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Survey of Microbial Quality of Drinking Water in Rural Areas of Kashan-Iran in Second Half of 2008

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Abstract: The objective of the study is surveying microbial quality of drinking water in Kashan rural areas and determining the rural population that using safe water in terms of microbial quality in second-half of 2008. In this cross-sectional study, microbial quality of water in all rural areas was determined in 3 stages based on 3 parameters as Total Coliforms, Fecal Coliforms and Heterotrophic Plate Count (HPC). The results of this study illustrates that 100.0, 47.71 and 92.99% population in under coverage and non under coverage areas of Kashan Rural Water and Wastewater Company (KRWWC) and all Kashan rural areas, respectively using safe water in terms of Fecal Coliforms and 98.4, 21.2 and 88.00% population in under coverage and non under coverage areas of KRWWC rural areas and all Kashan rural areas, respectively using safe water in terms of Total Coliforms. There is also a meaningful difference in microbial quality between under coverage and non-under coverage rural areas. The results of this study express that the fecal contamination in under coverage rural areas is excellent, but there is a bad condition in non-under coverage areas. Generally, the microbial quality in all Kashan rural areas is approximately equal to national microbial criteria. Its been also illustrated that the role of KRWWC in supplying safe drinking water in terms of microbial quality for rural population is very important.

Key words: Kashan rural areas, drinking water, microbial quality, kashan rural water and wastewater company

INTRODUCTION

The importance of water in disease transmission is one of the main concerns of world health organization (World Health Organization, 1976). According to international Organization report, 2.2 million people die every year due to lack of access to safe drinking water and 58% of these people live in small communities (WHO, 1999; Cortruvo *et al*., 1999) ADB/UNDP/UNESCAP/ WHO, 2006). However, inadequate quantity, poor quality of drinking water and poor sanitation are the main reasons in incidence and prevalence of diseases in the world, which are preventable (WHO, 2004a). In general, safe drinking water must not has hazard of infection or high unacceptable levels of chemical matters hazardous for health and must be accepted aesthetically for consumer. Initially, infectious hazards are those that may be caused by fecal contamination (WHO, 2004b).

Comprehensive evaluation of microbial quality of water requires survey of all pathogens that have potential for human infection. These pathogens can be classified into bacteria, viruses and protozoa (USEPA, 2001). However, the issues related to testing individual pathogens resulted to using some intestinal organism as indicator to estimate and determination of intestinal pathogens in environment (Crane *et al*., 1979). Indicator organisms such as total coliforms, fecal coliforms have the major application in the determination of drinking water quality. Although total coliforms are as indicator in the determination of water quality, but their resistance in the environment or distribution systems is a unreliable indicator of fecal coliform (WHO, 2004a). Then the microbial indicator is number of Fecal Coliform bacteria (FC) in water samples. Also, HPC is using as a public water quality indicator in distribution system (Bartrani *et al*., 2003). WHO drinking water quality guidelines and Iranian standards both recommend that FC must not exist in 100 mL of water sample (WHO, 2004a). In recent years, many studies have been conducted in certain location of Iran concerning drinking water quality, but report about rural areas water quality published only in 2006 (Ghanadi and Mohebi, 2008). The

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purpose of this study is surveying of drinking water quality of Kashan rural areas and also determining amount of population access to safe drinking water. Since some village of Kashan are not under the coverage of Kashan Rural Water and Wastewater Company (KRWWC), in addition, another aim of this study is determination the role of KRWWC in the safe drinking water supply by comparing water quality in these two groups of village.

MATERIALS AND METHODS

Studied area: Kashan has an area about 9647 km^2 and 335875 people, is in Esfahan province and is the second important city in this province (considering population). Kashan surrounded by Kavir desert from north and east and also by central mountain of Iran from south and west. According to KRWWC statistics, only 40 villages from 57 villages are under the coverage of this company and 17 villages are not. The total population of studied area is 22527 people that 19545 people live in villages under the coverage of this company and 3027 people don't.

Sampling and measuring methods: This study was a cross- sectional descriptive study which has been carried out from July to December 2009. In this study water microbial quality was analyzed by considering three parameters such as total Coliforms, Fecal Coliforms and Heterotrophic Plate Count (HPC). Common approach in determining amount of microbial safety of public water distribution systems is based on sampling strategies in consumption point or water faucet (Ainsworth, 2004). Therefore, sampling method is a critical factor in determination the microbial quality of distribution systems. Since according to drinking water standards (WHO, 2004a) the number of Coliforms and Fecal Coliforms must be zero in any situation, therefore sampling point was selected as the point with most likely sensitive to contamination and minimum disinfectants residual.

Thus, raw water supply and tap water were selected as sampling points. Microbial sampling was done according to standard No. 4208 of Institute of Standards and Industrial Study of Iran (ISIRI, 2007). Measurement of experiments No. 9221-B, 9221-E and 9215 presented in 20th edition of 'Standard Methods for the Examination of Water and Wastewater' (APHA/AWWA/WPCF, 2005).

Number of samples: As noted above, Kashan has 57 village. According to Iranian standard (ISIRI, 2007) two must be considered for sampling include raw water supply and distribution network (consumption point)

According to sampling standard (WHO, 1996) for microbial quality control of drinking water in village with population less than 5000 habitant, one sample per month required for each location. Thus a total sample of 342 number were taken and analyzed for mentioned parameters (57 village×3sample/village×2 location = 342 sample).

RESULTS

The purpose of this study is surveying drinking water microbial quality of Kashan rural areas and determination of amount accessibility level of people in these rural areas to safe drinking water. As noted above, village in Kashan divided to two groups: Village of Kashan Rural Water and Wastewater Company and village without coverage.

As shown in this Table 1 the mean number of positive samples for total coliform, feed coliform and HPC were 12.28, 4.63 and 5.8% as, respectively.

In Table 2-4 the drinking water quality at consumption points (Distribution network) for two types of kashan village as three microbial qualities has been illustrated. In 5% of villages with coverage of KWWRC water sample in consumption points was positive regarding to total coliform bacteria (Table 2). In addition, this result for village without coverage of KWWRC was shown in Table 3. Also, 7% of kashan rural population uses drinking water with HPC more than 500 cfu mL^{-1} (Table 4). Results of coverage status of drinking water in two types of kashan village for microbial quality shown in Table 5-7, fecal coliform bac test in total sample for all village with coverage of KWWRC were

Table 1: Positive microbial parameters of raw water sources in Kashan village during second half of year 2008

		Pos. total coliform bacteria		Pos. fecal coliform bacteria		HPC>500 cfu mL^{-1}	
Sampling stages	Total No. of village	No. of village (%)	Population served (person) (%)	No. of village (%)	Population served (person) (%)	No. of village (%)	Population served person (%)
First	57	7(14.89)	2765	2(3.5)	790	3(5.2)	1185
Second	57	7(12.28)	2765	3(5.2)	1185	3(5.2)	1185
Third	57	7(12.28)	2765	3(5.2)	1185	4(7)	1580
Mean	57	12.28	2765	4.63	1053	5.8	1316

Table 2: Positive microbial parameters in drinking water at consumption points in village with coverage ok KRWWC in second half of year

		Pos. total coliform		Pos. Fecal coliform		HPC>500 cfu mg^{-1}	
Sampling stages	No. of village	No. of village (%)	Population served (%)	No. of village (%)	Population served (%)	No. of village (%)	Population served (%)
First	40	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)
Second	40	2(5.00)	790 (3.5)	0(0.00)	0(0.00)	2(5.00)	790(3.5)
Third	40	4(10.00)	1580 (7)	0(0.00)	0(0.00)	1(2.50)	395(1.75)
Mean	40	2(5)	790 (5)	0.00	0.00	1(2.5)	395(2.5)

Table 3: Positive microbial parameters in drinking water at consumption points in village without coverage of KRWWC in second half year at 2008

		Pos. total coliform bacteria		Pos. Fecal coliform Bac.		HPC>500 cfu mL^{-1}	
Sampling stages	No. of village	No. of village(%)	Population served (%)	No. of village (%)	Population served	No. of village (%)	Population served (%)
First	17	5(29.41)	1975(29.4)	1(5.88)	395(5.88)	4(23.53)	1580(23.5)
Second	17	4(23.53)	580(23.5)	2(11.76)	790(11.76)	3(17.65)	1185(17.64)
Third	17	4(23.53)	1580(23.5)	4(23.53)	1580(23.5)	2(11.76)	790(11.76)
Mean	17	4.33(25.49)	1711(25.4)	2.33(13.72)	922(13.7)	3(17.65)	1185(17.64)

Table 4: Positive microbial parameters in drinking water at consumption points for total Kashan village

		Pos. total coliform		Pos. Fecal coliform		HPC>500 mL^{-1}	
Sampling stages	No. of village	No. of village (%)	Population served (%)	No. of village (%)	Population served (%)	No. of village (%)	Population served (%)
First	57	5(8.77)	1975(8.77)	1(1.75)	395(1.75)	4(7.02)	1580(7.01)
Second	57	6(10.53)	2370(10.52)	2(3.51)	790(3.51)	5(8.77)	1975(8.77)
Third	57	8(14.04)	3160(14.04)	4(7.02)	1580(7.01)	3(5.26)	1185(5.26)
Mean	57	6.33(11.11)	2502(11.11)	2.33(4.09)	922(4.09)	4(7.02)	1580(7.01)

Table 5: Results of coverage status of drinking water in kashan village regarding to total coliform Bac. test in consumption point

	Presence of coliforms bacteria in water consumption points (No. of sample)		
Village type	Positive	Negative	Total samples in three stages
With coverage	6 (5%)	114 (95%)	120
Without coverage	13(25.5%)	38(74.5%)	51
Fisher exact test p-value<0.0001			

Table 6: Results of coverage status of drinking water in kashan village regarding to fecal coliform Bac. test in consumption point

	Presence of Fecal coliforms bacteria in consumption points (No. of sample)		
Village type	Positive	Negative	Total samples in three stages
With coverage	0	120 (100%)	120
Without coverage	7(13.7%)	44 (86.3%)	51
Fisher exact test p-value<0.0001			

Table 7: Results of coverage status of drinking water in kashan village regarding to HPC Test in consumption point

	HPC in water samples in consumption points (No. of sample)		
Village type	<500 cfu mL^{-1}	>500 cfu mL^{-1}	Total samples in three stages
With coverage	117(97.5%)	3(2.5%)	120
Without coverage	42(82.3)	9(17.7%)	51
Fisher exact test p-value<0.0001			

negative. While for village without coverage of KWWRC in 7 samples this test were positive (Table 6), HPC test in 2.5% of sample in village without coverage were more than 500 cfu mL^{-1} (Table 7).

It is important to note that the criteria for microbial quality are Iranian national standards and also WHO drinking water guidelines and the results are provided based on population and number of villages.

DISCUSSION

The microbial quality of drinking water in consumption points in under and non under coverage villages were surveyed, since KRWWC has focus only on some of these rural areas.

According to Iranian drinking water standards, probable presence of fecal coliforms must be zero. In 2006, rural drinking water safety in view of microbial quality in countrywide in Iran, concerning indicator as absence of *E. coli* bacterial was 93.07% (Ghanadi and Mohebi, 2008), while 100% people in under coverage villages and only 47.71% people in non under coverage villages use safe drinking water in term of fecal coliform and generally 92.99% people in all rural areas in Kashan use safe drinking water in term of fecal coliform. For comparison, indicator for absence of fecal coliforms in drinking water was 88% in rural areas of saqqez, Iran (Ghaderpoori *et al*., 2009) and 61.1% in Northeastern

Trinidad (Welch *et al*., 2000). Moreover, 7% of household water samples were taken from rural and urban areas in Brazil was contaminated to Fecal Coliforms (Nogueira *et al*., 2003). Also, according to WHO guidelines, the indicator as absence of Fecal coliforms in drinking water of communities with population more than 5000 persons is 90%. Furthermore, the indicator as absence of Fecal Coliforms in all supply points of drinking water in Kashan was 94.3%, while this indicator in rural areas of Bangladesh was 61%. (Hoque *et al*., 2006).

Also, the results illustrates that 98.4% people in under coverage villages, 21.2% people in non under coverage villages and 88% people in all Kashan rural areas access to water without coliforms. Nonetheless, 83 and 79% of Total Coliforms bacteria tests was positive in drinking water of rural areas in Brazil (Nogueira *et al*., 2003) and Northeaster Trinidad (Welch *et al*., 2000), respectively Thus, the condition of areas with coverage is excellent concerning coliforms, but areas without coverage are in bad situation. In general, drinking water quality in all rural areas of Kashan is somewhat near to national criteria. The contamination of water source resulted to contamination of distribution system. Thus, two main reasons for contamination of distribution systems in these rural areas are: Water source contamination and absence of chlorine residue in distribution system.

The microbial quality in under coverage and non under coverage rural areas is significantly different (Table 5-7). On descriptive basis, water microbial quality in under coverage rural areas is better than those without coverage of KRWWC, then KRWWC has a considerable role in supplying safe drinking water in these rural areas. In a study on rural areas of Zanjan Iran, the important role of RWWC (rural water and wastewater company) for safe drinking water supply was demonstrated (Sadeghi *et al*., 2007). It's recommended that non under coverage areas at least become under the supervision of Quality Control Unit of KRWWC as soon as possible.

CONCLUSION

In this study the situation of drinking water microbial quality in consumption points and water sources of Kashan rural areas is presented. The results illustrates microbial quality of drinking water in under coverage rural areas is excellent and is unsuitable in non under coverage areas. The water microbial quality in all of these areas is near to national microbial criteria. Also, the results illustrates microbial quality in under coverage rural areas is better than those without coverage of KRWWC, indicates the important role of the company in providing safe drinking water.

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