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Quality of Drinking Water of Household Filter Systems in Shiraz, Southern Iran

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Abstract: Contamination of drinking water is one of the causes of digestive diseases such as diarrhea while controlling of this contamination can reduce the prevalence of gastrointestinal diseases. One of the ways to overcome this problem is to apply household water filter systems (WFS), so monitoring of these filter system are crucial. This study was performed to determine microbiological quality of drinking water from household water filter systems in Shiraz, Southern Iran. A trained environmental health technician was responsible to provide 54 samples from WFSs and tap water in sterile sampling flasks. All tap water samples were chlorinated. Contamination with *P. aeruginosa* was 3.70% in tap water while 20.37 % of WFS. Coliform growth at 37°C and 22°C was noticed in 16.66% and 3.70% of dispensers, respectively. One of the tap water samples was positive for not-heat-resistant coliforms. All *P. aeruginosa* contaminated WFS were resistant to amoxicillin/clavulanic acid, cefuroxime and meropenem while they were sensitive to piperacillin/tazobactam, ciprofloxacin, ceftazidime, meropenem, amikacin, piperacillin and gentamicin. So, periodical decontamination and regular filter exchanging are mandatory. Recommendation of new legislation according to international regulatory agencies to standardize the products seems necessary.

Key words: Water Filter System · Bacterial Contamination · Drinking Water · Iran

INTRODUCTION

Regarding knowledge of community, the quality and safety of the drinking water still is an important public health issue [1-3]. Water borne pathogens include a variety of microorganisms accounting for 4billion cases of infections. Each year, they may lead to 2.5 million deaths from endemic diarrheal diseases [4].

The consumption of water derived from different sources especially purification of tap water by micro-filtered water dispensers (MWD) is popular among the household consumers. By using this method, the waterborne pathogens and the potential undesirable chemicals from the water may be reduced to a safe level [5, 6]. MWD is the apparatus directly attached to portable water supplies in private residences, offices, restaurants, hospitals, etc, to improve the organoleptic and compositional characteristics of the tap water [7]. However, recently concerns about hygiene and health issues have been raised [8-10]. The quality of this method is important due to its potential to cause waterborne outbreaks associated with drinking water, particularly in newborn infants and immune compromised populations [2].

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It was shown that when water flows through a network of narrow bore tubing made of plastic material (e.g. dental units), multispecies of bacteria can adhere biofilm on the inside lining of the waterlines [7, 11]. Nowadays, the production of biofilm is a major problem in water distribution systems as well as in domestic water filtration ones [12]. This could also occur when microbial community accumulates on the surface of exocellular polymers [13]. If biofilm attaches to the surface of the hidden devices and the microorganisms can become a source of undesirable levels of opportunistic pathogens or endotoxins in water supplies [14-16].

Contamination of supply water predominantly occurs with aerobic, heterotrophic and Gram-negative bacteria [17, 18]. *Pseudomonas aeruginosa* is a common opportunistic pathogen and due to its low nutritional needs, it can easily reproduce specially in humid environments. Consumption of this bacterium may cause human infections, particularly in the elderly, infants and immune compromised individuals [19, 20]. Moreover, *P. aeruginosa* is more resistant to the disinfectants used with potable waters than other waterborne bacteria [21] and may cause hospital and community-acquired infections (pneumonia, bacteremia, septicemia and soft tissue infections) in patients who are severely immunosuppressed or in debilitating conditions [20, 22-24]. Treatment of infections with *P. aeruginosa* may be problematic due to the acquisition of antibiotic resistance to many currently available broad spectrum antimicrobials [23].

Data on the bacteriological quality of the water from water filter systems (WFS) are very limited and in some studies, the water from the devices was found to be more contaminated than the water supplied to them. Therefore, the aim of this study was to determine the rate of contamination and the presence of any *P. aeruginosa* and coliform species in tap and filtered water sources. Moreover, the antibacterial susceptibility patterns of the bacteria isolated from the filter of dispensers were evaluated.

MATERIALS AND METHODS

Collection of Samples: Fifty four households using WFS participated in this study. A trained technician collected two separate samples from each householdone containing 250 ml of tap water and the other containing 250 ml filtered water from the dispenser in a sterile flask carried to Shiraz Health Center laboratory affiliated to Shiraz University of Medical Sciences for microbiological tests. All tap water samples were chlorinated. The participants completed a questionnaire including demographic information, type and model of filter, duration of filter usage and daily water consumption and its application source. Date and time of sampling was recorded by the trained technician.

Coliform Count: Three double LST (Lauryl sulfate tryptose) brothcontaining Durham tubes and 6 single media containing Durham tubes were used for each sample. Ten ml of water was placed in the double strength LST media, 1 ml of water sample in the first 3 single strength media and 0.1 ml in the second 3 single strengh media and all were incubated at 35°C for 48 hours [25]. Each tube containing growth and gas was named positive and coliform count was obtained from the MPN (most probable number method) table. The positive Durham tubes producing gas were sub cultured in brilliant green bile broth containing Durham tubes and were incubated at 35°C for 48 hours. Gas producing LST media were also sub-cultured in Ec broth containing Durham tubes and incubated in water bath at 44.5°C for 48 hours to identify any fecal coliforms. Finally, positive Ec broth tubes were sub cultured on L-EMB agar and then standard biochemical tests were carried out to determine any presence of *E. coli* species [26]. All samples were checked for pH and any residual chlorine.

P. Aeruginosa Count: One hundred ml of water sample was passed through 0.45 μ microfilters and then the filter was placed on *Pseudomonas* CN selective medium and incubated at 36°C for 48 hours [27]. To confirm presence of *P. aeruginosa*, the filtered waters were checked by specific biochemical reactions [27]. The number of *P. aeruginosa* was determined and reported in 100 ml water.

Antibacterial Susceptibility of *P. Aeruginosa:* The sensitivity of the isolated *P. aeruginosa* to ten antibiotics (Mast Co., Merseyside, Uk) including imipenem, pipracillin/tazobactam, ciprofloxacin, ceftazidime, meropenem, amikacin, amoxicillin/clavionic acid, cefourxim, pipracillin and gentamicin was determined according to Kirby-Bauer method [28]. *P. aeruginosa* (ATCC 27853) was used as a control strain in antibacterial susceptibility determination and interpretation was done as recommended by National Committee for Clinical Laboratory Standards [29].

Statistical Analysis: *Chi Square* and *Fisher's Exact* tests were used for statistical analysis. SPSS software (version 15, Chicago, IL, USA) was applied. The significance level was defined as $p<0.05$.

RESULTS

The mean value of total residual out coming water chlorine was 0.229 mg/L and no chlorine was reported from any of the filters. The water pH was 7.26 and 6.74 in tap and filtered water samples, respectively. The filters were reported to be used 15 days to 53 months while most of them were not replaced after this period. Contamination with *P. aeruginosa* was 3.70% (2 samples) in tap water and 20.37% for filters (11 samples). Coliform growth at 37°C and 22°C was noticed in 9 (16.66%) and 2 (3.70%) dispensers, respectively. No significant relationship was visible between the duration of filter installation and contamination. Filtered water samples were mainly used for drinking. Also, they were used for cooking, ironing, flowering, preparing tea or coffee and infant formulas. Only 2 households used filtered water to prepare infant formulas and no contamination was detected from these devices.

All *P. aeruginosa* contaminated filters were resistant to amoxicillin/clavulanic acid, cefuroxime and meropenem while they were sensitive to piperacillin/tazobactam, ciprofloxacin, ceftazidime, meropenem, amikacin, piperacillin and gentamicin.

DISCUSSION

A major challenge in water distribution systems and water filtration units is quality and hygiene [30]. The institute of standard and industrial research of Iran has suggested that heat resistant coliform count should be 0 in 100 ml of drinking water (Institute of Standard and Industrial Research of Iran). The results of this survey revealed no heat-resistant coliform organism in the filter system samples while one of tap water samples was positive for heat-resistant coliform organisms. In another study, one home had post-treated water concentration of 4900, 4320 and 1920 colonies/100 mL of total coliforms, fecal coliforms and *E. coli,* respectively, when compared with 124, 70 and 0 in the source water [31]. It has been reported that in Cambodia, up to a 3 log increase of *E. coli* in field tests and 17% of all filter samples had higher concentrations of *E. coli* in the treated water than the influent water [32,]. Another investigation found higher total coliforms and *E. coli* concentrations in the effluent water from 4 and 2 of 49 pre-and post-filtrationwater filters in homes in Nicaragua, respectively [33]. It has been proposed that because the tap on the receptacle is located at the bottom, there is a volume of water that always remains in the receptacle. If this is not cleaned periodically, it could allow re-growth of bacteria and recontamination of the water [31-34].

In the present study, the mean value of total residual chlorine was 0.229 mg/L in the out-coming water and no chlorine was reported from any of the filters. Similar results were achieved from another study with the incoming water mean values of total residual chlorine of 0.17 mg/L while in out-coming water residual chlorine was not noticed [6].

In the present study, contamination with *P. aeruginosa* was 3.70 % (2 samples) in tap water while 20.37 % of filters (11 filters) were contaminated with this bacterium. Some studies have found that there are more bacteria in the treated effluent water than in the source water. In a study in Italy, *P. aeruginosa* was found in only one sample of the tap water and in 28.9 and 23.7% of the non-carbonated and carbonated water samples, respectively [35]. A study by Daschner*et al.* [36] showed that in 24 of 34 filters used in households, bacterial counts increased in the filtered water up to 6000 cfu/ml and in 4 of 6 filters tested in the laboratory, bacterial counts in the fresh filtrate were higher than in tap water suggesting growth or biofilm formation in the filter material. In some cases, colony counts in the filtered water were 10,000 times more than in tap water [36]. In the study by Payment *et al.* [35], 307 households used their usual tap water without a filter whereas 299 households were supplied with a domestic water filter system. The estimated annual incidence of gastrointestinal illnesses was 0.76 among drinkers of tap water, compared with 0.50 among drinkers of filtered water. However, the tap water in the study was prepared from sewage-contaminated surface water. Coliform organisms *(Klebsiellapneurnoniae,Escherichia coli, Enterobacteraerogenes,*and *Enterobacter cloacae)* isolated from an operatingdrinking water system were shown to growbetter than clinical isolates in un supplemented distribution water [36]. Moreover, in one report, *P. aeruginosa* and *S. aureus* were not detected in the incoming water while in the output water; the mean concentration of *P. aeruginosa*was 105 cfu/100 mL [6]. Therefore, a periodic adequate disinfection of water dispensers needs to be carried out in order to keep the level of microbiological contamination as low as possible. Besides, it can be suggested that consumers of these filters should be warned about using these waters to prepare food for newborn infants or immunocompromised patients. National or international regulatory agencies should obligate water filter producing companies to market only filters which do not result in deterioration of the microbiological quality of drinking water and provide a periodical schedule to exchange the filters regularly.

In conclusion, many dispensers of tap water used in the present study were not safe in terms of microbial decontamination and they may contaminate the water after filtration. To overcome this problem, periodical decontamination and regular filter exchanging are mandatory. Furthermore, preparation of new legislation to standardize their products according to national or international regulatory agencies is highly recommended.

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