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The characteristics of drinking water in the water coolers of Babol University of medical science (2015)

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Abstract
Background and purpose: The safe drinking water supply is necessary for providing of students health in the university and other educational centers. In this study, the quality of water drinking of water coolers in the different locations of Babol university of medical sciences as physical, chemical and bacteriological parameters were investigated.
Materials and Methods: In this study, turbidity, pH, chlorine residual, total and fecal coliforms and heterotrophic bacteria in the water samples were investigated. All parameters were determined according to standard methods for the examination of water and wastewater. Of the total water coolers (46 units), 19 units were randomly selected. Data obtained were analyzed by SPSS version 19.
Results: Turbidity range of the samples varied from 0 to 0.72 NTU. Residual chlorine and pH ranges in the water entering of water coolers were 0.1-0.8 mg/l and 7.44-7.96, while, water outlet of the water coolers were 0-0.4 mg/l and 7.01-8.05, respectively. None of the studied samples contained fecal coliforms, and the non-fecal coliforms of the water samples were 5.3%, while that of heterotrophic bacteria was 10.6%.
Conclusion: Results of this research showed that no bacteria of the non-fecal coliforms in entering water to the water coolers, which suggested the water was safe. However, it was proved that non-fecal coliforms found in water outlet of water coolers, and heterotrophic bacteria existed in before and after of water coolers.

Keywords: Drinking water, Turbidity, pH, Chlorine residual, total and fecal coliforms, Heterotrophic bacteria, Water coolers

1. Introduction

People's health depends on the water they drink and the food they eat. Therefore, everybody must be aware of the quality of what they consume [1, 2]. Water, as the most important and the most widely used nutritious material, must be safe and healthy and, hence, periodical control of drinking water quality is of utmost importance [3]. Nowadays, one of the important topics related to preserving health and personal hygiene of people in any society is the provision of safe drinking water [4]. Although it is possible to obtain water of suitable physical, chemical, and microbial quality through employing various methods in water treatment, preserving this quality during the transfer and distribution of water is a critical subject in the treatment and water supply systems [5]. Water transfer lines, storage reservoirs, distribution networks, and domestic water treatment devices installed by consumers affect water quality, and there are concerns regarding the loss in water quality and occurrence of secondary microbial infections in water [6].

Biofilms on the surfaces of water pipes lines, reservoirs, and in domestic water treatment devices are one of the major problems in the conservation of safe water [7]. Growth and regrowth of bacteria and biofilms formation is desirable in some water systems. They cause numerous problems and concerns in medicine, industry, and water systems [8, 9]. Microbial biofilms that form on water pipe are resistant to disinfectants and, therefore, provide suitable conditions for the growth of opportunistic and pathogenic bacteria [5]. Klebsiella, Mycobacteriums, Legionella, coliforms, and Pseudomonas are among opportunistic bacteria found in biofilms [6].

Water coolers (dispensers) are among the equipment widely used, in warm seasons. Because of their structure, and since water remains stagnant in them, water coolers provide an environment for the growth and development of biofilms [10].

Other potential problems related to water coolers include the presence of metallic pipes and fittings and soldering operations that can act as an important factors for the increasing of metals concentrations such as lead, cadmium, and iron into water [11].
Water analysis for identifying all pathogenic agents can be very time-consuming and costly; hence, indicator bacteria are used for this purpose [12]. Microbiological testing of water is usually performed to determine total and fecal coliforms [12]. Recently, the World Health Organization (WHO) has approved methods that are more reliable in determining the microbiological quality of drinking water. One of them is the heterotrophic plate count (HPC) method. HPC, as defined by the WHO, is an indicator of the presence of all bacteria in water that can grow in incubator at 22- 37 ˚C. This indicator is a standard widely employed in monitoring the microbial quality of water, and the permissible standard of HPC in drinking water recommended by the WHO is 500 colonies in one milliliter of water [13].
Based on the WHO standards, there should be no coliforms or fecal coliforms in any 100 ml sample of drinking water [14].
Growth of bacteria in water distribution networks depends on the physical and chemical conditions of the use of water treatment facilities [9, 11]. The most important factors that affect on microbial growth in water treatment systems include free residual chlorine, dissolved organic carbon, temperature, pH, pipe material, and pipe corrosion [13]. It is necessary to identify the main sources of fecal contamination in order to improve water quality and to minimize public health risks caused by such contaminations [15, 16]. Human infection through these contaminations may occur directly by drinking water contaminated with human or animal feces, or through indirect contact [17].
Considering to the importance of the safe water drinking supply for conservation of human health and monitoring of water quality in dormitories of universities, this research was conducted in all student dormitories of the Babol University of Medical Sciences.

2. Materials and Methods
In this cross-sectional study, which was carried out in the autumn and winter of 2015, after facility location and counting the number of existing water coolers, physical, chemical and bacteriological characteristics of drinking water entering and leaving water coolers such as Turbidity, pH, Chlorine residual, total coliforms, fecal coliforms and heterotrophic bacteria was studied. All experiments were conducted and samples taken according to the standard methods for water and wastewater examinations of the American Public Health Association [18]. Of the 46 water coolers, 19 machines that were most used were selected and 50 samples (38 samples plus 12 repeat samples) were taken. The samples were taken from the taps closest to the water coolers. Three hundred ml glass bottles with sandpaper lids were used for sampling. The bottles were washed and rinsed with distilled water, 2 ml of 3% sodium thiosulfate were added to each one, and they were sterilized in an autoclave at 121˚C and 15 pound per square inch pressure for 20 minutes.
Chlorine residual was measured at sampling locations using a chlorine test kit with DPD (diethyl p- phenylenediamine) indicator, and pH and turbidity were measured using a model AQUALITIC pH meter and a HANA Instrument turbidity meter, respectively. The multiple-tube (nine-tube) fermentation technique, the results of which are expressed in terms of the Most Probable Number (MPN), was used for measuring coliforms, and the heterotrophic plate count (pour plate count) method for the HPC test, according to standard methods for water and wastewater [18]. Single and double strength lactose broth culture media (13 and 19.5 g/l of distilled water, respectively) were employed for the presumptive stage of the multiple-tube fermentation technique for identifying coliforms. To assess coliforms and thermotolerant coliforms, Brilliant Green Bile Broth (BGB) at 40 g/l and EC Broth at 37 g/l were used for the confirmed stage and the completed test, respectively. Moreover, Plate Count Agar culture medium was employed for measuring colonies of heterotrophic bacteria. The incubation temperature for lactose broth, Plate Count Agar, and Brilliant Green Bile Broth culture media was 37 ˚C and incubation duration 24-48 hours, but the temperature of 44 ˚C and duration of 24 hours were selected for EC Broth culture media. The data was analyzed using statistical methods, SPSS version 19.

3. Results
Turbidity range of the water samples in entering and leaving water of water coolers varied from 0 to 0.72 NTU, which was desirable according to the international standards (Table 1). The residual chlorine range in the entering and leaving water of these equipments were 0.1- 0.8 mg/l and 0-0.4 mg/l respectively. The pH ranges in the entering water of these machines was 7.44-7.96, and the leaving water was 7.01-8.05. Therefore, residual chlorine in water declined after it entered the machines and, in most cases, its levels were lower than the international standards, which shows the effectiveness of water coolers in reducing residual chlorine. The values of pH also changed when water left the machines, but they were at international standards. None of the studied samples contained fecal coliforms, and the non-fecal coliforms of the water samples were 5.3%, while that of heterotrophic bacteria was 10.6% (Tables 2, 3).

Table 1: The quality of entering and leaving water in the water coolers

Parameter	Water inlet			Water outlet		
	Mean	Min	Max	Mean	Min	Max
Turbidity(mg/l)	0.7	0	0.72	0.1	0	0.5
pH	7.5	6.5	8	7.8	7	8.7
Chlorine residual(mg/l)	0.6	0.1	0.8	0.2	0	0.4
Total coliforms(MPN/100 ml)	0	0	0	23.5	4	43
Fecal coliforms(MPN/100 ml)	0	0	0	0	0	0
Heterotrophic plate count bacteria(CFU/100ml)	8	0	8	936	1	2766

Table 2: The number distribution of total coliforms in the position samples

Total coliforms numbers (MPN/100)		0	1-20	21-40	41-60	>60	Total
Inlet water	Number	19	0	0	0	0	19
	Percent	100	0	0	0	0	100
Outlet water	Number	17	1	0	1	0	19
	Percent	89.4	5.3	0	5.3	0	100

4. Discussion

Microorganisms grow naturally in biofilms in water and on surfaces in contact with water. Growth of microorganisms in water treatment facilities and water distribution systems is called regrowth of microorganisms. The high levels of HPC is especially observed in parts of the piping systems where water is stagnant, in domestic pipe fittings, in bottled water, and in equipment such as water softeners, carbon filters, and water coolers [15-18].

Table 3: The number distribution of Heterotrophic Plate Count Bacteria in the position samples

Total HPC (CFU/100)		0	1-500	501-1000	> 1000	Total
Inlet water	Number	18	1	0	0	19
	Percent	94.7	5.3	0	0	100
Outlet water	Number	16	2	0	1	19
	Percent	84	10.7	0	5.3	100

Results of this research indicated microorganisms were able to grow in piped water networks, water coolers, and domestic desalinization facilities and bacteria of the coliform group did not grow in water before it entered water coolers, but grew in water after it entered these machines. Heterotrophic bacteria grew in both samples tested prior to and after water entry into water coolers. Moreover, residual chlorine decreased after water entered these machines and, in most cases, its levels was lower than the international standards, which shows the effects of water coolers in lowering residual chlorine. The values of pH also changed after water passes through the machines, which indicated contamination, although at a slight level, did exist in water coolers. Results of research by Benoit in a city in northern Unites States in 1994, in which microbial contamination of water coolers and distributed bottled water was studied, showed that 22% of the studied water coolers had microbial contamination [19]. Their results conform to those obtained in the present study, and they indicate water coolers may be an environment for the growth of various types of bacteria. Alex *et al*. carried out research in 2009 and stated that the HPC levels had an inverse relationship with free residual chlorine, temperature, and level of absorbed ultraviolet light [20], and their results agree with those of the present one with respect to the growth of heterotrophic bacteria under conditions of low free chlorine levels.

In the research conducted by Mohammadi *et al*. at the Shahid Beheshti University in 2013, it was found heterotrophic bacteria had grown in water samples that were taken from water coolers and were cultured [18]. Results of the present study also proved heterotrophic bacteria existed in water leaving water coolers. Moreover, research carried out by Yari *et al*. entitled "Study of the Physical, Chemical, and Microbial Qualities of Water Treated in Water Desalinization Plants in Qom" showed that 6% of the samples had microbial contamination and the residual chlorine levels and pH values were lower than the standard ones [1]. Their results are in agreement with the study presented in this article.

Results of this research proved there were no bacteria of the non-fecal coliform group before water entered water coolers, which suggested the water was safe. However, it was proved non-fecal bacteria of the coliform group were present after water left water cooler, and heterotrophic bacteria existed in water before it entered water coolers and after it left them. Moreover, studied samples had turbidity that was independent of gas bubbles in most tests at the presumptive stage, which showed the microbial contamination was other than that caused by total and fecal coliforms. Residual chlorine levels declined after water left the machines and, in most cases, they were lower than the international standard, which shows the effectiveness of water coolers in reducing residual chlorine levels. The pH values in water after it left the machines was also changed, but were at levels recommended in the international standards.

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