Desalination and Water Treatment
www.deswater.com

doi: 10.5004/dwt.2017.20320

65 (2017) 208–214
February

Microbial, chemical and physical properties of drinking water in Bushehr distribution network system

Alireza Raeisi[a], Farshid Soleimani[b], Sina Dobaradaran[b,c,d,*], Mozhgan Keshtkar[b], Vahid Noroozi Karbasdehi[b]

[a]*The Persian Gulf Tropical Medicine Research Center, The Persian Gulf Biomedical Sciences Research Institute, Bushehr University of Medical Sciences, Bushehr, Iran, email: darman719@yahoo.com*
[b]*Department of Environmental Health Engineering, Faculty of Health, Bushehr University of Medical Sciences, Bushehr, Iran, emails: sina_dobaradaran@yahoo.com (S. Dobaradaran), f.soleimani72@yahoo.com (F. Soleimani), keshtkar_m88@yahoo.com (M. Keshtkar), noroozivahid66@yahoo.com (N. Karbasdehi)*
[c]*The Persian Gulf Marine Biotechnology Research Centre, The Persian Gulf Biomedical Sciences Research Institute, Bushehr University of Medical Sciences, Boostan 19 Alley, Imam Khomeini Street, Bushehr, Iran, Tel./Fax: +98 7514763448, email: s.dobaradaran@bpums.ac.ir*
[d]*Systems Environmental Health, Oil, Gas and Energy Research Center, The Persian Gulf Biomedical Sciences Research Institute, Bushehr University of Medical Sciences, Bushehr, Iran*

Received 12 June 2016; Accepted 28 October 2016

ABSTRACT

Due to importance of drinking water quality in distribution network, this study was carried out to give a clear view of physical, chemical and microbial quality of drinking water of distribution network in Bushehr. In this cross-sectional descriptive study, 50 samples were taken from 10 stations of drinking water distribution network (5 times from every station). The mean values of physical, chemical and microbial parameters of drinking water in distribution network were as follows: turbidity (0.274 NTU), electrical conductivity (1,149.3 μS/cm), pH (7.12), total hardness (458), calcium hardness (390.9), magnesium hardness (68), alkalinity (171.5) mg/L $CaCO_3$, magnesium (16.95), calcium (156), residual chlorine (0.63), chloride (83.26), fluoride (0.48), iron (0.11), phosphate (0.053), nitrite (0.0026), nitrate (3.08), sulfate (728.4), TDS (577.66) mg/L, heterotrophic plate counts (HPC; 299.8 CFU/mL), total coliform (0) and fecal coliform (0). Results of the present study revealed that except TDS, sulfate, and HPC (14% of samples) the mean concentration levels of all examined parameters in drinking water of distribution network in Bushehr generally complied with the Iranian National Regulation (INR), EPA and WHO drinking water guidelines.

Keywords: Bushehr; Drinking water; Distribution network; Physicochemical and microbial quality

1. Introduction

Availability of safe drinking water is a basic need for human health and health conservation [1–3]. Many human illnesses are pertinent to deficiency of secure and hygienic water. Today, it is estimated that about 450 million people suffer from water shortages worldwide [4]. The gradual increase of pollution, changing nature of water resources pollutants, moving sources from consumption points, extent of water transmission lines and water distribution networks is followed by a gradual decrease in water quality [5]. Supply of drinking water is important for the development of any country, but when polluted it may become the source of undesirable materials hazardous to human health [6]. Drinkable water supports public health and ensures economic growth [7]. About 80% of infant mortality worldwide occurs due to gastrointestinal diseases such as diarrhea following drinking of unsafe water [8].

* Corresponding author.

Physical, chemical and microbial parameters of drinking water may affect its safety and consumer's consent [1,9,10]. The main requirements for drinking water are that it should be free from pathogenic organisms, containing no compounds that have a harmful effect in the short or long term on human health [3]. Due to the WHO and European Council guidance, a concentration of microorganisms, parasites or substances sparking a conceivable risk to human health has to be prevented [9,11]. Drinking water contaminated with animal and human fecal is the major way of transmitting pathogens to human beings. Alternative water supply, shortage of chlorination and sewer flooding seem to be associated with self-reported illness [12,13]. The provision of safe drinking water is one of the important principles of drinking water supply structure. Therefore, the monitoring of drinking water from source to consumption is an important step toward health safety [2]. Water supply in Bushehr city is carried out by piped distribution network. The main source of portable water for urban communities in this city is surface water. The aims of this study were to investigate the physical, chemical and microbial properties of drinking water from distribution network in Bushehr city, Iran, and compare measured properties with the Iranian National Regulation (INR), EPA and WHO guidelines for drinking water.

2. Materials and methods

2.1. Sample collection

Water samples were collected from 10 stations (5 times from every station) in Bushehr, Iran. Each sample was taken directly from tap water. All microbial samples were collected in 250 ml sterile containers, placed in an icebox at 4°C and immediately transported to the laboratory. Physicochemical samples were also collected in plastic containers.

2.2. Chemical and physical analysis

Electric conductivity (EC) and turbidity were measured using Greisinger-GLM020 electrical conductivity meter and LUTRON-2016 turbidity meter, respectively. Residual chlorine level and pH were measured by using DPD colorimetric kit test and pH meter, respectively. Hardness and chloride were measured by standard method [14]. Spectrophotometric method was used for analyses of F^- (570 nm), Fe^{2+} (510 nm), NO_2^- (507 nm), NO_3^- (400 nm), SO_4^{2-} (450 nm) and PO_4^{2-} (890 nm), using a DR/2000 spectrophotometer (HACH Company, USA).

2.3. Microbial analysis

To determine heterotrophic bacteria, heterotrophic plate culture technique, following the standard method, was used [11]; 0.1 ml water samples were spread on to R2A agar plates and incubated at 35°C for 48 h; and colonies were counted using a Scan 100 Interscience colony counter, and results reported as CFU/mL. For total coliform (TC) and fecal coliform (FC) analysis, 100 ml of collected samples were subjected to multiple-tube fermentation method [15]. Lactose broth and brilliant green bile lactose were used for the determination of TC (incubated at 35.5°C ± 0.5°C for 48 h) while brilliant green bile lactose was used for the determination of FC (incubated at 44.5°C ± 0.2°C for 24 h) and the results were reported as Most Probable Number per 100 mL (MPN/100 ml). Statistical analyses were carried out by using SPSS software (Version 16) and Microsoft Excel 2013. The results were expressed as mean ± SD and mean value of each parameter was compared with national and international guidelines for drinking water.

3. Results and discussion

The EPA, WHO and INR guideline values for physicochemical and microbial parameters of drinking water are presented in Table 1.

The measured physicochemical parameters of drinking water distribution network are presented in Tables 2 and 3. The mean level value of pH in this study ranged from 7.04 to 7.22. EC, TDS and turbidity analyses showed that the mean level values of these parameters ranged from 1,108.2 to 1,218 μS/cm, 554.1 to 609 mg/L and 0.08 to 0.61 NTU, respectively. In a study, the mean level values of pH, EC and TDS in tap water samples were 6.54, 35.6 μS/cm and 20 mg/L [16].

Table 1
EPA, WHO, and INR guidelines for drinking water

Drinking water quality guidelines			
EPA[a]	WHO[b]	INR[c]	
EC, μS/cm	ND	ND	1,500
pH	6.5–8.5	ND	6.5–9
Turbidity, NTU	5	ND	5
Residual chlorine, mg/L	ND	ND	ND
TDS, mg/L	500	500	1,500
Ca^{2+}, mg/L	ND	ND	ND
Mg^{2+}, mg/L	30[d]	ND	ND
Cl^-, mg/L	250	ND	400
Fe, mg/L	0.3	ND	0.3
F^-, mg/L	4	1.5	1.5
NO_3^-, mg/L	45	50	50
NO_2^-, mg/L	0.3	3	3
SO_4^{2-}, mg/L	250	ND	ND
PO_4^{2-}, mg/L	ND	ND	ND
Alkalinity, mg/L as $CaCO_3$	ND	ND	ND
Bicarbonate, mg/L as $CaCO_3$	ND	ND	ND
Total hardness, mg/L as $CaCO_3$	ND	ND	500
Ca hardness, mg/L as $CaCO_3$	ND	ND	250
Mg hardness, mg/L as $CaCO_3$	ND	ND	50
Total coliform, MPN/100 mL	0	0	0
Fecal coliform, MPN/100 mL	0	0	0
HPC, CFU/ml	500	500	500

[a]US Environmental Protection Agency guideline for drinking water (maximum admissible concentration).
[b]World Health Organization guideline for drinking water (maximum admissible concentration).
[c]Iranian National Regulation guideline for drinking water (maximum admissible concentration).
[d]Desirable admissible concentration.
ND – Not determined.

Table 2
Mean level values of measured physicochemical parameters of drinking water in distribution network

Station	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	SO_4^{2-} (mg/L)	Cl^- (mg/L)	F^- (mg/L)	Fe (mg/L)	NO_3^- (mg/L)	NO_2^- (mg/L)	TDS (mg/L)	pH
1	148.64 ± 11.19	17.25 ± 2.4	686.36 ± 133.72	80.57 ± 21.13	0.43 ± 0.07	0.12 ± 0.1	2.97 ± 0.47	0.002 ± 0.001	566.1 ± 51.32	7.1 ± 0.21
2	150.88 ± 14.42	14.86 ± 3.4	655.63 ± 120.45	79.37 ± 22.54	0.44 ± 0.11	0.06 ± 0.01	3.06 ± 0.47	0.002 ± 0.0008	556.8 ± 40.13	7.04 ± 0.13
3	149.92 ± 11.35	16.45 ± 2.77	656.48 ± 72.21	80.87 ± 21.077	0.45 ± 0.07	0.11 ± 0.1	2.86 ± 0.3	0.003 ± 0.001	558.8 ± 52.99	7.2 ± 0.22
4	147.16 ± 10.03	16.75 ± 1.14	633.73 ± 99.56	79.37 ± 21.32	0.42 ± 0.07	0.16 ± 0.11	2.51 ± 0.61	0.001 ± 0.001	554.1 ± 51.51	7.1 ± 0.21
5	156 ± 17.34	15.96 ± 2.02	680.38 ± 165.68	72.47 ± 20.27	0.43 ± 0.05	0.36 ± 0.61	2.66 ± 0.49	0.005 ± 0.004	577.7 ± 56.49	7.04 ± 0.13
6	163.68 ± 5.01	17.45 ± 0.93	898.58 ± 125.22	88.27 ± 16.62	0.52 ± 0.08	0.06 ± 0.03	3.51 ± 0.14	0.002 ± 0.0008	601.5 ± 34.97	7.08 ± 0.21
7	159.84 ± 8.06	19.85 ± 4.11	822.34 ± 107.36	84.97 ± 18.09	0.59 ± 0.11	0.06 ± 0.02	3.54 ± 0.3	0.003 ± 0.0008	588.7 ± 35.25	7.14 ± 0.15
8	163.36 ± 12.69	17.25 ± 1.43	807.54 ± 101.96	86.17 ± 19.33	0.54 ± 0.05	0.06 ± 0.05	3.42 ± 0.65	0.003 ± 0.001	581 ± 43.89	7.22 ± 0.16
9	159.36 ± 9.11	21.14 ± 7.26	807.26 ± 69.73	85.57 ± 17.88	0.45 ± 0.08	0.04 ± 0.004	2.94 ± 0.47	0.003 ± 0.00	583.7 ± 24.69	7.16 ± 0.13
10	164 ± 7.1	16.95 ± 3.9	635.49 ± 220.73	84.97 ± 17.46	0.51 ± 0.1	0.05 ± 0.01	3.36 ± 0.18	0.002 ± 0.005	609 ± 40.18	7.16 ± 0.13
Mean ± SD	156 ± 6.65	16.95 ± 2.39	728.4 ± 9.57	83.26 ± 19.57	0.48 ± 0.058	0.11 ± 0.096	3.08 ± 0.36	0.0026 ± 0.01	577.66 ± 18.95	7.12 ± 0.062

Table 3
Mean level values of measured physicochemical parameters of drinking water in distribution network

Station	Total hardness (mg/L $CaCO_3$)	HCO_3^- (mg/L $CaCO_3$)	EC (μS/cm)	Ca hardness (mg/L $CaCO_3$)	Mg hardness (mg/L $CaCO_3$)	PO_4^{3-} (mg/L)	Turbidity (NTU)	CO_3^{2-} (mg/L $CaCO_3$)	Alkalinity (mg/L $CaCO_3$)	Residual chlorine (mg/L)
1	440.8 ± 30.25	180 ± 12.24	1,132.2 ± 102.64	371.6 ± 27.97	69.2 ± 9.65	0.05 ± 0.01	0.5 ± 0.7	0.0 ± 0.0	180 ± 12.24	0.48 ± 0.08
2	436.8 ± 45.86	176 ± 13.87	1,113.6 ± 80.27	377.2 ± 36.07	59.6 ± 13.66	0.06 ± 0.02	0.27 ± 0.37	0.0 ± 0.0	176 ± 13.87	0.56 ± 0.08
3	440.8 ± 35	172 ± 5.7	1,117.6 ± 105.98	374.8 ± 28.37	66 ± 11.33	0.05 ± 0.01	0.27 ± 0.41	0.0 ± 0.0	172 ± 5.7	0.48 ± 0.28
4	437.6 ± 29.3	174 ± 15.66	1,108.2 ± 103.03	370.4 ± 25.07	67.2 ± 4.6	0.03 ± 0.01	0.61 ± 0.95	0.0 ± 0.0	174 ± 15.66	0.7 ± 0.07
5	454 ± 48.33	170 ± 12.24	1,155.4 ± 112.98	390 ± 43.35	64 ± 8.12	0.06 ± 0.02	0.26 ± 0.58	0.0 ± 0.0	170 ± 12.24	0.64 ± 0.05
6	479.2 ± 10.63	170 ± 12.24	1,203 ± 69.94	409.2 ± 12.53	70 ± 3.74	0.04 ± 0.02	0.08 ± 0.18	0.0 ± 0.0	170 ± 12.24	0.54 ± 0.15
7	479.2 ± 16.4	168 ± 9.08	1,177.4 ± 70.5	399.6 ± 20.16	79.6 ± 16.51	0.07 ± 0.02	0.14 ± 0.31	0.0 ± 0.0	168 ± 9.08	0.72 ± 0.08
8	477.6 ± 36.75	170 ± 9.35	1,162 ± 87.79	408.4 ± 31.73	69.2 ± 5.76	0.06 ± 0.04	0.29 ± 0.33	0.0 ± 0.0	170 ± 9.35	0.68 ± 0.08
9	483.2 ± 35.73	171 ± 8.94	1,167.4 ± 49.39	398.4 ± 22.77	84.8 ± 29.14	0.05 ± 0.02	0.18 ± 0.4	0.0 ± 0.0	171 ± 8.94	0.68 ± 0.04
10	460.4 ± 35	164 ± 8.2	1,218 ± 80.37	410 ± 17.88	50.4 ± 20.94	0.06 ± 0.05	0.14 ± 0.29	0.0 ± 0.0	164 ± 8.2	0.7 ± 0.07
Mean ± SD	458 ± 18.12	171.5 ± 4.4	1,149.3 ± 38.6	390.9 ± 16.25	68 ± 9.57	0.053 ± 0.012	0.274 ± 0.165	0.0 ± 0.0	171.5 ± 4.4	0.618 ± 0.1

In another study, the mean level values of turbidity, TDS and pH are 0.4–2.5 NTU, 99.6– 445.7 mg/L and 7.3–8.4, respectively [17]. The mean values of EC and turbidity met EPA, WHO and INR guidelines for drinking water but in the case of TDS, the mean values were higher than EPA and WHO guidelines.

The total hardness of water may range from trace amounts to hundreds of milligrams per liter [18]. EPA and WHO have not set a guideline value for total hardness, but the INR has set a guideline value of 500 mg/L $CaCO_3$ for total hardness in drinking water [19]. The value of total hardness in the present study ranged from 392 to 536 mg/L $CaCO_3$.

Calcium and magnesium cations make water hard. Both of these elements are necessary for the human body. Calcium is a part of bones and teeth and plays a role in neuromuscular excitability (decreases it). Magnesium plays a main role as a cofactor and activator of more than 300 enzymatic reactions [20–22]. The recommended calcium and magnesium daily intake for adults ranges between 700 and 1,000, and 300 and 400 mg, respectively [22,23]. The mean concentration levels of calcium and magnesium hardness in the present study ranged from 370.4 to 410 and 50.4 to 84.8 mg/L $CaCO_3$, respectively. Results showed that the concentration levels of calcium and magnesium ranged from 134.4 to 184 and 21.14 to 14.86 mg/L, respectively. In a study, El-Harouny et al. [24] reported the mean concentration levels of calcium and magnesium in tap water were 9.43 and 13.61 mg/L, respectively. According to the hardness classification for drinking water [25], 62% of the drinking water samples in the present study were considered as hard, and 38% as very hard water. In Fard et al. [1] study in Bushehr, 2% of the bottled drinking water samples were considered as soft, 10% as moderately hard, 54% as hard and 34% as very hard water. Comparison of Fard et al [1] results and present study showed that drinking water samples from distribution network had higher hardness compare with commercial bottled drinking water samples in Bushehr.

The mean concentration level of alkalinity in the present study was ranged from 164 to 180 mg/L $CaCO_3$. Analyses of carbonate and bicarbonate showed that amount of CO_3^{2-} in all samples was equal to zero (0 mg/L), and the mean concentration level of HCO_3^- was between 164 and 180 mg/L $CaCO_3$.

High concentration levels of nitrate and nitrite in water or food can affect the health of consumers especially in the case of children. The mean concentration levels of nitrate and nitrite were 3.08 and 0.0026 mg/L, respectively. The mean concentration levels of nitrate and nitrite in commercial bottled drinking water available in Bushehr were also 3.68 and 0.14 mg/L, respectively [1]. Therefore, drinking water sources in Bushehr including drinking water of distribution network and commercial bottled drinking water met EPA, WHO and INR guidelines for drinking water, and there were no concerns regarding concentration levels of nitrate and nitrite in Bushehr.

Analysis of residual chlorine showed that the mean concentration level was 0.48–0.72 mg/L. In Majdi et al. study, 66.7% of chlorine residual of water had standard rate (0.5–0.8 mg/L), and 33.3% of the cases were higher or lower than the standard [26,27].

EPA and INR set a 0.3 mg/L guideline value for iron in drinking water [19,28]. Exposure to excess iron levels may be the cause for wide range of common diseases, also may be the cause for corrosion of the pipes in drinking water distribution network [29]. The concentration levels of iron in drinking water of distribution network in this study were found between 0.03 and 1.47 mg/L with a mean concentration level of 0.11 mg/L. Therefore, except one station, other stations of this study met the INR, EPA and WHO guidelines [28,29]. In Chinedu et al. study, the mean content of iron in tap water were 0.077 mg/L [16].

Fluoride is widely distributed in the environment and is therefore of special concern. Excess fluoride intake can cause a wide range of adverse health effects [30–34]. In this regard, various studies in Iran have reported the occurrence of high fluoride concentration levels in drinking water [35–39], air, fish, herbal distillates and sea [40–43] as well as in connection with its removal from high-F waters [44–50]. The concentration levels of fluoride in this study were found between 0.02 and 0.16 mg/L with a mean concentration level of 0.48 mg/L. The concentration levels of sulfate ion in this study were found between 257.08 and 1,104.55 mg/L with a mean concentration level of 728 mg/L. The concentration levels of chloride ion in this study were found between 57.98 and 117.46 mg/L with a mean concentration level of 83.26 mg/L. The maximum mean concentration levels of sulfate and chloride ions were 898.58 and 88.27 mg/L, respectively. All results of chloride measurements met the maximum admissible concentration set by EPA guideline, but all results of sulfate measurements were greater than of maximum admissible concentration set by EPA guideline [28]. Among all examined physicochemical parameters that were measured in this study, only two parameters including TDS and sulfate had higher concentration levels than their safety guidelines (Table 1).

The results of heterotrophic plate counts (HPC), FC and TC measurements of all samples are presented in Table 4. The results of HPC measurements compared with the EPA, WHO and INR guidelines in Fig. 1. Table 5 shows the distribution of HPC in drinking water distribution network.

The results of all FC and TC measurements were negative. In other words, all of the drinking water in distribution

Table 4
Microbiological quality (mean ± SD) of drinking water in distribution network

Stations	Microbiological properties of drinking water in distribution network		
	Total coliform (MPN/100 mL)	Fecal coliform (MPN/100 mL)	HPC (CFU/mL)
1	0 ± 0.0	0 ± 0.0	386 ± 302.2
2	0 ± 0.0	0 ± 0.0	236 ± 324.23
3	0 ± 0.0	0 ± 0.0	252 ± 137
4	0 ± 0.0	0 ± 0.0	436 ± 561.67
5	0 ± 0.0	0 ± 0.0	214 ± 97.1
6	0 ± 0.0	0 ± 0.0	224 ± 130.69
7	0 ± 0.0	0 ± 0.0	310 ± 207
8	0 ± 0.0	0 ± 0.0	238 ± 44.38
9	0 ± 0.0	0 ± 0.0	444 ± 269.59
10	0 ± 0.0	0 ± 0.0	358 ± 305.07
Mean ± SD			299.8 ± 89.38

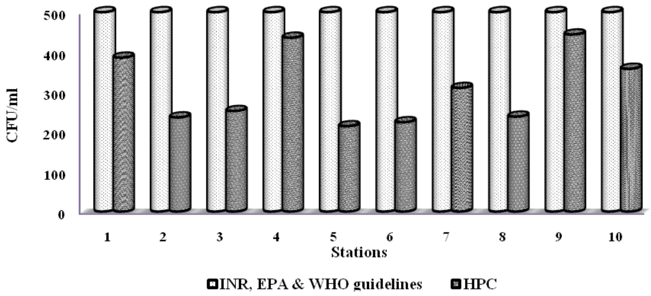

Fig. 1. Mean of the HPC counts compared to HPC guidelines for drinking water.

Table 5
Distribution of HPC in drinking water distribution network

HPC (CFU/mL)	Number of positive sample (percentage of positive sample)
<1	0 (0.0%)
1–500	43 (86%)
>500	7 (14%)
Range	30–900

network samples were found free from coliforms and met the INR, EPA and WHO guidelines (0 MPN/100 mL) [15,29,51]. As shown in Table 5, the results showed that 86% of all drinking water samples contained HPC within a range of 1–500 CFU/mL and 14% of samples contained a value higher than 500 CFU /mL. Therefore, 86% of samples in this study met the INR, EPA and WHO regulations [15,28,29].

4. Conclusion

Results of the present study demonstrated that except TDS, sulfate and HPC (14% of samples), all mean concentration levels of parameters examined in drinking water from distribution network in Bushehr generally complied with current drinking water guidelines based on their bacterial and physiochemical properties. Nevertheless, high TDS and sulfate content may increase diarrhea risk in consumer as well as corrosive effect of water. Finally, it should be noted that due to health care and prevention of related drinking water diseases the quality of drinking water in distribution network must be monitored continuously. Continuous monitoring and its results can be useful for policy makers, managers, stakeholders, companies, agencies, institutes and all that working in the fields of water to prepare safe drinking water.

Acknowledgment

The authors are grateful to the Bushehr University of Medical Sciences for financial support.

References

[1] E.S. Fard, S. Dobaradaran, R. Hayati, Chemical, microbial and physical evaluation of commercial bottled drinking water available in Bushehr city, Iran, Fresen. Environ. Bull., 24 (2015) 3836–3841.

[2] S. Völker, C. Schreiber, T. Kistemann, Drinking water quality in household supply infrastructure—a survey of the current situation in Germany, Int. J. Hyg. Environ. Health, 213 (2010) 204–209.

[3] WHO, Water Health and Human Rights, World Water Day, 2001. Available at: http://www.worldwaterday.org/themtic/hmnrights

[4] C. Guler, Evaluation of maximum contaminant levels in Turkish bottled drinking waters utilizing parameters reported on manufacturer's labeling and government-issued production licenses, J. Food Compos. Anal., 20 (2007) 262–272.

[5] K. Godini, K. Sayehmiri, G. Alyan, S. Alavi, R. Rostami, Investigation of microbial and chemical quality of bottled waters distributed in Ilam (Wester Iran), 2009–10, J. Ilam Univ. Med. Sci., 20 (2010) 33–37. [Persian]

[6] S. Dobaradaran, A.H. Mahvi, R. Nabizadeh, A. Mesdaghinia, K. Naddafi, M. Yunesian, N. Rastkari, S. Nazmara, Hazardous organic compounds in groundwater near Tehran automobile industry, Bull. Environ. Contam. Toxicol., 85 (2010) 530–533.

[7] M. Mohsin, S. Safdar, F. Asghar, F. Jamal, Assessment of drinking water quality and its impact on residents health in Bahawalpur city, Int. J. Humanit. Soc. Sci., 3 (2013) 114–128.

[8] J.M. Balbus, M.E. Lang, Is the water safe for my baby? Pediatr. Clin. of North Am., 48 (2001) 1129–1152.

[9] WHO, Guidelines for Drinking Water Quality, Vol. 1, 3rd ed., Geneva, 2008.

[10] M.S. Ngari, W.T. Wangui, N.S. Ngoci, W.J. Mavura, Physicochemical properties of spring water in Kabare and Baragwi locations, Gichugu Division Kirinyaga County of Kenya, Int. J. Sci. Res., 2 (2013) 280–285.

[11] M.D. Sobsey, S. Bartram, Water quality and health in the new millennium: the role of the World Health Organization guidelines for drinking water quality, Forum Nutr., 56 (2003) 396–405.

[12] E. Emmanuel, M.G. Pierre, Y. Perrodin, Groundwater contamination by microbiological and chemical substances released from hospital wastewater and health risk assessment for drinking water consumers, Environ. Int., 35 (2009) 718–726.

[13] S.S. Abu-Amr, M.M. Yassin, Microbial contamination of the drinking water distribution system and its impact on human health in Khan Yunis Governorate, Gaza Strip: seven years of monitoring (2000-2006), Public Health, 122.11 (2008) 1275–1283.

[14] APHA – American Public Health Association, Standard Methods for the Examination of Water and Wastewater, 21th ed., APHA, AWWA, WEF, Washington, D.C., 2008.

[15] Detection and Enumeration of Coliform Organisms in Water by Multiple Tube Method, ISIRI No. 3759 Institute of Standards and Industrial Research of Iran, 2008. Available from: http://www.isiri.org/portal/files/std/3759.htm. [Persian]

[16] S.N. Chinedu, O. Nwinyi, A.Y. Oluwadamisi, V.N. Eze, Assessment of water quality in Canaanland, Ota, Southwest Nigeria, Agric. Biol. J. North Am., 2 (2011) 577–583.

[17] A. Fadaei, M. Sadeghi, Evaluation and assessment of drinking water quality in Shahrekord, Iran, Resour. Environ., 4 (2014) 168–172.

[18] M.A. Saleh, E. Ewane, J. Jones, B.L. Wilson, Chemical evaluation of commercial bottled drinking water from Egypt, J. Food Compos. Anal., 14 (2001) 127–152.

[19] Drinking Water – Physical and Chemical Specifications, ISIRI No. 1053 Institute of Standards and Industrial Research of Iran, 2008. Available from: http://www.isiri.org/Portal/Home/Default.aspx?CategoryID=cab3ebf1-95d7-4813-b28cc5fc205c35b3

[20] F. Kožíšek, Health significance of drinking water calcium and magnesium, Natl. Inst. Public Heal. Czech Repub., 1 (2003) 219–227.

[21] C. Derry, D. Bourne, A. Sayed, The relationship between the hardness of treated water and cardiovascular disease mortality in South African urban areas, S. Afr. Med. J., 77 (1990) 522–524.

[22] M.P. Sauvant, D. Pepin, Drinking water and cardiovascular disease, Food Chem. Toxicol., 40 (2002) 1311–1325.

[23] Committee on Dietary Reference Intake, Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride, National Academy Press, Washington, D.C., 1997.

[24] M. El-Harouny, S. El-Dakroory, S. Attalla, N. Hasan, R. Hegazy, Chemical quality of tap water versus bottled water: evaluation of some heavy metals and elements content of drinking water in Dakhlia Governorate - Egypt, Internet J. Nutr. Wellness, 9 (2010) 7.

[25] M. van der Aa, Classification of mineral water types and comparison with drinking water standards, Environ. Geol., 44 (2003) 554–563.

[26] Institute of Standards and Industrial Research of Iran, Drinking Water, Chemical and Physical Properties, National Iranian Standard No. 1053, 5th Revision, 2009. Available from: http://markazsalamat.behdasht.gov.ir/uploads/1053_ 180364.pdf (Accessed on 2 June 2015).

[27] H. Majdi, L. Gheibi, T. Soltani, Evaluation of physicochemical and microbial quality of drinking water of villages in Takab Town in West Azerbaijan in 2013, J. Rafsanjan Univ. Med. Sci., 14 (2015) 631–42. [Persian]

[28] EPA, Drinking Water Standards and Health Advisors, Office of Drinking Water, US Environmental Protection Agency, Washington, D.C., USA, 2012.

[29] WHO, Guidelines for Drinking Water Quality, 4th ed., World Health Organization Geneva, 2011. ISBN: 978 92 4 154815 1.

[30] B. Spittle, Dyspepsia associated with fluoridated water, Fluoride, 41 (2008) 89.

[31] A. Ostovar, S. Dobaradaran, M. Ravanipour, A. Khajeian, Correlation between fluoride level in drinking water and the prevalence of hypertension: an ecological correlation study, Int. J. Occup. Environ. Med., 4 (2013) 216–217.

[32] A. Rahmani, K. Rahmani, S. Dobaradaran, A.H. Mahvi, R. Mohamadjani, H. Rahmani, Child dental caries in relation to fluoride and some inorganic constituents in drinking water in Arsanjan, Iran, Fluoride, 43 (2010) 179–186.

[33] S. Dobaradaran, A.H. Mahvi, S. Dehdashti, D.R.V. Abadi, Drinking water fluoride and child dental caries in Dashtestan, Iran, Fluoride, 41 (2008) 220–226.

[34] Y.M. Shivarajashankara, A.R. Shivashankara, S.H. Rao, P.G. Bhat, Oxidative stress in children with endemic skeletal fluorosis, Fluoride, 34 (2001) 103–107.

[35] S. Dobaradaran, A.H. Mahvi, S. Dehdashti, Fluoride content of bottled drinking water available in Iran, Fluoride, 41 (2008) 93–94.

[36] S. Dobaradaran, A.H. Mahvi, S. Dehdashti, S. Dobaradaran, R. Shoara, Correlation of fluoride with some inorganic constituents in groundwater of Dashtestan, Iran, Fluoride, 42 (2009) 50–53.

[37] I. Nabipour, S. Dobaradaran, Fluoride concentrations of bottled drinking water available in Bushehr, Iran, Fluoride, 46 (2013) 63–64.

[38] M. Shams, S. Dobaradaran, S. Mazloomi, M. Afsharnia, M. Ghasemi, M. Bahreini, Drinking water in Gonabad, Iran: fluoride levels in bottled, distribution network, point of use desalinator, and decentralized municipal desalination plant water, Fluoride, 45 (2012) 138–141.

[39] V. Karbasdehi Noroozi, S. Dobaradaran, A. Esmaili, R. Mirahmadi, F. Faraji Ghasemi, M. Keshtkar, Data on daily fluoride intake based on drinking water consumption prepared by household desalinators working by reverse osmosis process, Data Brief, 8 (2016) 867–870.

[40] S. Dobaradaran, F. Fazelinia, A.H. Mahvi, S.S. Hosseini, Particulate airborne fluoride from an aluminium production plant in Arak, Iran, Fluoride, 42 (2009) 228–232.

[41] S. Dobaradaran, D.R.V. Abadi, A.H. Mahvi, A. Javid, Fluoride in skin and muscle of two commercial species of fish harvested off the Bushehr shores of the Persian Gulf, Fluoride, 44 (2011)143–146.

[42] I. Nabipour, S. Dobaradaran, Fluoride and chloride levels in the Bushehr coastal seawater of the Persian Gulf, Fluoride, 46 (2010) 204–207.

[43] M. Keshtkar, S. Dobaradaran, F. Soleimani, V. Noroozi Karbasdehi, M.J. Mohammadi, R. Mirahmadi, F. Faraji Ghasemi, Data on heavy metals and selected anions in the Persian popular herbal distillates, Data Brief, 8 (2016) 21–25.

[44] S. Dobaradaran, M.A. Zazuli, M. Keshtkar, S. Noshadi, M. Khorsand, F.F. Ghasemi, V.N. Karbasdehi, L. Amiri, F. Soleimani, Biosorption of fluoride from aqueous phase onto Padina sanctae crucis algae: evaluation of biosorption kinetics and isotherms, Desal. Wat. Treat., 57 (2016) 28405–28416.

[45] M.R. Boldaji, A.H. Mahvi, S. Dobaradaran, S. Hosseini, Evaluating the effectiveness of a hybrid sorbent resin in removing fluoride from water, Int. J. Environ. Sci. Technol., 6 (2009) 629–632.

[46] M. Shams, M. Qasemi, S. Dobaradaran, A.H. Mahvi, Evaluation of waste aluminum filling in removal of fluoride from aqueous solutions, Fresen. Environ. Bull., 22 (2013) 2604–2609.

[47] M.A. Zazouli, A.H. Mahvi, S. Dobaradaran, M. Barafrashtehpour, Y. Mahdavi, D. Balarak, Biosorption of fluoride from aqueous solution by modified *Azolla Filiculoides*, Fluoride, 47 (2014) 349–358.

[48] S. Dobaradaran, I. Nabipour, A.H. Mahvi, M. Keshtkar, F. Elmi, F. Amanollahzade, M. Khorsand, Fluoride removal from aqueous solutions using shrimp shell waste as a cheap biosorbent, Fluoride, 47 (2014) 253–257.

[49] S. Dobaradaran, M. Kakuee, A.R. Pazira, M. Keshtkar, M. Khorsand, Fluoride removal from aqueous solutions using Moringa oleifera seed ash as an environmental friendly and cheap biosorbent, Fresen. Environ. Bull., 24 (2015) 1269–1274.

[50] M. Keshtkar, S. Dobaradaran, I. Nabipour, A.H. Mahvi, F. Faraji Ghasemi, Z. Ahmadi, M. Heydari, Isotherm and kinetic studies on fluoride biosorption from aqueous solution by using cuttlebone obtained from the Persian Gulf, Fluoride, 49 (2016) 319–327.

[51] M. Zazouli, M. Safarpour Ghadi, A. Veisi, P. Habibkhani, Bacterial contamination in bottled water and drinking water distribution network in Semnan, 2012, J. Mazandaran Univ. Med. Sci., 22 (2013) 151–159.