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Study of Water Quality in Rural Regions of Northeastern Iran

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ABSTRACT

Background: Providing Safe drinking water is a prime concerninany community. This analytical study was carried out to evaluate the microbial quality of drinking water in rural areas of northeastern Iran.
Methods: The water microbial quality was determined in all villages (a population of 53047 people), in 3 rounds and based on 3 measurements, i.e. Total Coliform, Fecal Coliform, and Heterotrophic Plate Count. Census method was used for studying water distribution system too.
Results: Results of heterotrophic plate counts of over 500 were positive in 19 (19.8%) of the villages.Total coliforms were also detected in 37 (38.5%) of the villages. Water in villages receiving the services of Water and Wastewater Company had significantly lower levels of total and fecal coliforms contamination ($p<0.05$) compared to villages deprived of these services. In 4.3% of the villages where the Company delivered services, the HPC≥ 500 results were positive, while this percentage rose to 24.7% in other villages ($p = 0.03$).
Conclusion: Comparison of the results of this study with guidelines published by WHO, regarding the microbial quality of water in 2006, indicated that the the microbial quality of the drinking water in rural areas in Maraveh Tappeh is desirable but lower than the Iranian standard.

1. Introduction

Water quality is a very important issue in public health and health management. Although more than three fourths of the Planet Earth is covered with water, a limited part of it is available for health purposes and for drinking. In many parts of the world, access to safe drinking water resources is of special importance (1). Provision of safe drinking water is one of the important goals of human societies, and achieving development and progress is feasible if people in the society are safe. Clearly, people’s health depends on provision of desirable drinking water (2).

According to the report published by the World Health Organization, 1.1 billion people in the world do not have access to safe water resources (1). On average, 4500 children lose their lives every day due to unsafe drinking water, and 2.2 million people (85 percent of whom live in small communities) die every year because they do not have access to safe drinking water and water resources are contaminated with pathogens (3). In general, drinking water should not pose the danger of infections and should not contain unacceptable concentrations of substances dangerous to health to be considered safe. Fecal infections are the most important of the dangers related to drinking water (4, 5).

Comprehensive assessment of the microbial quality of water requires studying all pathogens that have the potential to infect people (6).

Indicator organisms such as total and fecal coliforms are most often taken into account in defining the microbial quality of drinking water.

Although total coliforms have been broadly used as the basis for assessing water quality, their ability to survive in drinking water distribution system has turned them into an unreliable indicator of fecal pollution (5). Recently, heterotrophic plate count (HPC) has been selected as the indicator of the general quality of drinking water in water distribution systems (7). Fecal coliform bacteria concentration is the basic indicator of microbial and biological quality of water samples. Iranian standards, and the guidelines of the World Health Organization regarding the bacterial and biological quality of drinking water, suggest that fecal coliforms should not be present in any 100- milliliter water sample (8, 9). In recent years, extensive studies have been carried out on drinking water quality in Iran. In the report published on the microbial quality indicator of drinking water in rural areas in Iran, it was stated that the indicator bacteria Escherichia coli should be absent in 93.07 percent of water samples (10). Study of the microbial quality of drinking water in rural areas of Kashan showed that drinking water in 13.72 percent of the villages that did not receive the services of Water and Wastewater Company was contaminated with fecal coliforms (11).

Microbial test of drinking water in rural areas of Sanandaj revealed that 7.7 percent water available to people living there is polluted with coliforms (12). In a study on the microbial quality of drinking water in Brazil, it was reported that 83 and 48 percent of water samples were contaminated with TC and FC, respectively (13).

Study of the microbial quality of drinking water in rural areas of Trinidad indicated that 79, 61.1, and 66.5 percent of water samples were polluted with TC, FC, and E coli, respectively (14).

In a study on water quality in rural areas of the state of Pennsylvania, it was shown that 33 percent of the samples taken from the wells were contaminated with total coliforms and 14 percent with E coli (15).

The purpose of this study was to investigate the microbial quality of drinking water in rural areas of northeastern Iran and to determine the extent of people's access in these areas to drinking water that is safe with respect to microbial pollution.

2. Materials and Methods

Given the geographical location of northeastern Iran, and because the villages are scattered, the cluster method of sampling was employed and one cluster was selected at random. The selected cluster was a region named Maraveh Tappeh. The water distribution systems in all villages of this region were then studied using the census method.

Maraveh Tappeh has an area of 3400 square kilometers and a population of 53047 people, and is a part of Golestan Province (Figure1). This region is bordered by the Republic of Turkmenistan to the north, Northern Khorasan Province to the east, Gonbad-e Qabus to the west, and the Alborz Mountain Range to the south. Based on statistics published by WW Company, this company provides services to only 23 out of the 96 villages in Maraveh Tappeh, 15 villages do not have water pipe networks, and 58 villages are deprived of the services of this Company. The total population in the studied villages was 44200 people, of whom 40250 lived in villages receiving the services of the Company and 3950 in villages deprived of these services. This cross-sectional study was conducted in the autumn of 2014 to determine the microbial quality of drinking water in the rural areas of northeastern Iran based on the three parameters of total coliforms, fecal coliforms, and heterotrophic plate count.

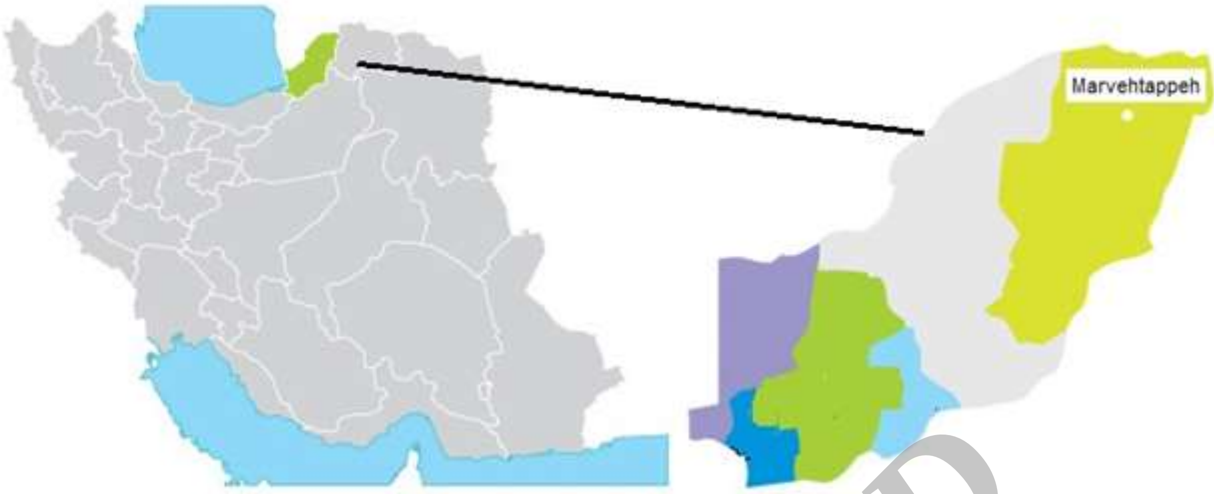

Fig.1: Maraveh Tappeh.

According to the standards, the total number of coliforms and fecal coliforms in tap water should be zero under all conditions (8, 9). Sampling sites were selected where the likelihood of contamination was the Standards and Industrial Research of Iran (16).

Total coliforms, fecal coliforms, and heterotrophic plate count were assessed using test numbers 9221-B, 9221-E, and 9215C of the standard methods of testing water and wastewater, respectively (17).

Overall, there are 96 villages in Maraveh Tappeh Based on sampling standards, in villages with population under 5000 people only one sample of the water used by people was taken each time (9). Moreover, because water was delivered to some of the villages by tanks, sampling in these villages was repeated three times and the total number of samples taken for microbial assessment reached 279 (186 samples from points where water was consumed and 93 from the tanks). Data was analyzed using the chi-square test.

3. Results and Discussion

Eighty-eight (91.66%) of the villages obtained drinking water from springs, and 81 (84.4%) of the villages had access to tap water. According to the report by the Water and Wastewater Company, the ratio of microbial contamination of drinking water in the villages in this city is about 8 percent.

The Water and Wastewater Company provided services for twenty-three (24%) of the villages, and 68 (70.8%) of the villages received water from private water supply networks. Fecal coliforms were found in 23 (24%) of the villages and the results of heterotrophic plate counts of over 500 were positive in 19 (19.8%) of the villages. Total coliforms were also detected in 37 (38.5%) of the villages (Table 1). Water in villages receiving the services of the Company had significantly lower levels of total and fecal coliforms contamination ($p < 0.05$) compared to villages deprived of these services. In 4.3% of the villages where the Company delivered services, the HPC ≥ 500 results were positive, while this percentage rose to 24.7% in other villages ($p = 0.03$). In general, in villages where there were private water supply networks, contamination levels were lower compared to other villages, however the relationship between water supply source and contamination was not statistically significant. Villages with tap water (19.8%) had significantly lower levels of fecal coliform pollution ($p = 0.025$) compared to other villages (46.7%). Furthermore, results showed the relationship between total

Table1: Water and water supply system characteristics.

Variable		N (%)
Water resource	**Spring**	88(91.66)
	Tank	3(3.1)
	Well	5(5.2)
Under the authority of WW Company	**Yes**	23(24)
	No	73(76)
Water supply system	**Private**	68(70.8)
	Public tap	18(18.8)
	Without	10(10.4)
Tap water	**With**	81(84.4)
	Without	15(15.6)
Fecal coliform	**Positive**	23(24)
	Negative	73(76)
HPC≥ 500	**Positive**	19(19.8)
	Negative	77(80.2)
Total coliform	**Positive**	37(38.5)
	Negative	59(61.5)

Table 2: Association between characteristics of the water distribution system and water contamination.

		Fecal Coliform			HPC ≥ 500			Total Coliform		
		Positive N (%)	Negative N (%)	P	Positive N (%)	Negative N (%)	P	Positive N (%)	Negative N (%)	P
Under the authority of WW Company	**Yes**	1(4.3)	22(95.7)	0.012	1(4.3)	22(95.7)	0.033	3(13)	20(87)	0.004
	No	22(30.1)	51(69.9)		18(24.7)	55(75.3)		34(46.6)	39(53.4)	
Water supply system	**private**	7(10.3)	61(89.7)	<0.000	7(10.3)	61(89.7)	<0.000	15(22.1)	53(77.9)	<0.000
	Public tap	12(66.7)	6(33.3)		10(55.6)	8(44.4)		16(88.9)	2(11.1)	
	Without	4(40)	6(60)		2(20)	8(80)		6(60)	4(40)	
Water supply resource	**Spring**	22(25)	66(75)	0.59	18(20.5)	70(79.5)	0.68	36(40.9)	52(59.1)	0.24
	Tank	0(0)	3(100)		0(0)	3(100)		0(0)	3(100)	
	Well	1(20)	4(80)		1(20)	4(80)		1(20)	4(80)	
Tap	**With**	16(19.8)	65(80.2)	0.025	14(17.3)	67(82.7)	0.15	28(34.6)	53(65.4)	0.06
	Without	7(46.7)	8(53.3)		5(33.3)	10(66.7)		9(60)	6(40)	

coliforms and tap water, and also between HPC ≥ 500 and tap water, were not significant (p = 0.06, p = 0.015), although total coliforms and HPC ≥ 500 in villages with tap water were lower compared to other villages (Table 2).

Based on Iranian drinking water standards, the fecal coliform bacteria level in drinking water should be zero. The indicator of drinking water quality in rural regions of Iran, with respect to the absence of Escherichia coli, has been estimated to be 93.07 percent (11). However, in 2007, 100% of the rural population receiving the services of the WW Company, and only 47.71 percent of the population of villages deprived of these services, enjoyed safe water with respect to heat tolerant coliforms. In general, 92.99% of the population of all of the villages had safe water with respect to heat tolerant coliforms. For example, the indicators of the absence of fecal coliforms in drinking water in the villages in Kashan (in central Iran) and in Saqqez (in western Iran) are 0.93 and 0.88, respectively (11, 18). Moreover, 7% of all water samples taken from rural and urban areas of Brazil are contaminated with fecal coliforms (16).

Based on World Health Organization guidelines, the indicator of the absence of heat tolerant coliforms in drinking water in communities with fewer than 5000 people is 90% (3). As for the quality of water resources, we can say that the indicator of the absence of fecal coliforms in all water resources of the villages in Maraveh Tappeh is 73%, while in rural areas of Bangladesh this index is 61% (19). On the other hand, 95.7% of the population in villages receiving the services of the WW Company, and 69.9% of the population of villages deprived of these services and, in general, 73% of the total population of Maraveh Tappeh enjoyed safe water with respect to coliform contamination. While 79% of drinking water samples taken from the rural areas of northeastern Trinidad and 17% of the samples of drinking water taken from the rural and urban areas in Brazil are contaminated with total coliforms (13, 14). Based on this, the situation in villages receiving the services of the Company is desirable with respect to fecal coliform pollution, but the conditions in villages deprived of these services are undesirable. In general, the microbial quality of drinking water in all of the villages in Maraveh Tappeh somewhat conforms to the national indicator. As for the pollution of the drinking water in villages, we can say that drinking water was contaminated in most of the villages not receiving the services of the Company. There are considerable differences in the microbial quality of water in villages receiving the services of the Company and those deprived of these services (Table 2). Descriptively speaking, the microbial quality of drinking water in villages receiving the services of the Company is higher compared to villages that do not receive these services, and the only main difference between these two groups of villages, and hence the difference in the microbial quality of their drinking water, results from the supervision of the Company. In studies on water quality in rural areas of Kashan and Zanjan, it was found that the WW Company had an important role in providing safe drinking water for rural areas (11, 20).

4. Conclusion

This research shows that the microbial quality of drinking water in villages receiving the services of the Company isdesirable, while in villages deprived of these services water quality isundesirable, and the the Company plays a very important role in the provision of safe water (with respect to microbial quality) to this region.

Therefore, we suggest that those villages deprived of the services of this Company should also receive them as soon as possible.

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