.05 \)), while the proportions of class A samples were similar for the two locations (\( X^2 = 0.25, P = 0.62 \)).

A second sampling of the contaminated faucets of residences and workplaces following a tap water flushing of 5 min showed only one of the tap water samples (41 TC per 100 ml) to be contaminated.

Various factors, such as socioeconomic status and the presence of very young children in the case of residences and type of enterprise (service or industrial) as well as number of employees in the case of workplaces, were considered in order to determine if they were related to the water coolers contaminated at the class A or the class B level. Moreover, we documented the maximum storage time of bottles, the duration of use of a bottle after installation on the dispenser, the frequency of cleaning of the water cooler, the interval between the last cleaning and sampling, and the type of cleaning. Statistically, for the two classes of contamination, no factors

<table>
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<th>TABLE 2. Comparison of the proportions of contaminated water coolers and faucets</th>
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<td>Class of contamination</td>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B^b</td>
</tr>
</tbody>
</table>

\* \* % of C, percentage of water coolers that were contaminated.
\* \* % of F, percentage of faucets that were contaminated.
\* \* Significance level (\( X^2 \) test).
\* \* ≥1 FC and/or ≥1 FS and/or ≥1 TC and/or ≥1 pathogenic bacterium per 100 ml.
\* \* ≥1 FC and/or ≥1 FS and/or ≥10 TC and/or ≥1 pathogenic bacterium per 100 ml.
stood out at a significance level of 0.05 (residences, \( P \geq 0.25 \) for all the factors; workplaces, \( P \geq 0.16 \) for all the factors). This may be due in part to the small sample size.

The quality and frequency of the cleanings were judged against the recommendations made by the Québec Bottlers Association and the Québec Ministry of Environment, which stipulate that the reservoir should be scrubbed with a commercial solution of sodium hypochlorite (6%) and rinsed every 2 months. Unfortunately, at the expense of the sample size, we had to stratify our data further to look for the influence of the frequency of cleanings when cleaning was done as recommended. In the residences, only one water dispenser of the six which were cleaned in the manner and at the interval recommended was contaminated at the class A level, and none were contaminated at the class B level. In contrast, 7 of the 12 water dispensers which were cleaned in the manner recommended, but not frequently enough, were contaminated at both levels. A comparison of these two sets of conditions for the cleaning of coolers using a Fisher test yielded probabilities of 0.15 for class A and 0.04 for class B, indicating that despite the very small sample size a benefit was derived from regular cleaning. On the other hand, there was no difference between the dispensers that were not cleaned in the manner recommended regardless of the frequency of cleaning (class A, \( P = 1.0 \); class B, \( P = 0.61 \)).

In the workplaces, when cleaning was in agreement with the recommendations, 2 of 12 water dispensers were contaminated at the class A level in contrast with 1 of 12 at the class B level. When cleaning was not done in the manner recommended, the proportions were 6 of 19 and 5 of 19, respectively (class A, \( P = 0.43 \); class B, \( P = 0.36 \)). Cleaning the water coolers as recommended seemed to influence the contamination, but the difference was not statistically significant. On the other hand, even when the cleaning was done in the manner recommended, the contamination of water dispensers was not affected by the cleaning frequency. Three water coolers of nine cleaned at the interval recommended were contaminated at the class A level, and two of nine were contaminated at the class B level. Similarly, two and three of the nine water coolers cleaned in the manner recommended, but not frequently enough, were contaminated at the A and B levels, respectively. A comparison of these two proportions using a Fisher test yielded a probability of 1.0. It is possible that the higher level of water consumption in the workplaces limited the risk of contamination and the importance of regularly cleaning the dispenser. The average consumption of bottles was 3.92 bottles per month in the residences as opposed to 10.43 bottles per month in the workplaces.

### DISCUSSION

As expected, none of the 20 unopened bottles of spring water were contaminated by pathogenic or indicator bacteria, although small quantities of heterotrophs were recovered (Table 3). These small quantities of heterotrophs are in sharp contrast to the higher quantities reported in the literature, mainly from Europe (10, 26), and can be attributed to disinfecting processes (ozonation or UV irradiation) used by the manufacturers in Canada, which reduce bacterial numbers to low levels.

Interestingly, we found that the HPC in water coolers were much higher than those in the faucets (Table 3). Moreover, the distribution of HPC in the 20 new bottles was very similar to the result obtained with the faucet samples, indicating that the use of water coolers can promote the multiplication of heterotrophic bacteria.

In the residences, the water extracted from water coolers was markedly more contaminated than the first streams of tap water (Table 2). In the workplaces, however, the two sources were equally contaminated. The fact that in workplaces faucets are not often used and are not kept clean may be an explanation. The follow-up on the 11 contaminated faucets revealed that only 1 of them still showed signs of contamination after 5 min of flushing, thus pointing to the plumbing of the buildings rather than the municipal water system as the source of contamination.

To our knowledge, only one other study of the bacteriological quality of the water dispensed by water coolers has been done in North America. On the campus of Northeastern University, Kozlowski et al. (13) sampled 10 water coolers once a week over a period of 2 months to obtain HPCs. They found concentrations ranging from \( 2 \times 10^3 \) to \( 10^6 \) CFU/ml. On the basis of these results, the authors insisted on the necessity of cleaning water dispensers regularly.

As was the case in the above-mentioned study, we also obtained an HPC of at least \( 10^3 \) CFU/ml for 62% of the water dispensers we sampled. Generally, this indicator is used to establish the effectiveness of the treatment methods used in municipalities. The United States Environmental Protection Agency estimates that \( 5 \times 10^2 \) CFU/ml is the upper acceptable limit on the basis of the potential of high HPCs to interfere with detection of coliform bacteria (9).

Caution is needed when interpreting the public health significance of HPCs for bottled water. As mentioned previously, bottled water is already contaminated with a natural microflora essentially nonpathogenic for humans (7, 15). These bacteria may be potentially pathogenic to more vulnerable individuals, such as the elderly, infants, and the immunocompromised.

### TABLE 3. Distribution of the HPCs for the samples

<table>
<thead>
<tr>
<th>HPC (no. of bacteria/ml)</th>
<th>% of water coolers in:</th>
<th>% of faucets in:</th>
<th>% of new bottles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Residences</td>
<td>Workplaces</td>
<td>Residences</td>
</tr>
<tr>
<td>0–10</td>
<td>10</td>
<td>8</td>
<td>50</td>
</tr>
<tr>
<td>11–100</td>
<td>8</td>
<td>28</td>
<td>30</td>
</tr>
<tr>
<td>101–1,000</td>
<td>18</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>1,001–10,000</td>
<td>2</td>
<td>46</td>
<td>2</td>
</tr>
<tr>
<td>10,001–100,000</td>
<td>12</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>&gt;100,000</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Range*</td>
<td>0–270,000</td>
<td>0–260,000</td>
<td>0–2,400</td>
</tr>
<tr>
<td>Median*</td>
<td>7,000</td>
<td>1,990</td>
<td>12</td>
</tr>
</tbody>
</table>

* Number of bacteria per ml.
individuals, however, such as infants and immunosuppressed patients (26). A recent study found a relationship between HPCs in water treated with reverse-osmosis filtration units and the incidence of gastrointestinal problems (22).

The Québec Ministry of Environment stipulates that spring water should be bacteriologically pure and free of contaminants (23). Obviously, this regulation, like all qualitative norms, is not precise. Health and Welfare Canada, however, in its Food and Drug Act, specifies that mineral and spring water must not contain coliforms (16). The World Health Organization states that bottled water must be totally free of coliforms and *P. aeruginosa*; the latter requirement was included because of the vulnerability of children and the elderly to this organism (20). In Europe, the Council of the European Community states that natural mineral water (including spring waters low in minerals) must not contain any parasite, pathogenic microorganism, *Escherichia coli* or other coliform, fecal streptococci, sulfate-reducing anaerobic bacterium, or *P. aeruginosa*, and it stipulates that at 12 h after bottling the total number of bacteria must not exceed 100 CFU/ml (6). In the United States, only one 100-ml portion in the sampling procedure is permitted to contain four coliforms or more, but the arithmetic mean of the analytical units must not exceed one coliform per 100 ml (5). Whereas microbiological standards exist for bottled water, the same product once installed on a dispenser is generally not regulated and is rarely controlled.

Concerning our study, the proportion of water dispensers contaminated at the A and B levels is disturbing. This contamination is not related to the product itself but rather to the use of a water cooler as the dispenser. Unfortunately, we were unable to discern the dominant factors responsible for this contamination, and this constitutes a great limitation in the interpretation of the data. We must, however, look beyond the statistics. Even if certain relationships were not statistically significant, it is still revealing to look at the influence of cleaning on contamination. Regular cleanings as recommended should probably limit contamination.

As for the participants in our study, only 44% of those possessing water coolers in residences and 36% of those possessing water coolers in workplaces had been informed of the necessity of cleaning the equipment, let alone how to do it. Thus a variety of products had been used, from baking soda to vinegar and dishwashing liquid, instead of sodium hypochlorite as recommended.

On the basis of results obtained with a sampling of initial streams of water, the bacteriological quality of municipal tap water is superior to the quality of the water dispensed by water coolers in residential sites. In part because of more instances of contaminated tap water in the survey of workplaces, there was no statistical difference in contamination between the two sources of water (Table 2). However, we demonstrated in a follow-up sampling of the contaminated faucets that tap water contamination may be derived from the plumbing of the buildings. As with lead contamination (2), it is probable that the longer the water has been standing in the tap, the greater the potential there is for bacteria to accumulate if, of course, there is a source of bacteria in the building's plumbing system. It has been proposed that tap water should be permitted to flow until it is at a constant cold temperature before use (2).

Our results indicate that we should be cognizant of the quality of the water dispensed from water coolers. Although it is possible to manufacture water dispensers which are less likely to become contaminated (8), vendors and suppliers of water dispensers should impress on their clients the need for regular maintenance of the equipment.

In addition, studies determining the health impact of drink-

ing water from dispensers should be undertaken, and public health authorities should be made aware of water dispensers as a possible source of contamination when investigating food- or water-related epidemics.

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**REFERENCES**


