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Microbial quality of drinking water from microfiltered water dispensers

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ABSTRACT

A comparison was made between the microbial quality of drinking water obtained from Microfiltered Water Dispensers (MWDs) and that of municipal tap water. A total of 233 water samples were analyzed. *Escherichia coli* (EC), enterococci (ENT), total coliforms (TC), *Staphylococcus aureus*, *Pseudomonas aeruginosa* and heterotrophic plate count (HPC) at 22 °C and 37 °C were enumerated. In addition, information was collected about the principal structural and functional characteristics of each MWD in order to study the various factors that might influence the microbial quality of the water.

EC and ENT were not detected in any of the samples. TC were never detected in the tap water but were found in 5 samples taken from 5 different MWDs. *S. aureus* was found in a single sample of microfiltered water. *P. aeruginosa* was found more frequently and at higher concentrations in the samples collected from MWDs. The mean HPCs at 22 °C and 37 °C were significantly higher in microfiltered water samples compared to those of the tap water.

In conclusion, the use of MWDs may increase the number of bacteria originally present in tap water. It is therefore important to monitor the quality of the dispensed water over time, especially if it is destined for vulnerable users.

Introduction

In Italy the quality of municipal tap water has reached a fairly high level (Anonymous, 2012a). Despite this, problems of an organoleptic nature or regarding the maintenance of the water supply have led many consumers to resort to bottled water and Italy in fact holds the record in Europe for the highest consumption of mineral water (Anonymous, 2012b). However, the elevated costs and the excessive amount of energy needed to produce bottled water have recently led to a general reassessment of tap water (Aqua Italia, 2012). In this context, the use of devices that treat the drinking water at the point of use is becoming increasingly more widespread. Such devices are marketed as being able to eliminate unpleasant odors and tastes and to remove any undesirable substances from the tap water. They often include systems for the addition of CO_2 and for the cooling of the water. Compared to bottled water these devices offer the advantage of avoiding the need for the transport, storage and disposal of the bottles.

Numerous types of such devices are commercially available (Aqua Italia, 2012). One of the most commonly used in Italy is the microfiltered water dispenser (MWD). MWDs are devices directly attached to municipal drinking water supplies in private residences, offices, restaurants and hospitals. The treatment of the water by means of composite filters is carried out immediately before the water is dispensed.

There is very little data in the literature about the quality of the water dispensed from MWDs. Baumgartner and Grand (2006), Charberny et al. (2006), Lèvesque et al. (1994), and Liguori et al. (2010) analyzed the quality of drinking water dispensed from other types of water dispensers (water coolers or soda fountains). In general, the water dispensed from these devices was found to be more contaminated than the water supplied to them.

In previous studies (Sacchetti et al., 2009; Zanetti et al., 2009) we carried out laboratory tests on certain prototypes of MWDs to compare the ability of two disinfectants to ensure an adequate bacteriological quality of the dispensed water.

In the present study we investigated the microbial quality of drinking water from MWDs used in collective restoration environments in an area of Northern Italy. In particular, we compared the bacteriological characteristics of microfiltered drinking water with that of municipal tap water and we studied the various factors that might influence the quality of the water dispensed by MWDs.

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Materials and methods

Microfiltered water dispensers

The study focused on MWDs used in hospital and school canteens ($n = 36$) and a sample of MWDs in use in bars/restaurants ($n = 34$) in the area of Bologna, Northern Italy. The bars/restaurants were randomly selected from the list of collective restoration establishments in the territory. For each establishment selected for the study a phone call was made to verify that a MWD was in use.

To be included in the study, the water dispensers had to be directly attached to municipal drinking water distribution systems, and had to use composite filters (of the EVERPURE type) for the treatment. The composite filters consist of a disposable cartridge containing a microfiltering membrane (0.5 micron pore size), made of polyethylene fibers, and powdered activated carbon. Some of them also contain a bacteriostatic element (copper or silver salts).

For each MWD studied, information about the age of the device, the presence of a UV lamp, the presence of a bacteriostatic element in the filter, the amount of water consumed, the times of use/non use, the frequency and method of disinfection, the frequency of filter change, the interval between the last filter change and sampling and the last disinfection and sampling was collected by means of an ad hoc questionnaire.

On the basis of this information, the continuous use of the device throughout the week was defined "daily use" and the compliance with the directions supplied by the manufacturer regarding the means and frequency of disinfection (at least 2 times/year or 4 times/year if the device was installed in a hospital or school) was defined "adequate disinfection".

The main structural and functional characteristics of the MWDs included in the study are given in Table 1. This information was not available in three devices.

Water sampling

From October 2010 to May 2011, 70 MWDs were examined. Samples were taken of all the various types of drinking water available (still unchilled and chilled water, or still chilled and carbonated chilled water, or still unchilled, still chilled and carbonated chilled water) in order to assess any differences in contamination and to highlight any critcal areas. At the same time a sample of the tap water entering the dispenser was also collected. The samples were always taken in the morning, after the devices had been working for about an hour. When different types of drinking water were collected from a single device, the same sampling sequence was always repeated.

A total of 233 water samples were analyzed, including 70 samples of municipal tap water and 163 samples of water from MWDs (49 of still unchilled water, 63 of still chilled water, 51 of carbonated chilled water).

To ensure that the samples were representative of the water consumed, flushing was not performed before sampling and the outer surfaces of the nozzles were not sterilized (Lèvesque et al., 1994; Liguori et al., 2010).

Samples were collected in sterile 1 L plastic bottles containing 1 mL of sterile sodium thiosulphate solution (10%). They were kept at 4 °C and analyzed within 2 h in our laboratory.

Table 1
Structural and functional characteristics of the microfiltered water dispensers.

Age in months (mean ± S.D.)	44.2 (±34.9)
Bacteriostatic element (%)	
Yes	61.1
No	38.9
UV lamp (%)	
Yes	76.7
No	23.3
Daily use (%)	
Yes	47.1
No	52.9
Liters of water consumed per day (mean ± S.D.)	74.5 (±142.9)
Frequency of filter change per year (%)	
1	63.2
≥2	36.8
Frequency of disinfection per year (%)	
≤2	52.6
>2	47.4
Type of disinfectant (%)	
Chlorine	10.0
Hydrogen peroxide	44.0
Quaternary ammonium salts	46.0
Adequate disinfection[a] (%)	
Yes	55.0
No	45.0
Time since last filter change (days; mean ± S.D.)	160.0 (±155.5)
Time since last disinfection (days; mean ± S.D.)	123.2 (±146.6)

[a] Adequate disinfection = compliance with the directions supplied by the manufacturer regarding type and frequency of disinfection.

Bacteriological analysis

In accordance with Italian regulations for drinking water (D.Lgs 31/2001, application of EC directive 98/83), the following bacteriological parameters were quantified for each sample: *Escherichia coli* (EC), enterococci (ENT), indicator microorganisms of the quality of water (total coliforms – TC, heterotrophic plate count – HPC at 22 °C), and supplementary microorganisms (*Pseudomonas aeruginosa* – PA and *Staphylococcus aureus* – SA). HPC at 37 °C was also determined to obtain a more complete assessment of the bacteriological quality of the water. In Italy the measurement of the HPC at 37 °C is required only for water sold in bottles or containers.

The microbiological criteria for unbottled municipal drinking water are: absence in 100 mL per EC and ENT; absence in 100 mL per CT. The Italian regulations set no numerical value for HPC at 22 °C but state that there should be no "abnormal change" compared to the values obtained during routine official checks. Also for PA no limit is set. PA is a supplementary parameter to be determined at the discretion of the local health authority. SA is a supplementary parameter, but its absence in 250 mL of water is required.

All analyses followed the techniques proposed in the Standard Methods (APHA, 2005).

HPCs at 37 °C and 22 °C were determined by the pour plate method using Plate Count Agar- Standard Methods Agar (Oxoid). The mean value of three replicates was calculated.

The other microbial parameters were quantified by membrane filtration (0.45 micron pore-size sterile membrane, Millipore) in 100 mL of water (for EC, ENT, TC) and 250 mL (for PA and SA). The detection limit was 1 cfu per sample volume for all types of bacteria.

EC: The filter was transferred to C-EC agar (Oxoid). After incubation at 44.5 °C for 24 h, typical colonies (fluorescent green-blue under a Wood lamp and positive to indole test) were counted. Doubtful colonies underwent biochemical identification using the Enterotube II system (BBL).

ENT: The filter was transferred to m-Enterococcus agar (Oxoid). After incubation at 35 °C for 24–48 h, typical colonies (pink-brown in color and 0.3–2 mm in diameter) were confirmed by growth on Bile esculine agar (Oxoid) at 35 °C for 48 h and by growth on Brain-heart infusion broth (Oxoid) with 6.5% NaCl at 35 °C for 48 h.

TC: The filter was transferred to C-EC agar (Oxoid). After incubation at 37 °C for 24 h, typical colonies (green-blue) were counted. Doubtful colonies underwent biochemical identification using the Enterotube II system (BBL).

PA: The filter was placed on Pseudomonas CFC agar (Oxoid) and incubated at 30 °C for 48 h. Colonies that were smooth, mucoid,