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An Investigation of Microbial and Physicochemical Quality of Drinking Water in Kamyaran City During 2011-2014

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Abstract: Physical, chemical and microbial properties of drinking water are the base of judging its drinkability. Undesirable changes in these parameters can threaten consumers' health. Therefore, the purpose of this study is to investigate the physical, chemical and microbial quality of drinking water and compare it to national standards. This cross-sectional descriptive study was conducted in 2011-2014. Moment sampling was done from the water of distribution network of 15 locations in the city. Totally, 1780 samples were collected for microbial analysis and 30 samples were collected for chemical analysis. Standard methods according to the book "Standard Method" were used to carry out the experiments. Research results showed that the remaining chlorine in 2012 was zero in 22 samples and <0.2 Mg L^{-1} in 3 samples. Fecal coliform was negative in all cases. In addition, the physical and chemical parameters under study were standard. In 2013, the remaining chlorine was zero in 16 cases and more than 0.8 Mg L^{-1} in 23 cases. Thermo-tolerant coliform was also observed in 1 case. All the parameters were standard and desirable. In 2014, the remaining chlorine in the distribution network was zero in 19 cases and it was between 0.1-0.4 in one case and >0.8 in 8 cases. Also, in 2014, no coliforms were observed in the cases. It was clarified in physicochemical experiments that the amount of fluoride is less that the standard level. The health quality of drinking water in Kamyaran City is not problematic and it is not standard in many cases in terms of the remaining chlorine and fluoride.

Key words: Microbial, physicochemical, quality, drinking, water

INTRODUCTION

Water is not pure in nature but always has some minerals, suspended solids and dissolved gases that make water have different properties in different areas. Existence of some minerals in water is essential for human body while excessive amounts of them endanger it (Amini *et al*., 2014; Azimi *et al*., 2003). Presence of chemical compounds even in low levels can poison human beings and all other creatures if they are more than the determined global standards (Azimi *et al*., 2003). Unfortunately, these pollutions annually lead to millions of deaths in the world that brings about economic losses beside mental problems. On the other hand, by the increase in population growth and the increase in standards of living, human need to water is increasing (Clesceri *et al*., 1998). The significance of water for healthcare and improvement is so much that the World Health Organization (WHO) has announced the most important insufficiency of the twentieth century to be inaccessibility of all to improvements and healthy and sufficient drinking water (Dinarlou and Alipour, 2005). The water we want to use as the drinking water should be according to the existing standards that are presented by nationally or globally reliable organizations (Dinarlou and Alipour, 2005). The main purpose of qualitative investigations of drinking water is observing public health and consumers' health (Eaton and Franson, 2005). Desirable physical and chemical quality of water is necessary in terms of its acceptance to the consumers,

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observing consumers' health and maintaining the water network system. In some areas, controlling the concentration of some pollutants to provide people with a healthy life is necessary and these measures include carrying out chemical experiments on water supply resources (Guler, 2007). Many studies have been carried out in Iran and all over the world on the quality of drinking water. For example, in a study that was carried out on water in Mianeh, the main problem of the water in this city was total hardness of water, TDS and bicarbonate ion while other parameters were desirable (Hashemi and Hajizadeh, 2005). In another research n the chemical quality of water in Bandar-e-Abbas, the level of Fluorine, sulfate, chloride, sodium, total hardness, TDS and EC in underground water was higher than the desirable level. However, the quality of surface water was desirable (Heidari *et al*., 2010). Total solids in water were in two forms of suspended and dissolved solids. The suspended solids in water include minerals such as sand, silt and other organic materials and soil compounds such as plant fibers, algae and bacteria in water (Jabbari *et al*., 2012). Total Dissolved Solids (TDS) in drinking water include mineral salts with low concentrations of organic materials that are the main ions forming dissolved solids of carbonate, bicarbonate, chloride, sulfate, nitrate, sodium, potassium, calcium and magnesium (Kermanshahi *et al*., 2010). Water color is one of the parameters that is aesthetically significant. People will unintentionally avoid colorful water, even if it is totally healthy in terms of public health. Color usually appears by organic materials such as algae or humic compounds or dissolved materials like iron (Khodadadi *et al*., 2007). Hard water is water with high amounts of dissolved materials (metal ions). These ions mainly include $^{+2}$Ca and $^{+2}$Mg.

The PH is important in water refinery, disinfection and corrosion control (Khodadadi *et al*., 2007). Chlorine gas is usually used in dissolved form to disinfection water and is hydrolyzed to Hypochlorous acid (HOCl) and Hypochlorite acid ($^{-}$OCl) (Korkani *et al*., 2010).

In water refinery, turbidity is highly significant, especially the fact that darkness of water is aesthetically irritating and presence of micro colloidal particles make it difficult to eliminate or deactivate pathogenic organisms (Khodadadi *et al*., 2007). Drinking water containing high amounts of sulfate (200 ppm) and chloride (100 ppm) or calcium carbonate (300 ppm) will result in indigestion in most people. The aforementioned minerals might lead to severe diarrhea (Mezher *et al*., 2011). In other studies conducted in Iran, it was found that drinking water has insufficient quality.

Research results of the study conducted by Rajaii *et al*. (2011) showed that the remains of dry solids in 37% of the samples the 25% of hardness, 33% sulfate, 70% sodium, 25% chloride, 51% electrical conductivity were more than the maximum national standard and fluorine was less than the minimum recommended level in 92% of the analyzed samples (Mohammadian and Sadeghi, 2003).

In addition, in the study conducted by Jabbari *et al*. (2012), it was shown that in terms of quality, water resources of Zahidan plaint in its southern parts influenced by Rozak chalky-clay limestone formations have restrictions due to sulfate ions and totally, more than 60% of waters in this plaint had insufficient to bad quality. Water resources of this plaint have average chemo facies of chloric-sodic. The average dissolved minerals were 3078 Mg/l and the average electrical conductivity was 4707 microsiemens per second that shows the undesirable quality of water in the plaint (Rahimi and Matouri, 2011).

The study conducted by Korkani et al. (2004) showed that no methods were used for water disinfection in about 30.3% of cases. A total of 18.7% did not use any test to determine the quality of water but one of the three tests of microbial, chemical or calorimetry and/or a combination of them were used in 81.3% of the cases (Rajaii *et al*., 2011).

The study carried out by Kalantari and coauthors showed that the quality of underground water near Ajirub River (western part of Siah Mansour Dezful) is relatively better than other areas. Microbial tests showed that underground waters are severely contaminated, such that at least one microbial contaminant has been detected in all stations (Sadeghi and Rohollahi, 2007). If the physical and chemical impurity of drinking water is more than the maximum standard amount, it might result in irreparable damages in long term like methemoglobinemia and digestive disorders in human beings. Considering the role of the quality of water in residents' health and the necessity of permanent measuring of its different parameters, this project was carried out to determine the physical and chemical quality of drinking water in Kamyaran City.

MATERIALS AND METHODS

This cross-sectional and descriptive study was conducted in 2011-2014. Samplings from the water of distribution network were done momentarily from 15 areas in the city. Totally, 1780 and 30 samples were collected for microbial and chemical analysis, respectively. Sterilizing the plates, samplings, transportation and storage were done in laboratories and according to the instructions of the standard method (Safari and Vaezi, 2003). Therefore,

sterile glass containers containing sodium thiosulfate were used for microbial sampling. Samples were maintained near ice and were immediately transported and tested in water and wastewater laboratory for microbial tests. The 1 liter clean poly ethylene containers were used for sampling and determining physical and chemical parameters. The PH and the free chlorine remaining in sampling area were assessed. To this end, pH sensor kit and phenol red were used to assess pH and Chlorine sensor kit and DPD (N and N diethyl parafnylyn diamine) were used to assess the remaining free chlorine. Then, Excel was used to analyze the results and drawing the corresponding charts and tables.

RESULTS AND DISCUSSION

The drinking water in Kamyaran County is provided by 8 resources. The watering network has 3 chlorination stations that in total 5884 times chlorination was done in this network in 2012, in 22 cases of which the remaining chlorine was zero and it was >0.2 Mg L^{-1} in 3 cases. In addition, 660 cases were under for microbial test of fecal and thermo-tolerant coliforms in the same year, all of which showed negative results.

In 2013, 6925 cases were tested. The remaining chlorine was zero in 16 cases and it was higher than 0.8 Mg L^{-1} in 23 cases. The level of chlorine was desirable and standard in other cases. Out of the 684 cases of microbial test, one thermo-tolerant coliform was found. However, no fecal coliform was seen in the samples.

In 2014, in total 4432 cases were tested for chlorine which showed zero level of chlorine in 19 cases, 0.1-0.4 in one case and more than 0.8 in 8 samples that were undesirable. In addition, 436 samples were sent for microbial test in 2014 and no coliforms were seen in any of them.In physicochemical tests, the parameters of pH, turbidity, electrical conductivity, alkalinity of methyl orange, total hardness, chloride, fluorine, nitrate, nitrite, sulfate, phosphate, ammonium, calcium, magnesium, sodium and potassium were studied.Results of physicochemical tests in 2012 showed that all the parameters under study were standard. However, total hardness of $CaCO_3$ was 294 Mg L^{-1} while its desirable level is 250 Mg L^{-1} and the standard level is 500 Mg L^{-1} which is a little higher than the desired level. The amount of ammonium was zero (Fig. 1).

Results of physicochemical tests in 2013 showed that all the parameters under study were standard and desirable and the amount of ammonium was zero (Fig. 2). Results of physicochemical tests in 2014 showed that all the parameters were standard and desirable except for fluoride whose level was 0.3 Mg L^{-1} which is less than the standard 0.5-1.5 Mg L^{-1}. The amount of ammonium and phosphate was also achieved (Fig. 3).

In 2012, the remaining chlorine was zero in 22 samples and it was <0.2 Mg L^{-1} in 3 cases. In 2013, the remaining chlorine was zero in 16 cases and it was >0.8 Mg L^{-1} in 23 cases. Results of this study were consistent with the results of the study conducted by Sarpoushi *et al.* (2012) on the investigation of microbial and chemical quality of drinking water in villages of Robat Sarpoush and Shamkan rural areas which showed that the remaining chlorine was zero in 1% of the villages and it was >0.8 Mg L^{-1} (Samaii *et al*., 2007).

No microbial infections were observed during 2012 and 2014 which was not consistent with the studies conducted by Sarpoushi *et al.* (2012), Samaii *et al.* (2007) and Sadeghi and Rohollahi 2007. However, thermal-tolerant coliform was observed in one example in 2013 which is consistent with this study.

Turbidity and pH were standard in all samples which was consistent with the studies conducted by Rajaii *et al.* (2011), Mohammadian and Sadeghi (2003), Kalantari *et al.* Sadeghi and Rohollahi (2007), Sarpoushi *et al.* (2012) and Samaii *et al.* (2007).

Electrical conductivity was standard and desirable in this study and the results are not consistent with the study of Rajaii *et al.* (2011), Mohammadian and Sadeghi (2003), Jabbari *et al.* (2012) and Rahimi and Matouri (2011). However, it was consistent with the study conducted by Samaii *et al.* 2007, Sarpoushi *et al.* 2012. In a study conducted on water resources of Behshahr, Zahedi Kalaki stated that by the increase in the temperature to 1 degree Celsius, EC increases by 2%. Therefore, EC is expected to increase during the drought and when the temperature increases (Souri *et al*., 2005).

The average chlorine in all samples was desirable. Research results of Rajaii *et al.* (2011) indicate that this parameter was more than the standard level in 25% of drinking water wells in Birjand plaints and Ghaen villages (Mohammadian and Sadeghi, 2003). The average fluorine in 2014 was less than the national standard which was consistent with the study carried out by Rajaii *et al.* (2011), Mohammadian and Sadeghi (2003). Therefore, the standards presented for fluoride ion concentration in drinking water by different organizations are different. These variations in standards depend on seasonal changes. The governing logic is the direct relationship between temperature and water consumption per capital. In other words, consumption of drinking water in warm seasons of the year increases compared to the cold seasons. Therefore, assuming the fluoride ion

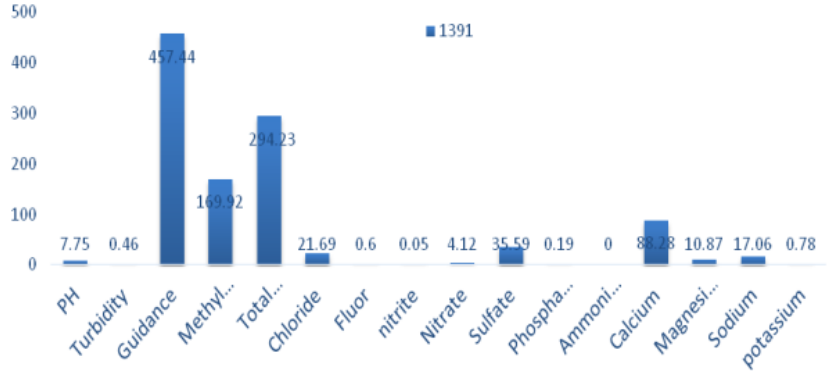

Fig. 1: Test for chloride

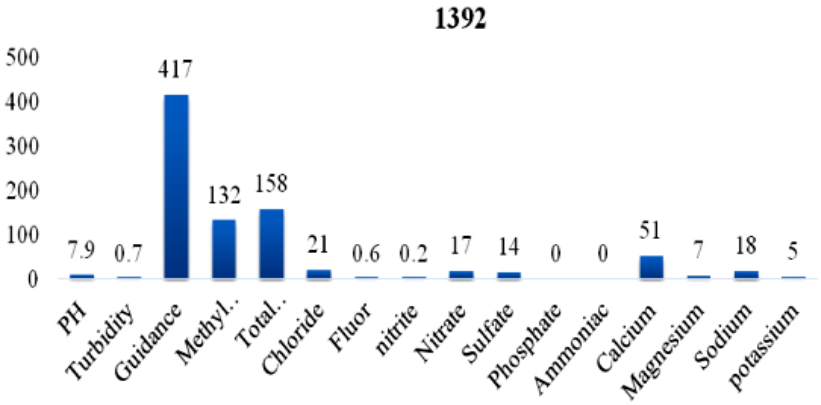

Fig. 2: Result of Phvsicochemical test in 2013

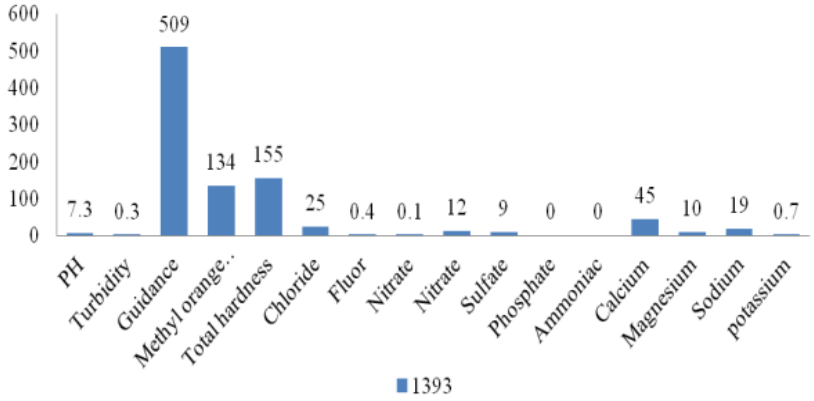

Fig. 3: Result of Physicochemical test in 2014

concentration to be fixed in water, it receives more fluoride in warm seasons of the year. According to Iran's standard, the optimum concentration of fluoride is 0.7 Mg L^{-1} during the warm seasons and 1.2 Mg L^{-1} in cold seasons. It seems that using water entails the risks of dental and skeletal fluorosis (Taghavi *et al*., 2013).

The study conducted by Sadeghi and Rouhollahi showed that the average concentration of fluorine in drinking water of Ardebil is 0.6 Mg L^{-1} whose highest concentration is 1.35 Mg L^{-1} and the least concentration is 0.35 Mg L^{-1} (WHO, 2015).

The amount of nitrate and nitrite was in line with the national standard and desirable in all samples and the results of this study was consistent with the results of study conducted by Kalantari, Sadeghi and Rohollahi and inconsistent with the results of the study carried out by Rajaii *et al*. (2011), Mohammadian and Sadeghi (2003). In the study conducted by Mohammadian Fazli and Sadeghi,

it was specified that the amount of nitrate is higher than the standard level in 11% of drinking water resources of Zanjan (Wachinski, 2003). The amounts of sulfate and phosphate were according to the national standard and desirable in all samples. However, it was more than the national standard in 33% of wells in the study carried out by Rajaii *et al*. (2011).

CONCLUSION

Considering these studies, it can be concluded that the desirability index of lack of thermo-tolerant coliform bacteria in Kamyaran County is in a good level according to the guidelines of World Health Organization. The microbial quality of drinking water of this county was better than the microbial quality index of drinking water. The amount of nitrate and nitrite of all samples was less than the standard level in Iran and guidelines of World Health Organization. The amount of ammonium was almost zero in all samples. Although, the microbial and chemical quality of water is around the standard level, maintenance and improvement of the current situation is vital considering the conditions and potentials of the infections in the area and requires permanent monitoring. The new nanotechnology methods is new trend in environmental sciences (Zahedi, 2004; Zand, 2000), this new trend must be used for removal pollution from water.

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