WATER QUALITY ASSESSMENT OF PUBLIC STREET COOLERS IN SHARJAH, UNITED ARAB EMIRATES

LUCY SEMERJIAN, SAHWA ABDELMONIM, NOURA AL-JABRI, & AMNA YOUSEF
Department of Environmental Health Sciences, College of Health Sciences, University of Sharjah, UAE

ABSTRACT

Street water coolers are available in selected areas of Sharjah (UAE) and are potential sources of drinking water for many individuals as a goodwill initiative to make cool water available to the general public. Yet, water quality from such dispensers may be subjected to recontamination due to possible lack of proper maintenance and clean up, corrosion, or unhygienic use. Thus, such drinking water sources need proper monitoring, routine maintenance and cleaning measures to safeguard public health. The aim of this study is to determine the quality of waters dispensed by street water coolers in selected areas of Sharjah. A total of sixty water samples were collected in accordance to standard water sampling protocols and analyzed for a list of water quality parameters. When compared to national and international drinking water guidelines, recorded results reveal that all investigated water samples exhibited a water quality in compliance with allowable levels of sulfates, nitrates, nitrites, and turbidity, and were microbiologically safe in terms of total coliforms. Thirty three percent of analyzed water samples exhibited soft water hardness while the remaining was moderately hard. Conductivity and pH levels were within acceptable national standards except for a single cooler with low average conductivity level of 15.95 uS/cm at 25°C, and another cooler with a single pH reading exceeding the acceptable pH level of 9.2. However, only 7% of analyzed samples satisfied the minimum residual chlorine requirements of 0.2 mg/L proposing a potential risk of recontamination. Iron, lead, and copper concentrations were within acceptable levels yet at instances, iron levels approached the maximum allowable levels suggesting the need for preventive maintenance. Visual observations revealed that most coolers (85%) were in an acceptable appearance with few coolers showing signs of corrosion and deterioration. Re-chlorination, routine maintenance and cleaning measures of street coolers are recommended to limit recontamination and safeguard public health.

Keywords: public water coolers, drinking water quality, public health, United Arab Emirates.

1 INTRODUCTION

The provision of safe drinking water has improved over the last decades in almost every part of the world, yet approximately one in nine people still remains without access to safe sources of drinking water and one in three people lacks access to adequate sanitation [1]. According to the World Health Organization (WHO), 663 million people lack in access to improved drinking water while 1.8 billion people use fecally contaminated drinking water [2]. These figures certainly translate into serious public health issues as waterborne diseases, mainly owing to contaminated reservoirs, poor sanitation and unhygienic conditions, result in global increases in infectious diseases, serious health issues, as well as high mortality rates. On the other hand, safe drinking water can contribute to good health and enhanced social as well as economic productivity. Therefore, an essential basic requirement for health protection is to provide the public with adequate supply of drinking water that is safe and meets promulgated drinking water quality standards.

The United Arab Emirates (UAE) is situated at the heart of the Arabian Gulf and hosts the emirates of Abu Dhabi, Dubai, Sharjah, Ajman, Umm Al Quwain and Ras Al Khaimah. The climate of the UAE is generally tropical, hot, and dry. Maximum temperatures reach up to 47°C in summer, while the average annual summer temperature ranges between 35-40°C. Winters are shorter and run from December to February with temperature drops, especially in inland areas. UAE has low rainfall with an average annual rainfall of less than 120 mm in

www.witpress.com, ISSN 1746-448X (on-line)
doi:10.2495/WS170151

coastal areas, yet in some mountainous areas annual rainfall often reaches 350 mm [3]. Under such climatic conditions, maintaining body hydration becomes a challenge and high drinking water consumption a priority, especially when outdoors. Currently, UAE is categorized as the tenth leading country by per capita consumption of bottled water (29.6 US gallons, 112 liters) within the global bottled water market. In fact, bottled water consumption has been growing steadily worldwide during the last three decades and is regarded as the fastest growing and most dynamic sector of all the food and beverage industries [4]. The worldwide consumption of bottled waters was estimated to escalate from 62,305.3 million US gallons (235,851.2 million liters) in 2010 to 87,013.3 million US gallons (329,381.2 million liters) in 2015 [4]. This dramatic increase in bottled water consumption has been mainly attributed to (a) consumers' concern over securing safe and accessible drinking water, especially when outdoors; (b) consumers' objection to offensive tastes and odors from municipal water supplies as well as to fluoride, chlorine, and other additives; (c) consumers' awareness in regarding bottled water as a healthy alternative to other beverages to improve diet and health; (d) consumers' belief that natural mineral waters have beneficial medicinal and therapeutic effects; (e) consumers' perception that bottled water consumption confers higher social status; and finally, (f) manufacturers' successful and efficient promotion of bottled water as pure and impeccably clean water, ideal for infants, elderly, and immune-suppressed individuals [5].

Although per capita bottled water consumption is significant in UAE, yet bottled water may not always be affordable by specific sectors of the population, especially who may have the highest exposure to extreme temperatures and thus become vulnerable to dehydration. In addition to alternative water supplied to such susceptible sectors of the population, public street coolers are installed in selective streets in UAE as a goodwill initiative and as an alternative source of drinking water. In fact, in recent years, there has been a substantial global increase in the use of water coolers and water dispensing machines at homes, workplace, schools, community centers and even in public streets. Such water coolers may either accommodate bottled water carboys or operate bottle-less when connected to a main potable water supply source. Whilst these machines have a significant role in providing suitable refreshment to people, mostly perceived as safe water, their use may not be without hazard. Such water coolers, whether operating with bottled water or in bottle-less mode, may be subjected to recontamination due to possible lack of proper maintenance and clean up, corrosion, water stagnation or unhygienic use. On the other hand, individuals may refrain from the use of water coolers, especially in public areas, as such dispensers may be perceived as not regularly maintained and the water quality unsafe for consumption. Therefore, such drinking water dispensers need proper monitoring, routine maintenance and cleaning measures to safeguard public health and boost confidence of consumers in the dispensed water quality as clearly point of use (POU) water quality is a critical public health indicator.

Several studies have been conducted on bottled water coolers [6]–[12], and on bottle-less drinking water coolers in households, teaching institutions and commercial shops or water vending machines [7], [13]–[18]. Yet, the extent of studies targeting the quality assessment of public water coolers located in streets is much less [18], [19]. A study conducted in Alexandria, Egypt related to the quality of water dispensed from public coolers located in random districts revealed that 85% of water cooler samples contain less than 0.5 mg/L free residual chlorine, 65% exhibited lead concentrations exceeding 0.01 mg/L, 15% were microbiologically contaminated with *Cryptosporidium parvum* and total coliform groups, and 5% gave positive results for thermotolerant coliforms and *Streptococcus feacalis*, all attributed to the failure to thoroughly clean the coolers on a regular basis [19]. In a similar study from Cairo, Egypt, water samples collected from public street water coolers were in compliance with the WHO drinking water guidelines [20] for the chemical parameters except for 28.6% of samples not meeting the minimum requirement of 0.5 mg/L free residual chlorine and 19.1% of samples exhibiting lead concentrations exceeding 0.01 mg/L. Microbiological analyses showed that 14.3% of cooler samples have higher levels of Total Bacterial Counts and total coliforms and 9.5% for fecal coliforms in relation to WHO guidelines, thus proper monitoring is essential [21]. In Saudi Arabia, 400 water samples from public bottle-less coolers were collected from Riyadh area and analyzed for trace metals. Results revealed that 95.5% of samples met the national and international drinking water guidelines, while 4.5% exhibited elevated levels of Fe, Pb, and Ni [22].

This study aims at investigating the chemical and biological water quality from random public water coolers located in selected streets in Sharjah to serve as a first attempt in observing water quality dispensed from such sources. Results are compared to national and international drinking water standards and guidelines [20], [23], [24] to trace compliance. The objectives of the study are to (1) safeguard consumers from possible chemical and microbial contaminants which may occur in such public water coolers, (2) set recommendations for proper maintenance and cleaning measures, and (3) increase public awareness and confidence in the quality of water consumed.

2 MATERIALS AND METHODS

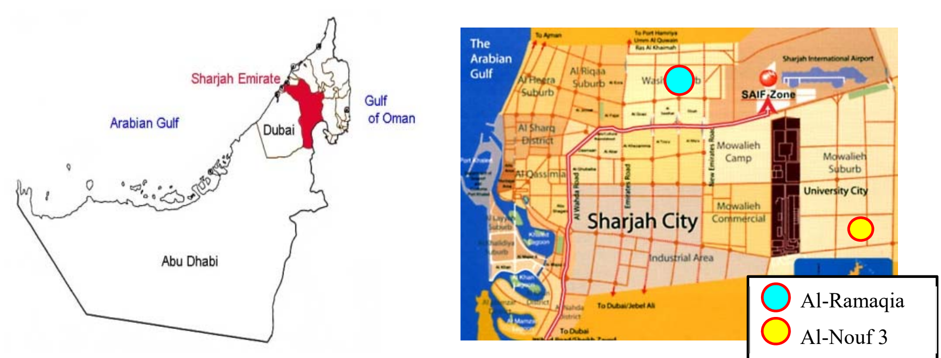
2.1 Study area

The study was focused in the Emirate of Sharjah of UAE (Fig. 1(a)). Two major suburbs of Sharjah City, namely Al-Ramaqia (Area 1) and Al-Nouf 3 (Area 2) were selected as study areas (Fig. 1(b)) as public bottle-less metallic water coolers were observed to be commonly available in selected streets of these areas.

2.2 Sampling procedures

Twenty public water coolers (as shown in Fig. 2) were randomly selected and sampled on three different sampling episodes, thus a total of 60 water samples were collected.

Sterile 250-ml glass bottles were used for sample collection from the public water coolers



(a)
Source: http://www.geo.uni-tuebingen.de/.

(b)
Source: http://www.avantgarde-uae.com/index.php.

Figure 1: (a) Emirate of Sharjah in United Arab Emirates; (b) Study areas in Sharjah City suburbs.

Figure 2: Metallic public water coolers investigated in the study.

in accordance to the following procedure. The cooler taps were disinfected with bleach to eliminate any external contaminants, water was let to run for five minutes, and then the sterilized bottles were opened and directly filled with dispended water. Collected samples were stored in a portable cooler for preservation, and carried to the laboratory for analysis within allowable holding times.

2.3 Analytical methodologies

All samples were analyzed within maximum holding times according to the Standard Methods for Examination of Water and Wastewater [25] as summarized in Table 1. pH, free residual chlorine and total residual chlorine were measured on-site using a portable pH meter

Table 1: Analytical parameters and reference methods.

Parameter	Method principle	Reference method
pH (@ 25°C)	Electrometric	SM 4500-H+
Conductivity (uS/cm @ 25°C)	Electrochemical	SM 2510 B
Total hardness (mg/L as $CaCO_3$)	Titrimetric	SM 2340 C
Turbidity (NTU)	Nephelometry	SM 2130 B
Sulfates (mg/L)	Turbidimetric	HACH 8051
Nitrites (mg/L)	Colorimetric	HACH 8507
Nitrates (mg/L)	Colorimetric	HACH 8039
Free & total chlorine (mg/L)	Colorimetric	HACH 8021 & 8167
Metals (Fe, Cu, Pb)	ICP-OES	SM 3120 B
Coliforms (MPN index/100 ml)	Multiple-tube lactose fermentation	SM 9221 B-C

(Sartorius, Germany) and a pocket chlorine colorimeter (HACH, USA). Electrical conductivity and turbidity of samples were determined in the laboratory by conductivity meter (HACH HQ14d, USA) and turbidimeter (HACH 1900C, USA), respectively. Sulfates, nitrites and nitrates were measured colorimetrically using DR 2800 spectrophotometer (HACH, USA). Metal analyses (iron, copper, and lead) were conducted on acidified aliquots of the samples using Inductively Coupled Plasma-Optical Emission Spectrometry (Varian, USA). The microbiological quality of samples in terms of total coliform loads was assessed using the multiple tube lactose fermentation technique.

3 RESULTS AND DISCUSSION

3.1 Water quality assessments

As previously mentioned, 60 water samples dispensed from 20 random public water coolers were analyzed for an array of physico-chemical as well as microbiological parameters. Collected samples exhibited varying ranges and averages (expressed in bold) of quality characteristics as summarized in Table 2. Recorded outcomes were compared to national drinking water quality guidelines as set by the Gulf Cooperation Countries Standardization Organization (GSO) for un-bottled drinking water GSO 149/2008 and endorsed by the Emirates Authority for Standardization and Metrology (ESMA), as well as the Water Quality Regulations (WQR) issued by The Regulation and Supervision Bureau for the water, wastewater and electricity sector in the Emirate of Abu Dhabi [24]. For unlisted parameters, the Bureau typically considers the GSO Drinking Water Standards or the WHO Water Quality Guidelines as a reference for the Regulations' maximum Prescribed Concentrations or Values (PCV). Recorded outcomes were also compared to available international drinking water quality guidelines as set by WHO [20].

Recorded result ranges reveal that all investigated water coolers exhibited a water quality in compliance with allowable levels of sulfates, nitrites and nitrates. One sample (1.6%) was above the maximum guideline value recommended by WHO (1 NTU) for turbidity yet within the PCV specified by WQR (4 NTU), thus does not pose major public health concern. Conductivity and pH levels were within acceptable national standards except for a single cooler with low average conductivity level of 15.95 uS/cm at 25°C, and another cooler with a single pH reading exceeding the acceptable highest threshold for pH level of 9.2 specified within WQR. Low conductivity levels do not pose a major health concern but they render the water more prone to leach metallic ions from cooler components. Recorded total hardness levels were all below the guideline value recommended by WQR as 300 mg /L as $CaCO_3$ at 25°C; thirty three percent of analyzed water samples exhibited soft water hardness (0-<75 mg /L as $CaCO_3$ at 25°C) while the remaining was moderately hard (75-150 mg /L as $CaCO_3$ at 25°C). Iron, lead, and copper concentrations were within acceptable national and international levels yet at instances, average iron levels approached the maximum allowable levels by WQR (0.2 mg/L) suggesting the need for preventive maintenance. On the other hand, only 7% of analyzed samples satisfied the minimum free residual chlorine requirements of 0.2 mg/L, and a single sample exceeded the 0.5 mg/L maximum residual chlorine PC set by WQR. The unavailability of additional free residual chlorine poses a potential risk of recontamination, thus proper chlorination or if necessary re-chlorination needs to be maintained to safeguard public health.

When comparing average values to promulgated drinking water guidelines as represented by the comparative graphs in Fig. 3, all investigated water coolers exhibited a water quality in compliance with allowable levels of the investigated physico-chemical parameters, except

Table 2: Recorded ranges and averages of analyzed physico-chemical water quality parameters.

ID	Analytical parameter											
	pH (@25°C)	Conductivity (µs/cm 25°C)	Total Hardness (mg/L $CaCO_3$)	Turbidity (NTU)	Sulfate (mg/L SO_4^{2-})	Nitrite (mg/L NO_2-)	Nitrate (mg/L NO_3^-)	Free Chlorine (mg/L)	Total Chlorine (mg/L)	Lead (mg/L)	Copper (mg/L)	Iron (mg/L)
A	7.60–8.34 **8.03**	823–1,010 **942**	100–112 **106**	0.24–0.39 **0.33**	100–110 **107**	**<0.007**	2.66–3.10 **2.95**	<0.02–0.02 **<0.02**	0.03–0.15 **0.09**	**<0.01**	**<0.5**	**<0.1**
B	7.76–8.63 **8.25**	631–962 **845**	80–92 **87**	0.19–0.29 **0.23**	75–95 **83**	**<0.007**	1.77–2.66 **2.22**	0.02–0.09 **0.05**	0.02–0.24 **0.12**	**<0.01**	**<0.5**	**0.15**
C	7.30–8.51 **8.03**	846–1,044 **972**	72–80 **76**	0.35–0.73 **0.51**	90–100 **95**	**<0.007**	1.77–18.1 **8.51**	<0.02–2.11 **0.73**	<0.02–2.28 **0.79**	**<0.01**	**<0.5**	**0.14**
D	7.90–8.50 **8.20**	869–1,044 **983**	85–112 **93**	0.27–1.85 **0.91**	100–115 **108**	**<0.007**	1.77–4.43 **2.95**	0.04–0.20 **0.10**	0.05–0.21 **0.11**	**<0.01**	**<0.5**	**0.14**
E	8.00–8.56 **8.26**	653–905 **764**	80–92 **83**	0.94–1.10 **0.99**	50–60 **57**	**<0.007**	2.22–22.59 **9.45**	0.06–0.10 **0.08**	0.08–0.16 **0.09**	**<0.01**	**<0.5**	**<0.1**
F	7.70–8.73 **8.39**	811–928 **885**	60–84 **73**	0.07–0.45 **0.28**	80–95 **88**	**<0.007**	1.33–3.54 **2.66**	0.06–0.09 **0.08**	0.06–0.16 **0.10**	**<0.01**	**<0.5**	**<0.1**
G	7.78–8.00 **7.91**	831–950 **898**	75–84 **80**	0.31–0.40 **0.35**	75–90 **82**	**<0.007**	1.77–3.10 **2.51**	<0.02–0.31 **0.12**	0.04–0.35 **0.15**	**<0.01**	**<0.5**	**0.12**
H	8.25–9.09 **8.78**	571–956 **805**	70–88 **75**	0.07–0.17 **0.11**	20–105 **62**	**<0.007**	1.77–2.21 **2.07**	0.03–0.12 **0.08**	0.04–0.18 **0.11**	**<0.01**	**<0.5**	**<0.1**
I	8.30–8.90 **8.67**	875–984 **928**	92–100 **96**	0.17–0.45 **0.29**	55–75 **62**	**<0.007**	1.77–2.66 **2.36**	0.05–0.20 **0.11**	0.11–0.21 **0.16**	**<0.01**	**<0.5**	**<0.1**
J	8.59–9.00 **8.73**	606–1,010 **857**	75–80 **77**	0.27–0.85 **0.50**	75–100 **86**	**<0.007**	1.77–2.22 **2.07**	0.05–0.10 **0.08**	0.07–0.13 **0.10**	**<0.01**	**<0.5**	**0.17**
K	7.30–8.27 **7.92**	883–963 **933**	76–85 **79**	0.21–0.31 **0.27**	70–120 **95**	**<0.007**	1.77–4.43 **3.10**	<0.02 **<0.02**	<0.02–0.06 **0.03**	**<0.01**	**<0.5**	**<0.1**
L	7.77–8.00 **7.92**	921–965 **942**	72–77 **75**	0.25–0.42 **0.33**	75–100 **86.7**	**<0.007**	1.77–4.43 **3.10**	<0.02 **<0.02**	<0.02 **<0.02**	**<0.01**	**<0.5**	**<0.1**
M	7.35–9.00 **8.20**	12.37–19.26 **15.95**	11–16 **13**	0.15–0.36 **0.23**	<2 **<2**	**<0.007**	<1.33–4.43 **2.66**	<0.02–0.03 **<0.02**	<0.02–0.07 **0.03**	**<0.01**	**<0.5**	**0.18**
N	7.60–8.00 **7.85**	907–964 **942**	84–100 **94.7**	0.45–0.78 **0.59**	75–100 **90**	**<0.007**	<1.33–4.43 **2.66**	<0.02 **<0.02**	<0.02 **<0.02**	**<0.01**	**<0.5**	**<0.1**
O	7.67–8.21 **7.96**	860–891 **880**	72–76 **74.7**	0.13–0.48 **0.29**	70–85 **78.3**	**<0.007**	<1.33–6.65 **3.25**	<0.02–0.02 **<0.02**	<0.02–0.04 **0.03**	**<0.01**	**<0.5**	**<0.1**

Table 2: Continued.

P	**7.67–8.50** 8.21	**959–1,078** 1,013	**88–108** 95.3	**0.39–0.55** 0.46	**60–100** 80	<0.007	**2.22–4.43** 3.25	**0.06–0.18** 0.12	**0.13–0.19** 0.17	<0.01	<0.5	0.16
Q	7.89–8.30 **8.06**	972–1,109 **1,033**	80–92 **86.3**	0.42–0.83 **0.57**	75–105 **93.3**	**<0.007**	1.33–4.43 **2.95**	<0.02–0.06 **0.03**	<0.02–0.07 **0.04**	**<0.01**	**<0.5**	**<0.1**
R	7.90–8.88 **8.32**	857–969 **914**	96–108 **101**	0.40–0.73 **0.59**	85–105 **93**	**<0.007**	1.77–6.65 **3.84**	<0.02–0.09 **0.05**	<0.02–0.12 **0.08**	**<0.01**	**<0.5**	**<0.1**
S	8.06–8.26 **8.19**	896–995 **933**	95–108 **99.7**	0.50–0.90 **0.70**	75–105 **86.7**	**<0.007**	2.66–8.86 **4.73**	<0.02–0.06 **0.03**	0.02–0.21 **0.09**	**<0.01**	**<0.5**	**0.14**
T	8.27–9.39 **8.64**	933–1,023 **973**	80–96 **85.7**	0.35–0.69 **0.49**	80–115 **95**	**<0.007**	2.66–6.65 **4.43**	0.02–0.12 **0.05**	0.03–0.15 **0.08**	**<0.01**	**<0.5**	**<0.1**

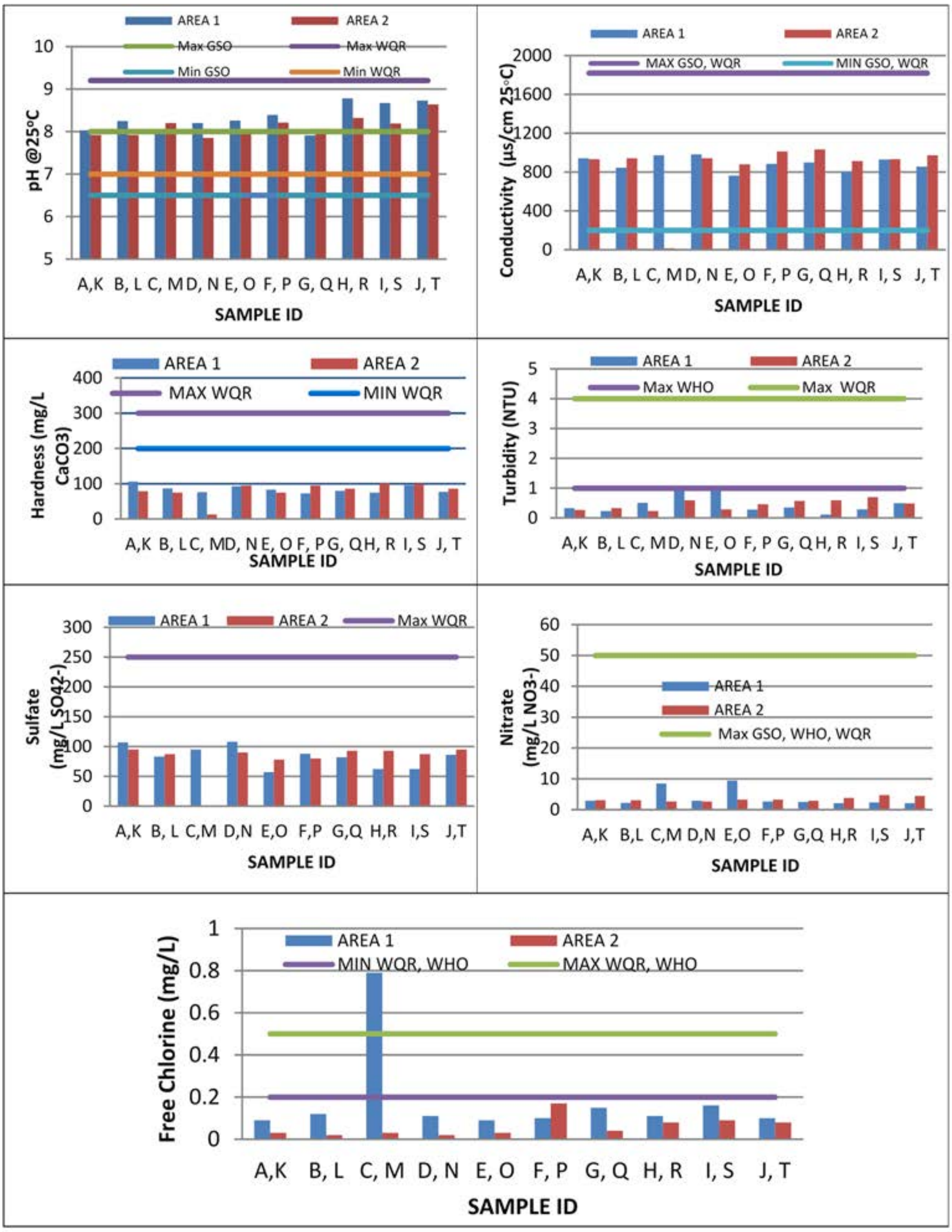


Figure 3: Average concentrations of investigated physico-chemical parameters compared to national and international drinking water quality guidelines.

for conductivity (1 cooler), and free residual chlorine (all 20 coolers). These observations reconfirm the safe quality of water dispensed from the investigated public water coolers yet highlight the need to maintain acceptable residual free chlorine levels to avoid any possibility of recontamination.

For the microbiological quality of cooler waters in terms of coliform loads as assessed using the multiple tube lactose fermentation technique, all investigated coolers exhibited contaminant free dispensed water.

3.2 Visual observations

Visual observations revealed that most coolers (85%) were in an acceptable appearance with few coolers showing signs of corrosion and deterioration. A routine maintenance program for such coolers is highly recommended to upgrade the aesthetic status of deteriorating coolers as well as more importantly prevent the recontamination of dispensed waters by metallic ions, particulates, or any microbial agents.

4 CONCLUSIONS AND RECOMMENDATIONS

In conclusion, analyzed cooler water samples do not demonstrate any microbial and major chemical risks. However, chlorination, routine maintenance and cleaning measures of street coolers are recommended to maintain a minimum free residual chlorine concentration of 0.2 mg/L in the dispensed water at point of use, thus limit recontamination and safeguard public health. Public water coolers located in the investigated areas serve as a safe alternative drinking water source for public use, especially in extreme ambient temperatures to maintain hydration. Additionally, the following recommendations ensure better cooler water safety: (1) using coolers made of materials safe for drinking water, (2) positioning public coolers in locations with minimal possibility of contamination, (3) monitoring coolers and dispensed waters regularly by their owners or the Sharjah Municipality to ensure compliance, (4) maintaining cooler components regularly to avoid corrosion and metal leaching, and finally (5) increasing consumer awareness about the importance of hygienic use of public water coolers for better public health.

REFERENCES

[1] International Decade for Action “Water for Life”, *UN-Water Fact Sheet on Water Quality,* 2005-2015, United Nations, http://www.un.org/waterforlifedecade/scarcity.shtml. Accessed on: 20 Jan. 2017.

[2] 25 Years Progress on Sanitation and Drinking Water, *Update and MDG Assessment*, 2015, World Health Organization (WHO), http://www.who.int/about/licensing/copyright_form/en/index.html. Accessed on: 15 Jan. 2017.

[3] *United Arab Emirates State of the Environment Report 2015*, Ministry of Environment and Water: Abu Dhabi, UAE, www.moew.gov.ae. Accessed on: 15 Jan. 2017.

[4] *Bottled Water 2015*, Beverage Marketing Corporation, www.bottledwater.org. Accessed on: 18 Jan. 2017.

[5] Semerjian, L., Quality assessment of various bottled water marketed in Lebanon, *Environmental Monitoring and Assessment*, **172**, pp. 275-285, 2011.

[6] Al Moosa, M.E., Khan, M.A., Alalami, U. & Hussain, A., Microbiological quality of drinking water from water dispenser machines, *International Journal of Environmental Science and Development*, **6**(9), pp. 710-713, 2015.

[7] Brennen, K., Nicoll, A. & David, G., Environmental Seminar, www.bc.edu/content/dam/files/schools/cas_sites/envstudies/pdf/Student%20Research/2015%20project%20paper/paper-7.pdf. Accessed on: 6 Jan. 2017.
[8] Farhadkhani, M., Nikaeen, M., Akbari Adergani, B., Hatamzadeh, M., Nabavi, B.F. & Hassanzadeh, A., Assessment of drinking water quality from bottled water coolers, *Iranian Journal of Public Health*, **43**(5), pp. 674-681, 2014.
[9] MacDonald, J., Morrison, C., Pembroke, C., Reed, V. & Tancock, S., *Cooler than tap water: A study of water coolers and tap water on Dalhousie University Campus, Final Report ENVS/SUST 3502*, 2011.
[10] Ezekiel, F., Abolade, O., Adeniyi, O. & Motunrayo, O., Incidence of bacteria of public health importance in drinking water from water dispenser systems in homes and offices in Lagos and Ibadan, Nigeria, *The Internet Journal of Microbiology*, **7**(1), 2008.
[11] Baumgartner, A. & Marius, G., Bacteriological quality of drinking water from dispensers (coolers) and possible control measures, *Journal of food Protection*, **12**, pp. 2824-3051, 2006.
[12] Levesque, B., Simard, P., Gauvin, D., Gingras, S., Dewailly, E. & Letarte. R., Comparison of the microbiological quality of water coolers and that of municipal water systems, *Applied and Environmental Microbiology*, **60**(4), pp. 1174-1178, 1994.
[13] Hashim, N.H. & Yusop, H.M., Drinking water quality of water vending machines in Parit Raja, Batu Pahat, Johor, IOP Conference Series, *Materials Science and Engineering*, **136**, 2016. DOI: 10.1088/1757-899X/136/1/012053.
[14] Asif, S. et al., Assessment of water quality for drinking purpose from water coolers of different teaching institutes in Lahore, *IOSR Journal of Environmental Science, Toxicology, and Food Technology*, **9**(2), pp. 18-22, 2015.
[15] Liguori, G., Cavallotti, I., Arnese, A., Amiranda, C., Anastasi, D. & Angelillo, I., Microbiological quality of drinking water from dispensers in Italy, *BMC Microbiology*, **10**(19), 2010. DOI: 10.1186/1471-2180-10-19.
[16] Schillinger, J. & Du Vall Knorr, S., Drinking water quality and issues associated with water vending machines in the city of Los Angeles, *Journal of Environmental Health*, **66**(6), pp. 25-31, 2004.
[17] Chaidez, C., Rusin, P., Naranjo, J. & Gerba, C., Microbiological quality of water vending machines, *International Journal of Environmental Health Research*, **9**(3), pp. 197-206, 1999.
[18] Al Saleh, I., Trace elements in drinking water coolers collected from primary schools, Riyadh, Saudi Arabia, *The Science of the Total Environment*, **181**, pp. 215-221, 1996.
[19] Hussein, R.A., Hassan, A.A. & Bakr, W.M., Assessment of the quality of water from some public coolers in Alexandria, Egypt, *The Journal of Egyptian Public Health Association*, **84**(1-2), pp. 197-217, 2009.
[20] Guidelines for Drinking Water Quality, World Health Organization, Geneva, **4,** http://www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en/, Accessed on: 7 Dec. 2016.
[21] Aly, A., Quality characteristics of water dispensed from some public coolers in Cairo, Egypt, *Journal of Applied Science Research*, **8**(6), pp. 3065-3070, 2012.
[22] Alabdula'aly, A.I. & Khan, M., Heavy metals in cooler waters in Riyadh, Saudi Arabia, *Environment Monitoring and Assessment*, **157**(1), pp. 23-28, 2009.
[23] GSO 149/2008: Un-bottled drinking water; GCC Standardization Organization (GSO), https://law.resource.org/pub/gso/ibr/gso.149.e.ds.2008.pdf, Accessed on: 15 Dec. 2016.

[24] The Water Quality Regulations (WQR), Regulation and Supervision Bureau-Abu Dhabi, **4**, http://rsb.gov.ae/, Accessed on: 15 Dec. 2016.
[25] American Public Health Association (APHA), American Water Works Association (AWWA) & Water Environment Federation (WEF), *Standard Methods for the Examination of Water and Wastewater,* **22**, APHA Publication: Washington D.C., 2012.