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Performance Evaluation of Qom Water Treatment of Plant during 2005 to 2014, Iran

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Background & Aims of the Study: Drinking polluted water can transmit diseases, so potable water treatment is one of the most challenging and complex systems in countries. Continuous monitoring for evaluation process in water treatment plant is important. This study aims to investigate performance evaluation of Qom water treatment plant to remove turbidity and coliform in 2005 - 2014.

Materials and Methods: In this cross-sectional descriptive study, daily results of experiments for coliform and turbidity parameters were collected in 2005 to 2014. Testing method is reported according to standard method. Statistical approaches were done using SPSS. Moreover, results of output water tests were compared with Iranian National standards.

Results: Range of turbidity level in raw water is observed from 1.05-253 NTU. Output turbidity values were less than the standard in all days. The annual average of turbidity and MPN in raw water for ten years were 7.495 NTU and 19.06 respectively. Maximum annual average of turbidity was between 2005 and 2006. Output turbidity values were less than Iranian National standard in all days.

Conclusions: Performance of Qom water treatment plant to remove turbidity and coliforms from water corresponds with Iranian National Standard. Because of desert climate of Qom and also probable creating flood conditions in some seasons, creating fluctuations in incoming water to the plant is possible, that shows the importance of preparedness treatment processes to deal with such critical situations. Studies in field of evaluation water treatment can improve performance processes and possible errors in treatment units.

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Background

Water is essential to sustain life. But, even in the 21st century many people, especially the third world countries do not have safe water for household use. More than a billion people do not access to safe water worldwide (1). Due to increasing industrialization and urbanization, river water pollution is becoming severe problem (2). Public health depends on the water quality (3). Drinking polluted water can transmit diseases such as shigellosis, gas gangrene, typhoid fever, cholera, diarrhea, hepatitis, malaria and digestive problems. Pathogenic bacteria, viruses, protozoans and intestinal parasites can cause such diseases in human beings (4-7). According to the report of the US Center for diseases which were associated with the outbreaks, have occurred from 1971 to 2006 (8). Water quality is described in four categories: physical parameters include color, turbidity, temperature and especially taste and smell; chemical parameters are often indicated by the reactions observed as a function of hard and soft water in washing and biological parameters are important related to public health. Finally, radiological factors, where water is in contact with radioactive materials (9,10).

Evaluation of water quality requires the investigation of all pathogens which have the potential for human infection. These pathogens divided into bacteria, protozoa and viruses (11). Fecal coliforms are not pathogenic but they can be used as an indicator for fecal contamination (new) which originated from plants or animals (12). Besides, the factors that cause turbidity included color combinations, clay particles, microscopic organisms, organic matter derived from decaying plant material and waste, silt, virus, bacteria, humic and fulvic acids, minerals such as asbestos, silica and radioactive particles (13). Increasing turbidity in the water usually indicates the increase of organisms like bacteria, Giardia, Cryptosporidium cysts and oocytes (14). Potable water treatment is one of the most challenging and complex systems in countries with considering limited resources. The main purpose of water treatment is pollutants removal from the water and makes it appropriate for human use through elimination and killing pathogenic organisms, taste, odor and other materials (15,16). Turbidity in water treatment processes is important for two reasons: first unpleasant turbid water aesthetically. Second, inactivation and elimination of pathogenic organisms in turbid water is difficult because of the particles. The lack of elimination turbidity in the water leads to regrow pathogens in distribution system and waterborne diseases (17-19). According to the study conducted by Eidib shown, turbidity in reservoirs output decreased. The results showed continuous monitoring and performance analysis in treatment units is very important (20). Presence of turbidity in water can affect the disinfection process and microbial inactivation (8). In a study conducted by Takdastan et al. on PAC performance for removal of turbidity and coliform bacteria and from the water of Karoon river, concluded that removal efficiency of turbidity, total coliform, in optimum condition was 96.59%, 90%, respectively when concentration of PAC was 10 ppm; while removal efficiency of turbidity, total coliform in optimum condition of PAC in the concentration of 30 ppm was 99%, 94.65%, respectively (21). Edib research considered the importance of continuous monitoring and laboratory analysis to assess the water treatment process (22,23). Either Hummer and Kiron Cross, agree that the maintaining documentation of the treatment plant is necessary, while the development and operation problems caused (23,24). Tasnia Ahmed noted that, the quality control of drinking water even after treatment methods such as filtration, etc. is essential to minimize health risks. This study showed that the MPN method is the least expensive and fastest method in developing countries (25). The total capacity of Qom plant is 3000 liters now. About 2 cubic meters per second in the main water treatment plant and 1.4 cubic meters are treating by high pressure filters.

Aims of the study:

Considering problems which were caused by bacterial agents in surface water and the importance of water microbial quality for public health, this study aimed to evaluate the performance of different units of Qom water treatment in order to remove turbidity and coliform in the years 2005 to 2014.

Materials & Methods

Qom water treatment plant is located near village Dudehak, 70 km in the north of Qom and 1400 meters above sea level. The total capacity of Qom plant is 3000 liter/s now. Population covered by this plant is 830,000. Raw water passes the screening in the stilling basin at 9 kilometers of the treatment plant. Then water enters through 1400 mm steel line.

In this study, the results of daily experiments for coliform and turbidity parameters conducted in the laboratory of Qom water treatment were collected in the years 2005 to 2014. Testing method is in accordance with routine procedures reference laboratory water and wastewater treatment (standard method). These data are included the results of experiments carried out in three-points treatment including raw water, outflow of clarifier water and output water (Figure 1). The mentioned results were confirmed by the Bureau of Water Quality Control Water and Wastewater. Statistical approaches, like T-Test, and correlation test for the factors and descriptive statistics done by analyzing data, using SPSS and statistical methods.

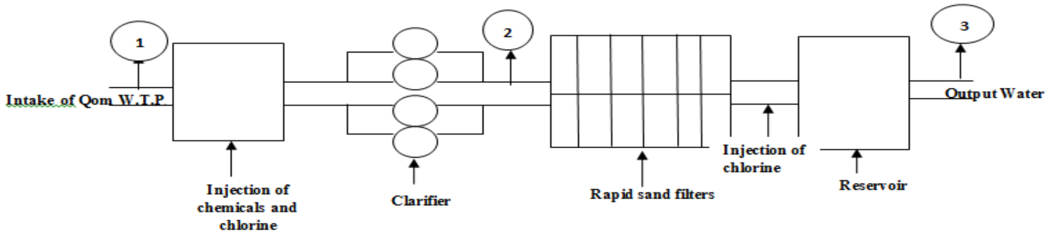

Figure 1) Diagram of Qom water treatment plant and locations of the sampling

Results

Daily turbidity observations at the intake of Qom W.T.P. for a ten-year period have been shown in Figure (2). Outliners or freak points are seen in this time plot. The high turbidity observations occured in several points due to the rainfall periods occurance.

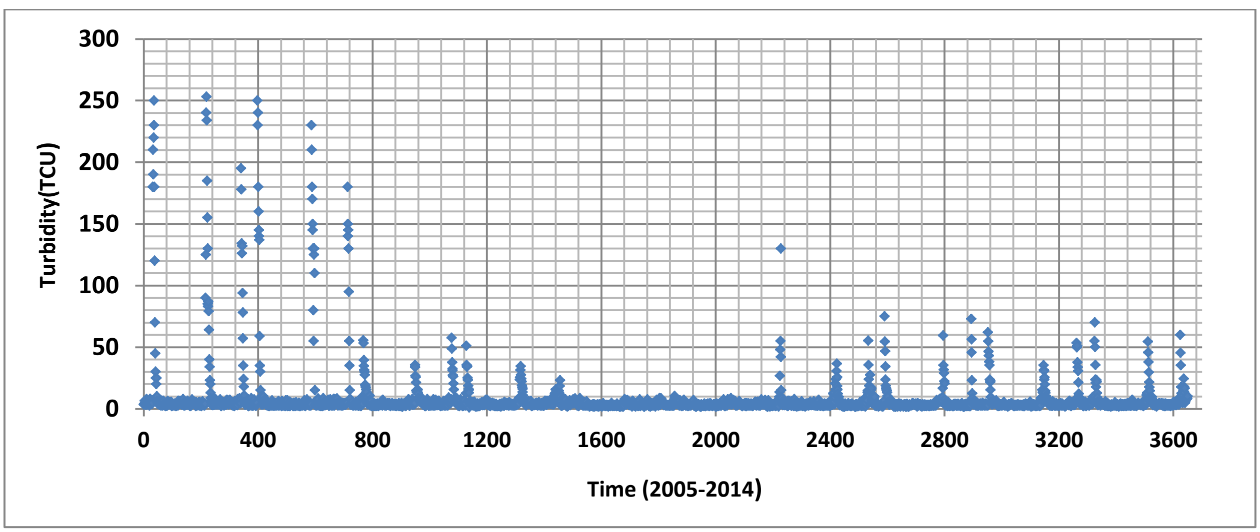

Figure 2) Daily Turbidity Observation at the Intake of Qom W.T.P. in 2005-2014.

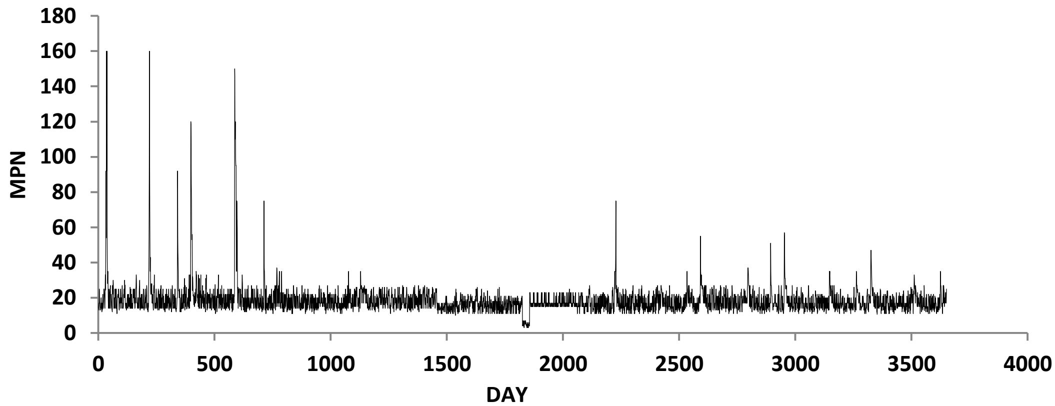

Figure 3) Daily MPN Observation at the Intake of Qom W.T.P. in 2005-2014.

Table 1) Statistical Description of Daily Raw Water Turbidity for Qom W.T.P.

W.T.P	N	Max.	Min.	Mean	Std.	Variance	Skewness	Kurtosis	CV
Qom	3652	253	1.05	7.46	20.41	416.7	8.04	72.84	2.73

Table (1) shows the statistics of the daily observations of turbidity at Qom water treatment plant. Range of turbidity level is observed from 1.05 NTU to 253 NTU.

Figure (4) shows a time plot of daily turbidity observations at the output of Qom W.T.P. The output turbidity value was less than the Iranian National Standard in all days in the period of ten years.

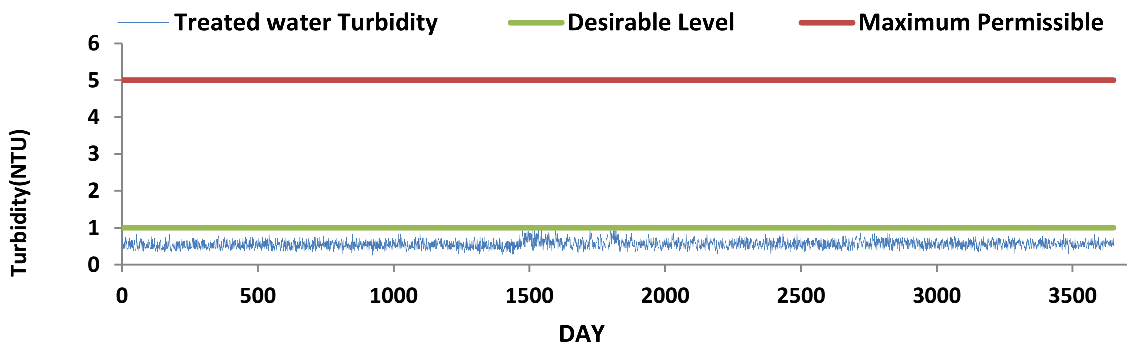

Figure 4) Daily Turbidity Observation at the Output of Qom W.T.P. in 2005-2014.

Results also showed, in all days for ten years period, MPN value in treated water has been less than 1.1 and turbidity value in water treated in all days of ten years period has been less 1 NTU.

The annual average of raw water for turbidity in total period of ten years is 7.495 NTU and for MPN has been 19.06 NTU. According to Table (2), the maximum annual average of turbidity between 2005 and 2006 is due to flood conditions in May and November in above mentioned years.

Table 2) The Annual Average of Turbidity and MPN at the Intake of Qom W.T.P.

year	turbidity	MPN
2005	17.17±23.05	24.7±13.77
2006	15.55±20.88	23.9±11.83
2007	6.34±4.65	18.14±1.5
2008	5.69±3.41	19.17±1.43
2009	3.6±0.86	16.06±0.86
2010	3.65±0.73	16.76±0.57
2011	5.89±4.46	17.81±2.15
2012	5.26±4.12	18.47±2.49
2013	5.82±4.59	17.81±2.26
2014	5.98±4.56	17.81±2.27

Table (3) shows the monthly average turbidity and MPN in the period 2005- 2014. According to this table, the highest monthly average turbidity and MPN has been in May and November, respectively.

Table 3) Monthly Average amount of Turbidity and MPN in 2005-2014 in Qom W.T.P

month	Row water		Clarifier		Output	
	Turbidity	MPN	Turbidity	MPN	Turbidity	MPN
April	3.6±0.59	17.18±1.86	1.07±0.17	5.28±0.51	0.55±0.039	<1.1
May	21.11±20.02	24.51±7.11	4.69±4.19	7.3±2.2	0.55±0.048	<1.1
June	3.53±0.53	17.56±1.16	0.98±0.08	5.36±0.51	0.54±0.038	<1.1
July	3.3±0.6	17.82±1.13	0.98±0.13	5.39±0.43	0.55±0.031	<1.1
August	3.16±0.6	17.82±1.25	0.96±0.11	5.38±0.45	0.55±0.042	<1.1
September	3.47±0.44	17.51±0.78	0.97±0.09	5.31±0.34	0.54±0.031	<1.1
October	3.46±0.7	17.84±1.1	1.04±0.19	5.27±0.35	0.54±0.03	<1.1
November	21.1±22.56	27.9±18.92	5.01±4.2	6.58±1.57	0.54±0.022	<1.1
December	3.61±0.93	17.46±0.71	1.01±0.11	5.4±0.37	0.55±0.03	<1.1
January	3.55±0.76	17.02±0.76	1.04±0.177	5.1±0.5	0.55±0.037	<1.1
February	3.8±0.59	16.93±1.34	1.11±0.17	5.06±0.56	0.56±0.037	<1.1
March	16.34±11.96	19.59±2.22	3.62±2.63	6.09±0.81	0.57±0.068	<1.1
Average	7.49±7.34	19.07±3.48	1.87±1.57	5.63±0.68	0.55±0.01	<1.1

Figure 5 and 6 shows the annual average removal efficiency of clarifier as well as overall efficiency of turbidity and MPN.

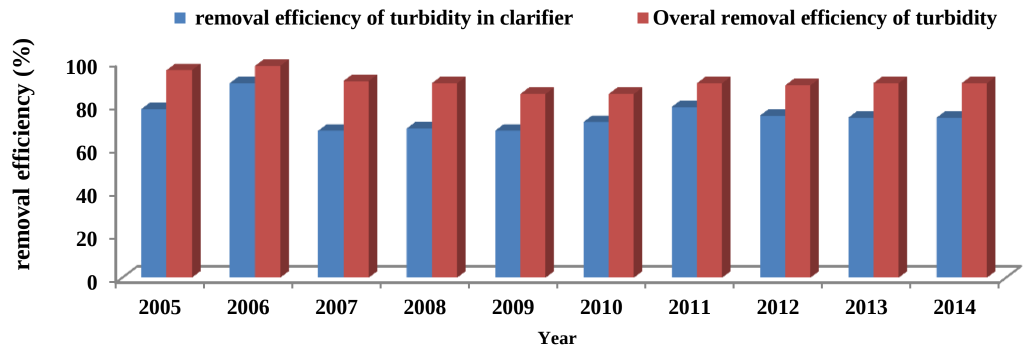

Figure 5) Annual Average Turbidity Removal Efficiency in 2005-2014.

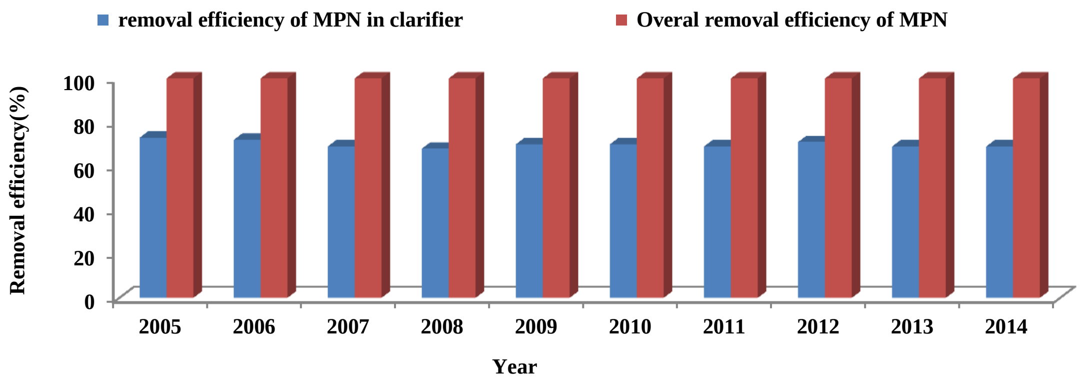

Figure 6) Annual average of MPN removal efficiency in 2005-2014.

Discussion

This study showed, in all years of the ten-years period, recorded parameters (turbidity and MPN) in water have been less than the standard in output water, which represents the function and operation of Qom water treatment is correct. According to Table (2), the annual averages of turbidity in the raw water at intake of the plant from 2006 onwards is less than 5 NTU. One of the reasons for this is raw water entering to the treatment plant from Dez branches. According to Table (2), monthly average turbidity in the ten-years period in May and June is highest with the 21.11 and 21.1, respectively; that is because of the rain and floods, especially in the years 2005 and 2006. Moreover, in these months (May and November), the monthly average of MPN value are the highest averages which were 24.51 and 27.9. According to the results of analysis of one way ANOVA, there is a significant difference between the turbidity average in three processes, at the intake, after clarifier and at the output water of treatment plants, statistically. So, the highest turbidity is for incoming water and lowest turbidity for output water. On the other hand, the amount of turbidity in outlet water treatment system of all days in the period of ten years is less than 1 NTU. According to the results of Single-sample T-test, a significant difference is between the turbidity average with fixed value statistically (P=0.001). The turbidity value is less than the standard amount of 1 NTU. The mean difference is 0.091. Figure 4 shows that the average percentage of turbidity removal efficiency of clarifier in the years 2005-2014 is between 68 to 79% which the highest removal rate is in 2011. The removal average rate at the clarifier in the years 2005 to 2014 coliforms is between 68 and 73%. The results presented in Figure (5,6) show the removal average rate of turbidity and coliform in all years of study is high and the plant has a good performance in the removal of these two important parameters. Control of turbidity in the water, is important because of aesthetic and health. Suspended solids can contain toxic substances such as heavy metals; also, it can protect microorganisms against disinfection. Turbidity also can be used as a parameter to indicate the safety of the water after filtration or to evaluate treatment performance in the plants (23,25,26). In a study in Kenya in relation to evaluating the performance of MOI treatment plants, turbidity parameter was used as the main parameter to evaluate treatment plants efficiency. Turbidity average in treatment plants were reported 16 NTU, while in some cases the turbidity of output water reported 7 NTU that indicated the possibility of defects in some treatment plants units (filtration and coagulation) or water distribution systems (26). Based on Eldib study to evaluate the performance of Meet Fares water treatment plant, raw water turbidity in the treatment plants and the output water turbidity were reported between 28-14 NTU and 0.6-0.1 NTU, respectively (22). Iran national standard for the drinking water turbidity is less than 1 NTU (27). Drinking water is a major source of bacterial pathogens in developing regions. Pathogenic organisms, which are transmitted via drinking water, are mainly fecal origin and are known enteric pathogens. Fecal coliforms and total coliforms are two good indicators of the efficiency of drinking water treatment to remove pathogens which are responsible for cholera (28). In a study conducted in Pakistan, MPN in raw water entering plant was estimated in the range of 1400-1600. High level of microbial contamination was due to the livestock grazing on the path to input channel. The results of the study showed the removal efficiency of 43% for total coliform in the process of coagulation, 52% for filtration and 100% for chlorination (29). In our study, the mean annual total coliforms in raw water at the intake of the treatment plant is between 16.93-27.9 NTU in the years 2005- 2014. The maximum MPN at the intake of Qom treatment plant is 160 that related to flood days. Coliforms removal efficiency on all days of the ten-years period was 100%. This is the indication of proper performance and operation of treatment plants during this period. Iran standard drinking water for microbial contamination, insists drinking water must be free of pathogenic microorganisms and coliforms in drinking water should not exist (30).

Conclusion

According to the results, the performance of Qom water treatment to remove turbidity and coliforms from water in the course of ten years corresponded with the National Iran standard. The mean values of recorded parameters show that the treatment system is functioning well. Because of climate desert of Qom and also probable creating flood conditions in some seasons, creating fluctuations in incoming water to the plant and a sudden increasing in turbidity is possible that shows the importance of preparedness of treatment processes to deal with such critical situations. This issue should be considered in the design of water treatment plants in such areas. It should be noted that continuous monitoring of the water treatment plant is essential due to the sensitivity of the public health. Studies in the field of evaluation of water treatment system can improve the performance of processes and shows possible errors in plant.

Footnotes

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Conflict of Interest:
The authors declared no conflict of interest.

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