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Analyzing chemical parameters of drinking water of urban water system – Kermanshah-Iran

Younes Sohrabi[1,2], Amir Hossein Nafez[1,2], Seyedeh Shadi Charganeh[3], Diyari Abdollahzadeh[1,2], Hamed Biglari[4]*

[1]*Students Research Committee, Kermanshah University of Medical Sciences, Kermanshah, Iran.*
[2]*Department of Environmental Health Engineering, School of Public Health, Kermanshah University of Medical Sciences, Kermanshah, Iran*
[3]*Students Research Committee, Zabol University of Medical Sciences, Zabol, Iran.*
[4*]*Department of Environmental Health Engineering, School of Public Health, Gonabad University of Medical Sciences, Gonabad, Iran*

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Chemical parameters of water determine if it is suitable for drinking. Drinking water that does not meet the standards from physical and chemical parameters viewpoint can cause irrevocable damages to the public health. The present study is an attempt to analyze chemical parameters of drinking water of water system of Kermanshah city. The study was carried out as a descriptive cross-sectional study in 2013. Nine physical and chemical parameters were examined in 80 specimens randomly collected from 16 water facilities in Kermanshah City-Iran. The samples were analyzed through descriptive method and the obtained results were compared with Iran and WHO water standards using Schoeller Diagram. The results showed that the samples met the standards with regard to pH, nitrate, nitrite, fluoride, total hardiness, calcium, and magnesium. As to the rest of the parameters, TDS and residual chlorine were 6.3% and 62.5% higher than the standards respectively. In addition, according to the categories of the diagram, qualitative parameters of the samples was at good condition. As shown by the findings, most of the chemical parameters under consideration were at standard range (IRIRAN water standard 1053). The results also indicated necessity of extending a routine water quality survey system to ensure quality of drinking water.

Keywords:chemical, water, drinking, urban, Kermanshah, Iran

INTRODUCTION

Water constitutes about 56% of body weight of living creatures, and doubtlessly, it is one of the most vital compounds of life on the earth [1]. According to The World Health Organization (WHO), water is one of the health development indices in the developing countries [2]. Supplying healthy drinking water to the whole world population by 2025 is an objective of WHO [3]. Access to health drinking water resources is a serious issue in many countries. As reported by WHO, 1.1billion suffer from lack of access to hygienic drinking water and 80% of children death due to digestive system diseases (e.g. diarrhea) is due to unhygienic drinking water [4, 5]. The drinking water supplied by public water system should meet national and international standards to preserve health and wellbeing in the society [6, 7]. Many elements found in the drinking water are needed for a healthy life; while, increase in concentration of these elements (e.g. Ni, Cd, Mn, Fe, C, Zn) might cause serious health problems [8]. Among the key physical and chemical parameters of drinking water are electrical conductivity, pH, total solid content, opaqueness, residual free chlorine, alkaline compounds, hardiness, chlrorous, calcium, magnesium, iron, nitrate, nitrite, sulfate, fluorine, and phosphate content. Lack or excessive amount of these elements threaten health and wellbeing of the consumer [9-11]. For instance, cavity is caused due to lack of fluorine, while extra fluorine intake causes dental-skeletal fluorosis, infertility, the Alzheimer's disease, nervous problems, and thyroid problems [12]. Extra nitrite content in drinking water might lead to methemoglobinemia in infants and formation of nitrosamine carcinogen compounds [13]. Increase in iron content of drinking water creates unpleasant taste, odor, color, and higher opaqueness [14]. High TDS content of water creates salty and unpleasant taste [12]. Drinking water with high sulfate and clorous or calcium carbonate causes indigestion and excessive mineral content causes severe diarrhea [15]. The main objective of doing water quality surveys is to preserve public health and wellbeing of the consumers [16]. Quality of water is one of the factors that are directly related to health and personal/public hygiene. Necessity of surveying quality of water and ensuring that the standards are met is of great importance [17]. Several studies have

To whom all correspondence should be sent:
E-mail:biglari.h@gmu.ac.ir

been conducted in different regions of Iran on quality of water. Ebrahimi et al. examined microbial-chemical quality of drinking water in Ravand city. They showed that calcium, magnesium, hardiness, and sulfate were higher than the standards [18]. Kalili examined total content of bio-carbon in drinking water system of Gorgan city and by examining 44 samples and concluded that the variable was at acceptable range [19]. A study by Dinarlou et al. to examine chemical quality of drinking water in Bandar Abbas showed that sulfate, chlorous, sodium, and total hardiness exceeded acceptable maximum level and nitrite, TDS, and calcium were higher than the preferred level [20]. Results of a study on the parameters of drinking water quality in Singaner villages in India by Yashbir (2010) indicated that quality of water was not acceptable and exceeded maximum level with regard to fluoride, nitrate, and alkaline compounds; the problem was due to synthetic and bio contaminators [21]. In addition, analyses of quality of drinking water in rural areas of Tian –China during rain and dry seasons showed trivial levels of contaminations so that iron, ammonium nitrogen, and coliform contents were higher than the standards (Wu-Yuan jia et al.) [22]. Taking into account increase of public awareness and higher attentions that is nowadays paid to qualitative and quantitative specifications of drinking water, quality of water has become one of the main measures of effectiveness of services and performance by the authorities. There is a growing needs for implementing routine water quality examination [1]. Quality of drinking water is directly related to and one of the main concerns of public health and wellbeing, which makes studying it an imperative necessity [23]. Given the above introduction, the present study is an attempt to examine physical and chemical specification of drinking water in reservoirs of Kermanshah City, Iran.

MATERIALS AND METHODS

The study was carried out as a descriptive cross-sectional work on drinking water reservoirs of Kermanshah City in 2013. The samples were collected from 16 reservoirs in the city. The experiments were performed for three time and totally 80 samples were collected. Sterilization of sample containers and handling were performed based on the standard guidelines [24]

Samples were collected in polyethylene bottles (1lit) and pH and residual chlorine were measured at the sampling sites. The whole sampling and measuring processes were performed according to the standards of water and sewage tests. Except for pH and residual chlorine, which were measured at the site, the rest of the parameters were measured either through titrimeter and spectrophotometer. Hardiness, calcium, and magnesium were measured through titrimetric method and other parameters such as nitrite and nitrate ions concentration and fluoride were measured using Hach spectrophotometer (ER4000u). Total dissolved solids (TDS) was measured by Hach conductivity-meter (C0150). All the measurements were performed as per Iran national water standard (105) and WHO standard. Statistical analyses were performed in EXCELL and SPSS-16 and mean scores were compared with Iran national standard 1053 and WHO standards [25, 23].

RESULTS

Mean score of concentration of each physical and chemical parameter was compared with Iran national standard (1053) and WHO standards. (Table 1).

Mean scores of physical and chemical parameters based on the sampling sites are listed in Table2.

Standard range of Schoeller diagram parameters is listed in Table 3. This table was used to determine quality of water samples.

In addition to national and international standards, other standards can be used to determine quality of drinking water, among them, Schoeller diagram is notable. Based on Schoeller classification, qualitative parameters of the water sample were at good condition (Table 4).

DISCUSSION

pH: The acceptable range of pH of drinking water based on Iran national standard and WHO standard is 6.5 – 8.5 (Table 1). Since the measurements indicated that this parameter was within the standard range, quality of the drinking water was at acceptable level as to PH. Mohammadi et al. reported that pH level of drinking water samples collected in Babol city was at standard range [23] and similar results was reported by Rajaie et al. in Birjand and Ghaen-Iran [26].

Table 1- Physical and chemical analysis of drinking water of urban reservoirs of Kermanshah water system

Physical and chemical parameters	Mean	Std. Deviation	Minimum ph	Maximum	Iran national standard (1053)		Standard WHO	Rate of the reservoirs within Iran standard range		
					Maximum desirable	Maximum permissible		Desirable (%)	Permissible (%)	More than the standard (%)
pH	6.8	0.19	(mg/l) Residual chlorine	7.3	6.5-8.5	6.5-9	6.5-8.5	100	0	0
(mg/l) Residual chlorine	0.88	0.34	TDS	1.8	-	0.8	-	0	37.5	62.5
TDS (mg/l)	418.38	545.14	(mg/l)	2456	1000	1500	500	93.7(15)	0	6.3(1)
Nitrate (mg/l)	16.4	6.3	Nitrate (mg/l)	31.5	0	50	10N	0	100(16)	0
Nitrate (mg/l)	0.026	0.084	Nitrate	0.33	0	3	<0/1	87.5(14)	12.5(2)	0
Fluoride (mg/l)	0.387	0.206	(mg/l)	0.8	0.5	1.5	2	68.7(11)	31.3(5)	0
Total hardness (mg/lCaCO3)	222.7	25.57	Fluoride	268	300	500	200	100(16)	0	0
Calcium (mg/l)	75.3	11.6	(mg/l)	96	300	400	75	100(16)	0	0
Magnesium(mg/l)	9.63	5.5	Total hardness	19.6	30	150	50	100(16)	0	0

Table 2- Mean scores of physical and chemical parameters based on the sampling sites

Sampling site	pH	Residual chlorine	TDS	Nitrate	Nitrite	Fluoride	Total hardness	Calcium	Magnesium
OlfatiNia	6.8	0.9	295.1	21.12	0.1	0.4	200	64	11
Mosala	6.8	1	2456	10.6	0.33	0.6	172	64	3.4
Ferdousi	7.1	1.8	337.1	19.8	0	0.4	268	80	19.6
Kousar	6.8	1	367	19.8	0	0.2	240	91	3.3
Pardis	6.7	0.6	303	21.5	0	0.2	240	80	11.7
Rezvan	7.1	0.1	329	31.5	0	0.8	228	84	4.6
Sarab Ghanbar	6.8	1	247	9.9	0	0.7	208	78	3.4
Jomhouri	6.8	0.5	276	21.12	0	0.2	200	67	9.1
Miandar band	6.8	0.8	266	8.3	0	0.4	212	57	19.5
Moalem	7.1	1	334	17.6	0	0.3	252	89	8
Takavar	7.3	0.8	245	17.2	0	0.3	208	67	11.4
Chaman	6.8	1	223	7.8	0	0.2	208	62	14.9
Shahid Nazari 2	6.8	1	237	18.4	0	0.2	240	96	5.7
Zafar	6.5	0.8	236	17	0	0.7	260	76	13.7
Shahid Nazari 1	6.8	1	236	11	0	0.2	220	83	3.4
Zamzam	6.8	0.9	307	11	0	0.4	208	67	11.4

Table 3- Range of the parameters of drinking water in Schoeller diagram (mg/l) [23, 26]

Parameter	Good	Acceptable	Average	Undesirable	Potable in emergency	Non-potable
pH	7.3	7.8	9	10	11	>11
Calcium	0-100	100-200	200-300	300-600	600-1000	>1000
Magnesium	0-70	70-120	120-200	200-400	400-800	>800
Sodium	0-100	100-220	220-470	470-920	920-1900	>1900
TDS	0-500	500-1000	1000-2000	2000-4000	4000-8100	>8100
Hardiness	0-250	250-500	500-1000	1000-2000	2000-4000	>4000
Chloride	0-190	190-380	380-800	800-1500	1500-3000	>3000
Sulfate	0-150	150-300	300-600	600-1200	1200-2200	>2200
Bicarbonate	0-200	200-300	300-600	600-1000	1000-2000	>2000

Table 4- Quality of drinking water samples based on Schoeller diagram parameters

Parameter	Good	Acceptable	Average	Undesirable	Potable in emergency	Non-potable
pH	100%	0	0	0	0	0
Calcium	100%	0	0	0	0	0
Magnesium	100%	0	0	0	0	0
TDS	93.7	0	0	6.3	0	0
Hardiness	100%	0	0	0	0	0

Table 5- Correlation coefficient between the physical and chemical parameters

	pH	Residual chlorine	TDS	Nitrate	Nitrite	Fluoride	Total hardness	Calcium	Magnesium
pH	1								
Residual chlorine	.082	1							
TDS	-.062	.091	1						
Nitrate	.303	-.417	-.204	1					
Nitrite	-.110	.087	.954(**)	-.184	1				
Fluoride	-.029	-.227	.276	.137	.273	1			
Total hardness	.049	.281	-.502(*)	.388	-.586(*)	-.064	1		
Calcium	.098	.089	-.233	.451	-.330	-.104	.671(**)	1	
magnesium	.028	.297	-.307	-.152	-.275	-.117	.264	-.494	

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Table 5 lists Pearson correlation coefficient between physical and chemical parameters.

Residual chlorine: average residual chlorine of the sample was 0.88mg/li so that this parameter was higher than the national standards in 62.5% of the samples (Table 1). Shabnkare et al. reported in their study that average residual chlorine was 0.6mg/l, which is acceptable as per Iran national standards [12].TDS: as listed in Table 1, TDS was between 223 and 2456mg/l and the mean score was 418.38mg/l. ZahediKalaki conducted a study on Behshar water reservoirs and reported that 1C^{o} increase in water temperature increased EC up to 2%. Therefore, during drought conditions when temperature is higher, higher TDS and EC levels are expectable [27]. National standard range of TDS is 1500mg/l; therefore, TDS of 6.3% of the samples in our study was higher than the standard. Rajaie et al. reported that TDS in 37% of the samples in Birjand and Ghaen was higher than the standard limits. [26].Nitrate and nitrite: variation range of nitrate was between 7.8 and 31.5mg/l with mean level of 16.4mg/l (Table 1). This parameter, in Rajaie et al.'s study, ranged from 5.01 to 48.1mg/l with mean level of 18.1mg/l [26]. Our results showed that nitrate level in all sites met the national standard range. Fazli and Sadeghi indicated that nitrate level in 11% of the drinking water samples collected from Zanjan City was higher than the standard range [28]. Our study showed that all the reservoirs met the standards with regard to nitrite level; while, Rajaie also reported consistent results [26]. Amouie et al. studied nitrate and nitrite concentration at different points of drinking water facilities in Babol City and indicated that these parameters in rural areas were equal with 2.7±4.4 and 0.04±0.02mg/li respectively at the grid and 8.3±5.3 and 0.03±0.035mg/li respectively at the consumption point; in addition, in urban areas, these parameters were 8±1.5 and 0.03±0.045gr/li respectively at the grid and 8.8±3.7 and 0.038±0.035gr/li respectively at the consumption point. They reported, also, that differences were significant only with regard to nitrate at the grid and consumption site in rural areas [29]. Nitrate and nitrite in drinking water grid of Bushehr city were at the ranges 2.51-3.51gr/l and 0.005-0.002gr/l respectively with total mean score of 3.08 and 0.003mg/li respectively [12].Fluoride: Several epidemiological studies have shown that absorption of fluoride through drinking water causes negative effects on skeletal tissue of human in long-run. Therefore, WHO announced 1.5mg/l as the acceptable level of this parameter. In this regard, Iran national standard indicates that the 0.5-1.5mg/li is an acceptable range [30, 31]. A study by Amouie et al. in rural areas of Khaf Village indicated that fluoride level ranged from 0.11 to 3.59mg/l so that 31% of the samples were less than the standard, 4% were higher than the standard, and 64% were at the standard range. [32].Total hardiness: the results indicated that this parameter was at the range 172-268mg/l so that all the samples met the standards in this regard (Table 1). Rajaie reported that this parameter was less than the standards in 25% of the samples and higher than the standards in another 25% of the samples [26]. Mohammadi et al. indicated that hardiness was at the range 238-578mg/li CaCO3, so that 25.7% of the samples were at desirable range, 69.2% were at acceptable range, and 5.13% were higher than the standard range [23]. Calcium and magnesium: Variation of calcium and magnesium was at ranges 57-96 and 3.3-19.6 respectively and mean value of these parameters were 75.3 and 9.6mg/l respectively. The results indicated that the level of calcium and magnesium at all sampling sites was at standard range. In Bushehr-Iran, calcium and magnesium levels were at the ranges 148.16-164mg/l and 12.56-21.14mg/l respectively; while mean scores of these parameters was 156.38 and 16.95mg/l respectively. [12].Categorization of the parameters based on Schoeller diagram.In addition to the national and international standards of quality of water, Schoeller diagram was used to examine quality of water in the category range of good,…, non-potable [3, 4]. As listed in Table 4, parameters pH, calcium, magnesium, and total hardiness were at good category of Schoeller diagram; 93.7% of TDS was in good category and 6.3% was at unacceptable category. Consistently, as reported by Rajaie et al. (Birjand and Ghaen) and Mohammadi et al. (Babol), qualitative parameters of the drinking water samples, based on Schoeller diagram, were at the range of good,…,average categories [23, 26].Correlation coefficient: as the results showed, there was positive correlation between TDS - nitrite, nitrate - calcium, and total hardiness – calcium and negative correlation between magnesium – calcium, nitrite-total hardiness, TDS- total hardiness, and residual chlorine-nitrate (Table 5).

CONCLUSION

In summary, parameters pH, nitrate, nitrite, fluoride, total hardiness, calcium, and magnesium were at acceptable range. In addition, 6.3% and 62.5% of the samples were higher than the standard range regarding TDS and residual chlorine. Studies have shown that high TDS of water causes unpleasant taste and appearance. However, in general, one may say that quality of drinking water in Kermanshah City causes no health problem with regard to the physical and chemical parameters under study. With regard to Schoeller diagram, the samples were at good category. Given importance and effectiveness of quality of drinking water, it is needed to design a routine monitoring system to ensure quality of the public drinking water.

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