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Microbiological Quality of Drinking Water in Shadegan Township, Iran

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Abstract: In this research, the villages with water supply systems under the supervision of the Water and Wastewater Company were studied. Turbidity, fecal coliform, Heterotrophic Plate Count (HPC) and free residual chlorine were analyzed. The measured turbidity and free residual chlorine in many of the villages were less than drinking water guidelines. Heterotrophic Plate Count (HPC) and fecal coliforms tests in drinking water samples were positive. According to the results, it is found out that the water source used for drinking consumption must be fully treated properly and finally be chlorinated Water and Wastewater Company should have a proper consideration on safe drinking water supply.

Key words: Drinking water % Fecal coliform % Heterotrophic Plate Count % Residual chlorine % Shadegan Township

INTRODUCTION

Obviously, the quality and safety of drinking water is an important public health issue. Pollution of water sources with pathogen microorganisms will cause in transferring infectious diseases and other related diseases [1]. In recent years as a matter of population increase, industrial development, wastewater generation and solid waste production, water shortage and water pollution has been resulted in all over the world [2]. According to World Health Organization's definition "drinking water" is water which is suitable for human consumption and for all other uses in home with good quality and being available in the community [3]. According to a report by WHO in 2000 and a member of the Asian Development Bank (ADP), United Nations Development Program (UNDP) and a complimentary report by WHO in 2006, out of 4 billion cases of diarrhea will end to 2.2 million death cases due to lack of access to safe drinking water, which 85% of these live in small communities [4-6]. So, in terms of microbial, physical and chemical parameters, safe and sanitary water supply is one of the main challenges facing human societies, especially in developing countries. The reason is that distribution of unsafe water and non-conformity with drinking water standards, in short term and especially in long-term will have irreversible effects on the health of consumers. In rural communities due to various problems such as worn out facilities in water distribution system, lack of proper maintenance of the system, improper disposal of animal waste and solid waste, low level of public health, industrial and agricultural wastewater discharge, uncontrolled use of pesticides and herbicides, lack of legal supervision on water supply systems by private sectors, development of urban and rural population near the water resources are causes of low quality water resources. Therefore, water quality monitoring is essential. Especially drinking water quality monitoring is necessary for environmental health [7-10].

Monitoring of turbidity, fecal coliform, Heterotrophic Plate Count (HPC) and free residual chlorine are some important parameters for environmental health. The presence of materials in drinking water such as humic acid or inorganic materials such as iron compounds may increase turbidity parameter. In water sources which amount of coliform pollution is high, there can exist a logical relationships between turbidity with coliform and pathogenic indicators [10-11]. Type of turbidity is an

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important factor in disinfection process. If organic materials are the cause of turbidity, the amount of chemical disinfectants should be increased [11]. Each component of turbidity in each sample of water, can affect the process of disinfection and pathogen inactivation rate. In various studies on drinking water quality, evaluations have been done between gastrointestinal diseases and turbidity [11-12]. According to Iranian National Drinking Water Standards the permissible and desirable guidelines for turbidity are 5 and 1NTU, respectively [12- 14].

The other quality parameter of drinking water is heterotrophic plate counts (HPC). In 1881 Robert Koch developed the heterotrophic plate counts (HPC) as one of the first methods for drinking water microbial quality analysis. Since then, the HPC is used as a monitoring tool to assess the general microbial quality of water. HPC generally covers all microorganisms which are capable to grow and form visible colonies in complex nutrient-rich media in suitable incubation time and temperature [15-19].

In this study the free residual chlorine, turbidity, fecal coliforms and Heterotrophic Plate Count (HPC) were measured according to Standard Methods for the Examination of Water and Wastewaters.

MATERIALS AND METHODS

Study Site and Sampling: Shadegan with a population of over 150,000 is one of the Townships in Khuzestan province with an area of 3500 square kilometers located in South West of Iran within 971 km away from Tehran, experiencing warm and humid climate. Shadegan Township rural water supply system entirely is fed from Karun River. The Township has 178 villages. The water supply systems in 151 of these villages are under the supervision of Shadegan Township Water and Wastewater Company and in the rest of the villages the water supply systems are not under authority of any Water and Wastewater Company. All of the communities under the authority of Water and Wastewater Company have water piping network and the rest does not have any piping network. According to the Water and Wastewater Company and Center of Health Statistics, 87,138 of population live in villages that are equivalent to 60 percent of the total population of this province (10).

This study was conducted in 2009. Water samples are transported to the laboratory in sterile, 250 mL polypropylene bottles containing sodium thiosulfate. The recommended maximum elapsed time between collection and examination of samples is 8 hours (maximum transit time 6 hours, maximum processing time is 2 hours). Pour Plate Technique used as HPC test then R2A agar media was used to enumerate HPC. Colonies arising from pairs, chains, clusters or single cells are included in the term "colony-forming units" (CFU) and all HPC are reported as colony forming units (cfu) per mL or per g [14].

Chemical Analyses: In Standard Methods for the Examination of Water and Wastewater (Part 9221 and 9222; APHA, 1998), coliform group members are described as: 1. all aerobic and facultative anaerobic, Gramnegative, non-spore-forming, rod-shaped bacteria that ferment lactose with gas and acid formation within 48 h at 35°C (multiple-tube fermentation technique; Section 3.1) or 2. all aerobic and many facultative anaerobic, Gram-negative, non-spore-forming, rod shaped bacteria that develop a red colony with a metallic sheen within 24 h at 35°C on an Endo-type medium containing lactose. When multiple tubes are used in the fermentation technique, the results of the examination by replicate tubes and dilutions are reported in terms of the Most Probable Number (MPN) of organisms present [14, 17].

In the study colorimetric DPD method is used in which DPD (N,N-diethyl-p-phenylenediamine) is oxidized by chlorine causing a magenta (red) color. The intensity of the color is directly proportional to the chlorine concentration in the samples. The basic procedures for the DPD Colorimetric method include the following steps (1 colorimetric DPD 4) [8]:

- Collect a water sample in the sample tube of the DPD test kit.
- Add DPD color reagent to the water sample.
- Match color sample with a color on the comparator to estimate the chlorine residual in mg/l.

The collected data were analyzed by use of the SPSS16.0 and Microsoft Excel software packages for determining the mentioned parameters.

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RESULTS AND DISCUSSION

Average drinking water pH in villages was 7.58 with Min. and Max. of 7.4 and 7.8. These values were between desirable pH limit values of the Iranian Drinking Water Standard which are 7-8.5. The results of this study are presented in Tables 1-4.

Water turbidity is one of the daily monitoring parameters in water quality operation and assessment which can affect the other drinking water parameters such as disinfection [12].

Results of the drinking water turbidity measurements represents that in %9 of the villages (in %6 of the population) was less than 1 NTU, in %65 the villages (in %68 of the population) was between 1-5 NTU and in %26 of the villages (in % 26 of the populations) was more than 5N TU (Table 1).

The free residual chlorine together with microbial tests was measured at the point of use. Results of the free residual chlorine analysis given in Table 2 represents that in %72 of the villages (in %72of the population) was zero and less than 0.2 mg/l, in %16 of the villages (in %22 of the population) was between 0.2-0.8 mg/l and in %12 of the villages (in %6 of the population) was more than 0.8 mg/l.

Results of the fecal coliform contamination in given in Table 3 represents that water samples in %54 of the villages (in %54 of the populations) were positive. Results of HPC analysis in given in Table 4 represents that in 33% of the villages (in 30% of the populations) water samples were desirable and in 67% of the villages (in 70% of the populations) water samples were undesirable.

In Table 5 the calculated P-Values and correlation between free residual chlorine with turbidity, fecal coliform, total coliform and HPC are presented.

In a country wide study in the year 2007, the rural water turbidity utility index from the viewpoint of health was found to be less than 1 NTU in %73 of rural population and from the viewpoint of Iranian Drinking Water Guideline was less than 5 NTU in %96 of rural population [21]. Comparing the results of these studies with Standards it can be concluded that the drinking water turbidities in Shadegan Township rural water supplies were poor from viewpoint of acceptability and public health [21]. According to Iranian Drinking Water Standards, in normal conditions, the recommended amount of free residual chlorine after 10 minute contact time at 20°C and in pH between 7 and 8 should be equal to 0.2 mg/l at the end of the water distribution system [20]. In emergency condition and epidemic of intestinal diseases, free residual chlorine could be up to 1 mg/l [21, 22]. Based on the results of tests conducted in this period, the free residual chlorine in %86 of villages was less than guideline value. Whereas in 2007 report, the index of microbial quality of Iran rural drinking water from the standpoint of lack of *E. coli* bacteria indicator was estimated %93.7 [21]. In a research which was done by Elisavet Amanatidou et al. on Physicochemical and microbiological characteristics of the potable water supply sources in the area of Kozani, Western Macedonia, it was found that because of poor conditions and inadequate health protection in water distribution network, water was easily contaminated and then continuous monitoring and systematic chlorination of drinking water was essential [23].

Table 1: Turbidity measurements (NTU)

<1				1-5				>5			
Village		Population		Village		Population		Village		Population	
Total	%	#	%	Total	%	#	%	Total	%	#	%
13	9	5324	6	98	65	56957	68	40	26	21766	26

Table 2: Measures of free residual chlorine (mg/l)

0 - 0.2				0.2-0.8				>0.8			
Village		Population		Village		Population		Village		Population	
Total	%	#	%	Total	%	#	%	Total	%	#	%
108	72	60036	72	25	16	18888	22	18	12	5123	6

Table 3: Measures of fecal coliform (MPN/100ml)

Desirable				Undesirable			
Village		Population		Village		Population	
Total	%	#	%	Total	%	#	%
70	46	38252	46	81	54	45795	54

Table 4: Measures of HPC (CFU/ml)

Desirable (HPC < 500)				Undesirable (HPC > 500)			
Village		Population		Village		Population	
Total	%	#	%	Total	%	#	%
40	33	26231	30	111	67	57824	70

Table 5: P-Values and the correlations between free residual chlorine and turbidity with fecal coliform, total coliform and HPC

Parameter	HPC	Total coliform	Fecal coliform
Correlations	-0.182	-0.170	-0.127
P-Value	0.015	0.024	0.040
P-Value	< 0.001	< 0.001	< 0.001
Correlations	0.571	0.530	0.639

Heterotrophic microorganisms are native organisms in water and in bio-films and always concentrations of them are greater than coliforms bacteria in distribution network systems. The HPC is useful in judging the efficiency of various treatment processes for both drinking water and swimming pools and for checking the quality of finished water in a distribution system. Increase in HPC may as result failure in water treatment, pollution after the treatment, regrowth in water distribution system and or presence of them in sediments and biofilms in the water distribution system [24]. The MCL for heterotrophic plate count has given by EPA rules. Under U.S. EPA Surface Water Treatment Rule, systems using surface water or groundwater under the direct influence of surface water must achieve a HPC of less than 500 bacterial colonies per milliliter [25]. HPC tests on water of Shadegan Township showed that 67 percent of villages (70% of the population) have HPC more than 500 at the point of consumption. Since, Karun River is the longest river in Iran and it passes through many populated residential areas (such as Ahwaz city) and a few agriculture areas, it is subjected to huge amount of wastewater discharge into the river. Because of this environmental condition, microbial pollution, pathogenic microorganism and other pollution will be entered to it. So, water is used for drinking consumption must properly be treated and finally chlorination process should be controlled.

CONCLUSION

According to the Shadegan Township Health Center report and the microbial results of rural drinking water samples in 2007, the quantity of the undesirable water samples were more than the desirable samples, which caused dissatisfaction in people and environmental health center experts in these rural areas. Because the villages are close together, it is recommended that by construction of a central water treatment plant equipped with the appropriate treatment systems a common basic need of this people be maintained.

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