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AN INVESTIGATION OF THE CONDITION OF THE WATERWORKS IN 121 VILLAGES WITH MORE THAN 20 HOUSEHOLDS IN THE ALIGOUDARZ COUNTY IN 2011

Reza Piri Alam[1] Omid Ali Papi[2], Mohammad Almasian[3], Zahra Khodakarami Fard[4*], Stayesh Derikvand[5], Ali Khodakarami Fard[6]

[1] Environmental health superintendent, Health Vice Chancellorship of the Lorestan University of Medical Sciences, Khorramabad, Iran

[2]Faculty member, Instructor, Loretan University of Medical Sciences, Khorramabad, Iran

[3]Department of the English Language, School of Medicine, Lorestan University of Medical Sciences, Khorramabad, Iran

[4] Research evaluation Superintendent, Research and Technology Vice Chancellorship of the Lorestan University of Medical Sciences, Khorramabad, Iran

[5]Environmental health superintendent, Health Vice Chancellorship of the Lorestan University of Medical Sciences, Khorramabad, Iran

6 Department Of Geology, Khorramabad Branch, Islamic Azad University, Khorramabad, Iran

*(Corresponding Author: Zahra Khodakarami Fard)

ABSTRACT

Adequate and clean water is the most essential need for humans. The main objective of the qualitative studies of water is to maintain the public health and the health of consumers up to a good level. Unfortunately, one of the major problems in some rural areas in Iran is the lack of adequate and clean water, which has led to the occurrence of diseases and irreparable damages. The present study has been conducted with the objective of examining the conditions of the waterworks and the bacteriological quality of the drinking water among the villages with more than 20 households in the Aligoudarz County. The present study was conducted using the cross-sectional – census-taking method. The status of the waterworks systems of the studied villages was investigated in terms of water supplies and reservoirs, transmission and distribution lines, methods of water disinfection, level of awareness of the water reservoir custodians, the age and type of installations, the microbial quality of water, and the services provided by the Rural Water and Sewage Company (Abfar). After summation, the questionnaire forms and the results of the bacteriological tests were analyzed statistically. On the whole, 35.5 percent of the villages were not covered by the Abfar services. 21.5 percent had inadequate or lacked clean water. 33.1 percent of the reservoirs had no protective enclosure. 11.6 percent of the supplies lacked sanitation. 18.2 percent lacked a sanitary piping network. 26.4 percent of the reservoir custodians lacked adequate awareness. 37.2 percent of the cases no disinfection was performed. The installations were old (25.6 percent between 10 to 20 years, and 19 percent older than 20 years). In 33.33 percent of the cases, inadequate chlorometry was observed. In 21.5 percent of the cases, microbial presence was observed. The present study demonstrated that 35.5 percent of the villages under study were not covered by the services provided by the Rural Water and Sewage Company, and as a result, there exists the possibility of the outbreak of water-borne diseases, and the endangerment of the health of the residents of these villages.

KEY WORDS: Drinking water, Waterworks System, Coliform, Escherichia Coli

INTRODUCTION

The availability of clean and adequate water is the most essential need for humans, so much so that without it, having a healthy life is even unimaginable. Unfortunately, one of the major problems of some Iranian rural areas is the lack of adequate and clean water, which has led to diseases and irreparable damage (Naddafi and Yazdanbakhsh, 1990). One of the pillars of ensuring public health is offering clean sanitary water to the people. Given the documents reports presented by international agencies and authoritative Iranian organizations, it is clear that a high percentage of diseases are directly associated with the drinking water. Therefore, paying attention to waterworks installations, especially water refineries, the selection of appropriate processes and treatments relevant to the type of water supply, the quality of the untreated water, and the presence of preliminary treatment units is of great importance (Mahvi, 2011). The most

important health problems related to water in the developing countries are the water-borne diseases, especially those that cause diarrhea among children. Adequate water supplies together with attempt at sanitation and improvements in health standards considerably reduces the outbreak of water-borne diseases, especially diarrhea in the developing countries. The standards related to tap water ensure that water is safe to drink (Jaafar, 2011). Additionally, according to WHO, water consumed by humans must be free of organisms and chemicals hazardous to human health. Moreover, good quality is a necessity for the supply of drinking water. The position of the water reservoir, the inspection of the water supply, and the distribution system must lead to the prevention of contamination of the water (World health organization, 1971). The preparation of healthy drinking water is possible when sensible decisions have been made regarding the source, or when after acquisition, the water has been treated (Nabi, 2011). The most effective method to ensure the safety of the water reservoir is to widely assess the potential hazards and use hazard management methods all the way from the source to the consumer. The quality of the drinking water can be monitored and controlled by using a combination of protecting the water reservoir, controlling the treatment stages, and managing the distribution and use of water (Nabi, 2011). Protection of the reservoir is the first challenge in ensuring water quality. Negligence in controlling water contamination can lead to irreparable damages and losses in every society (Noori, 1992; Raite, 1981). Water-borne diseases occur when pathogens enter the drinking water and can include a wide range diseases such as hepatitis, bacillary, and amebic diarrhea, and parasitic diseases. The threat of the above-mentioned diseases illustrates the importance of providing healthy and safe drinking water (Mahvi and Esa Loo). In addition, drinking water must be free of bacteria indicating fecal contamination. Drinking water, in comparison with water used for other purposes, requires thorough control in terms of contaminant and quality standards. The microbial quality of drinking water is determined based on the number and frequency of certain types of bacteria and contaminated water can contain pathogens such as bacteria, viruses, protozoa, and the oocytes of parasites (Asl Hashemi, 2003).

As human knowledge increases and awareness of the fact that water, if contaminated, can endanger human life, and that many contagious diseases are passed on via water, humans pay special attention to water quality, so that nowadays, certain standards have been set for each type of consumed water. One the other hand, there are various sources of contamination for water, the contamination of the sources of water has increased to such a degree that the environment has lost its ability to counteract it (Chalkesh Amiri, 1999; Huseinian, 1993; Hattersee, 1995). There could be various origins for the contamination. The water source (well, spring, subterranean canal, dam, river, or pond) could be contaminated (primary contamination) or water is exposed to contamination during treatment, in the distribution system (the plumbing system, water tower, and containers whether plastic or metal, buckets, pails, water-skin, etc.), or during storage and preservation at home (secondary contamination). The most important cause of infection with water-borne diseases is consuming water from sources contaminated by humans or animals. The presence of specific bacteria in the water indicate fecal contamination of the water, which likely suggests the present of pathogens in the water and the possibility of health-related hazards. Indicative bacteria which are often used for this purpose are the coliforms, and water samples are tested to determine the presence of fecal coliforms (Asl Hashemi, 2003). The guidelines set by WHO and the Iranian standards for the bacteriological quality of drinking water suggest that fecal coliforms must not be present in a 100 mL sample (PDSPC, 1992; World Health Organization, 2004).

According to the reports of the Aligoudarz county's health network, there are 121 villages with more than 20 households in that county. Therefore, given the importance of providing healthy and adequate water and the presence of uncontaminated waterworks to transport and distribute water to the residents of these villages, it seemed necessary to examine the conditions of the waterworks systems (from the reservoir up to the site of consumption) and also to investigate the quality of the drinking water in terms of bacteriology (MPN, Ecoli) in 121 villages with more than 20 households in Aligoudarz county, so that having determined the problems, suggestions and practical solutions could be put forward to improve water quality and protect the consumers' health.

MATERIALS AND METHODS

This study was conducted with the objective of presenting a clear picture of the conditions of the waterworks systems of 121 villages with more than 20 households in Aligoudarz county, and controlling the quality of the drinking water in these villages in terms of the bacteriological indices of the drinking water. The study and the field visits of the present research was of the cross-sectional type. First, the researchers and their colleagues examined the waterworks systems of

121 villages having more than 20 households in terms of water sources and reservoirs, transfer and distribution lines, the conditions of the enclosures of the sources and reservoirs, sanitation of the sources and reservoirs, methods of water disinfection, level of awareness of the reservoir custodians, the age of the installations, the type of pipes, the conditions of chlorometry and microbial sampling from the water, perchlorine source, coverage by the Abfar Company, methods of preparation and distribution of the source chlorine, the last time the water lines were repaired and the officials in charge of the disinfection of the water, and completed a questionnaire based on their investigations. Additionally, the drinking water was tested to determine the amount of remaining chlorine. To study the remaining chlorine, diethyl-*p*-phenylenediamine (PDP) was used together with chromatography and relevant reagents. Next, observing sterile conditions and in accordance with the standards, water samples were taken in sterile containers, having written all the necessary specifications of the samples on the labels on the glass containers, the sample containers were kept adjacent to ice and were carried to the laboratories of the water network of health and treatment bureau of Aligoudarz county, and the necessary microbial experiments were immediately carried out on the samples. The samples were studies using the 9-tube fermentation test to find coliforms. All the stages of sampling and testing were in accordance with the methods mentioned in the 21st edition of the *Standard Methods for the Examination of Water and Wastewater* (APHA/AWWA/WPCF 2005) (American Public Health Association, 2005). In later stages, the results obtained from the questionnaires were summed up, the averages of the data were calculated, and based on the obtained data regarding each question, the results were evaluated. Moreover, the results of the microbial tests on water samples of the villages were summarized, and the averages of the data were calculated and the results were evaluated. Then, the data were recorded on a computer. Data tables were prepared using Microsoft Excel and the data analysis was performed using SPSS 17. Next, the descriptive indices were tabulated in tables of frequency. The data were analyzed by the statistics advisor of the research project using the chi square test.

RESULTS

From among the studied population in the 121 villages with more than 20 households in Aligoudarz county, 40 percent of the reservoir custodians had at most primary school education (Table 1). 100 percent of the villages had a water reservoir. 87.6 percent of the reservoirs enjoyed sanitation, and 11.6 percent lacked sanitation (Table 2). 66.9 percent of the reservoirs and water sources had enclosure and 33.1 percent lacked enclosure (Table 2). 84.4 percent of the villages had healthy and safe water sources and 11.6 percent lacked a healthy and safe water source. 89.3 percent of the villages had a water tank and 13 percent lacked it. 84.3 percent of the villages had a working water tank and 4.1 percent lacked it. 95 percent of the villages had a plumbing network and 5 percent lacked it. 76.9 percent of the villages had a working plumbing network and 18.2 percent lacked it (Table 3). In 62.8 percent of the cases the water is disinfected by the reservoir custodians and in 37.2 percent it is disinfected by the workers of the health centers (Table 4). 62 percent of the chlorine needed for disinfection is provided by the Abfar Company and 38 percent is provided by the health centers (Table 4). The mean awareness level of the reservoir custodians regarding the methods of water disinfection was 26.4 percent. 34.7 percent of the health workers had scientific and practical knowledge and 2.5 percent of them had inadequate scientific and practical knowledge about the preparation and dispensation of the mother chlorine solution. In 22.3 percent of the villages that lack a plumbing network, the mother chlorine solution is replaced every month, and in 14 percent of these villages, this period is more than one month. 64.5 percent of the villages enjoy the services provided by the Rural Water and Wastewater Company (Abfar), while 35.5 percent do not (Table 3). The results of the chlorometry in 66.67 percent of the villages was satisfactory (Table 6). In 76.9 percent of the villages, there had been a sampling for microbial tests during a six month period prior to the time of the present study, and the sample had been tests, but in 23.1 percent of these villages, this was not the case. In 5 percent of the cases, in these tests Ecoli and MPN had been observed and in 37.2 percent none was found.

In 18.2 percent of the cases, water pipes were metal and in 74.4 percent of the cases, they were made of polyethylene. In 52.1 percent of the cases, the installations were 10 years old or less, 25.6 percent of the installations were 10 to 20 years old, and 19 percent of them were 20 years old or more (Table 5). In 78.5 percent of the villages, the sources of drinking water were adequate, while in 21.5 percent of the villages such was not the case. In 62.8 percent of the villages, the Abfar Company undertook the reparations of the water pipes; in 14 percent of the villages, the village council undertook the task, and in 23.1 percent of the villages, no one acted as the custodian of this task. The shortest time interval between the breakage of the pipes and their reparation and elimination of defects was one day (12 hours)

and the longest interval was 30 days. In 57.9 percent of the cases, MPN was found in a 100 mL water sample, and in 42.1 percent of the samples, MPN was not found (Table 6). In 21.5 percent of the cases, Ecoli was found in the 100 mL samples, and in 78.5 percent of the cases, no Ecoli was found (Table 6).

Table 1. Frequency distribution of the education level of the reservoir custodians

Literacy level	Absolute frequency	Relative frequency
Primary school	40	33.08
Junior high school	16	13.2
High school	5	4.1
University	14	11.6
The village has no reservoir custodian	46	38.02
Sum	121	100

Table 2. The distribution of frequency of sanitation, the presence of enclosure for the water reservoir

Sanitation of the water reservoir				The presence of an enclosure for the water reservoir			
Having sanitation	Percentage	Having Sanitation	Percentage	Having sanitation	Percentage	Having Sanitation	Percentage
106	87.6	106	87.6	106	87.6	106	87.6

Table 3. The frequency distribution of the water plumbing network in terms of being in a working condition and coverage by the Abfar Company

Plumbing network				Under the coverage of the Abfar Company		
In working conditions	Percentage	Defective	Percentage	There is coverage	There is no coverage	Percentage
93	76.9	22	18.2	78	43	5.35

Table 4. The frequency distribution of water disinfection by the custodian of the reservoir or health center worker and the method of procurement of the perchlorine.

Water is disinfected by the reservoir custodian		Water is disinfected by a health center worker		the method of procurement of the perchlorine			
Total number	Percentage	Total number	Percentage	Abfar Company	Percentage	Health center	Percentage
76	62.8	45	37.2	75	62	46	38

Table 5. The frequency distribution of the age of the waterworks installations.

Age of the installations	Absolute frequency	Relative frequency
10 years and less	63	52.1
10 to 20 years	31	25.6
20 years and more	23	19

Table 6. The frequency distribution of the conditions of the drinking water of the studies villages in terms of the remaining free chlorine, total coliform and Ecoli.

Measures of the amount of total remaining free chlorine		The presence or absence of coliforms		The presence of absence of thermoresistant bactreria	
Total	Percentage of satisfactory cases	Total	Percentage of satisfactory cases	Total	Percentage of satisfactory cases
121	66.67	121	42	121	78.5

Table 7. WHO guidelines for the assessment of the microbial health (2006)

The satisfactoriness criteria for the index bacterium Escherichia coli (0.0)			
The population under coverage			
	< 5000	**5000-100000**	**>100000**
Excellent	**90**	**95**	**99**
Good	**80**	**90**	**95**
Mediocre	**70**	**85**	**90**
Weak	**60**	**80**	**85**

DISCUSSION AND CONCLUSION

Generally, the results of this study indicate that 35.5 percent of the studied villages were not covered by the services of the Abfar Company. The results showed that 21.5 percent of the villages lacked healthy and clean water, which suggests that 78.5 percent of the residents of these villages do not have access to healthy water. It is important to note that the provision of healthy drinking water for everyone by 2025 is one of the objectives of the World Health Organization (Organization, 2009). Lack of legal frontage and enclosure of the water sources and reservoirs at a level of 33.1 percent indicates that the Abfar Company protects these resources inadequately in terms of preventing the entry of environmental contaminants, the entry of sundry and irresponsible individuals and also animals to the boundary of these installations, which may result in the endangerment of the healthfulness and quality of the water.

The findings of this research show that 11.6 percent of the water sources lacked the necessary sanitation which explains the presence of microbial contamination in these sources, and in addition to threatening the health of the consumers, can increase the costs undertaken by responsible organizations in the provision and distribution of water to the residents of these villages. The results of this study showed that 11.6 percent of the studied villages lacked safe and healthy water sources, which suggests that the residents of these villages resort to unhealthy and unsafe water sources for drinking and other uses and, as a result, their health is threatened. Lack of a working and safe plumbing network (18.2 percent) has led the residents of these villages to use local unsafe sources of water for drinking and other uses. The results of this study showed that the level of awareness of the custodians of water reservoirs about methods of disinfection and the amount of chlorine needed for disinfection was inadequate in 26.4 percent of the cases, which indicates that the officials of the Abfar Company have not paid close attention to providing satisfactory services to the residents of these villages and the insouciance of the custodians of some water reservoirs in this regard. Negligence in disinfecting the water in the studied villages by the water reservoir custodians of the Abfar Company in 37.2 percent of the cases has led to the presence of microbial contamination in the drinking water of these villages, and especially the villages which do not enjoy the services of the Abfar Company. A study of the results also indicated that lack of timely reparation of the breakages of the water transport and distribution lines and the defects of the waterworks systems (from 1 to 30 days) has led to the penetration of secondary contaminants into the water distribution networks, and as a result caused microbial contamination.

The use of metal pipes (18.2 percent of the cases) and the waterworks installations' being old (25.6 percent between 10 to 20 years and 19 percent more than 20 years) has led to repeated breakages and leaks in the transport and distribution lines, which in turn led to the penetration of contaminations into the water. Based on Iranian drinking water standards, the satisfactory level of remaining free chlorine at every point of the network must be 0.5 to 0.8 mg/L given the pH half an hour after initial contact under normal circumstances, and in emergency circumstances in case of intestinal epidemics and natural disasters, this amount must be 1 mg/L (Organization, 2006). The results show that in 33.33 percent of the samples, the amount of remaining free chlorine in the distribution network was unsatisfactory (mean 66.67; standard deviation 21.782), which was lower than the countrywide average in 2011 (80.89 percent), which indicates lack of awareness and inadequate education of the water reservoir custodians regarding issues related to water health, waterworks installations, chlorine requirements, the amount of chlorine needed, chlorination, and chlorine-related safety issues. In a study by Hashemi and Hajizadeh (2005) which was conducted on water samples taken from 432 villages in the Ilam province, in 74.75 percent of the samples the remaining free chlorine levels were satisfactory (Hashemi and Hajizadeh, 2005). The findings of this study show that that in 21.5 percent of the cases, there was found Ecoli in 100 mL samples and the microbial quality of the drinking water in these villages is lower than the mean countrywide index in 2011 (90.26 percent) and was unsatisfactory. Additionally, the mean satisfactoriness index for the presence of the thermoresistant Escherchia coli bacterium (21.5 percent) was lower than the guidelines set by the WHO in 2006 for small communities (Table 7) and thus the microbial quality of the water was assessed to be weak (WHO, 2006). In a study by Onilude et al on water samples from Nigeria, 97.8 percent of the samples lacked thermoresistant coliform bacteria (Olaoye and Onilude, 2009). Souri et al (2005) reported that 78.3 percent of the water sources of Pakdasht, Iran were free of microbial contamination, and stated that in the other cases the microbial contamination is eliminated by constant chlorination. A study by Heidari et al describes the conditions of the villages surrounding Kashan, Iran in terms of coliform contamination and shows that the activities of the Rural Water and Wastewater Company (Abfar) were to blame (Heidari et al., 2010). There being no specific officials for providing waterworks services in 23.1 percent of the studied villages, the sparse geographical distribution of the villages, not being covered by the services of the Abfar Company, the shabby state of the installations, lack of a plumbing network, lack of awareness of the water reservoir custodians, and the low level of public health measures, in the studied villages had made the provision, distribution, and monitoring the quality of the drinking water difficult, and put emphasis on the role of the Rural Water and Wastewater Company in providing adequate and safe water in terms of microbial quality for the rural populations.

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