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Evaluation of trends for iron and manganese concentrations in wells, reservoirs, and water distribution networks, Qom city, Iran

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Abstract

Background: This study aimed to evaluated trends for iron and manganese concentrations in wells, reservoirs, and water distribution networks in Qom city during the summer of 2012.

Methods: This was a cross-sectional study. The studied scopes consisted of groundwater (60 wells), reservoirs (10 tanks), and water distribution network (33 points). One sample was taken from each source monthly. Statistical tests used included post hoc tests (Tukey HSD). Finally, the results were compared with drinking water standards.

Results: The average concentrations of iron in groundwater, reservoirs, and distribution networks were 0.09, 0.07, and 0.07 mg/l, respectively. The average concentrations of manganese in groundwater, reservoirs, and distribution networks were 0.15, 0.09, and 0.1 mg/l, respectively. The turbidity averages in groundwater, reservoirs, and distribution networks were 0.58, 0.6, and 0.52 NTU, respectively. The average concentrations of free chlorine residual in water reservoirs and distribution networks were 1.74 and 1.06 mg/l, respectively. The pH averages in groundwater, reservoirs, and distribution networks were 7.4, 7.7, and 7.5, respectively. The amounts of iron, manganese, turbidity, free chlorine residual, and pH in the investigated resources had no significant differences ($P > 0.05$).

Conclusion: The amounts of iron, manganese, turbidity, free chlorine residual and pH in groundwater, reservoirs, and water distribution networks of Qom are within permissible limits of national standards and EPA guidelines. Only the amount of manganese was higher than the Environmental Protection Agency (EPA) permissible limit.

Keywords: Iron, Manganese, Drinking water, Qom

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Introduction

The existence of a variety of minerals in drinking water is essential for human health, while amounts exceeding permissible limits can threaten human health over the long-term. There are some minerals and suspended matters in water (1). Iron and manganese often exist in groundwater or in the hypolimnion of reservoirs. In anaerobic conditions, bacteria reduce iron and manganese to soluble Fe^{+2} and Mn^{+2} forms. In the presence of oxygen, these ions are oxidized to low soluble forms (Fe^{+3} and Mn^{+4}) that cause spotting on dishes and clothes and increase the color of water (2). The iron bacteria (Crenothrix and Gallionella) consume ferrous ions (Fe^{+2}) as a source of energy and create ferric hydroxide precipitates. In water containing iron, the growth of iron bacteria may lead to the clogging of pipes (3). Some anaerobic bacteria such as (Leptothrix) consume ferrous ions and increase the corrosion rate of the pipes (4). High concentration of iron in water results in the formation of sludge that affects the quality of drinking water (5).

Manganese is present in surface water and groundwater as divalent ions (6). High concentrations of manganese can affect the flavor of water and increase biological growth (3). It can also cause black spots on clothes during washing (5). Manganese may have adverse effects on the respiratory system and brain, and it causes bronchitis and Parkinson disease. Typical symptoms of manganese poisoning include headache, insomnia, imbecility, and myasthenia (7). Kondakis et al (8) investigated the impact of high manganese levels in drinking water on human health in 3 locations. The results revealed an association between manganese levels and an increase in neurological symptoms from chronic manganese toxicity.

Turbidity is the criteria for the absorption rate or light scattering by suspended material in water (9). The importance and health aspects related to turbidity include the attachment of microorganisms to particulates and interference in the disinfection process (3). Microorganisms are protected against disinfection by turbidity (9). Disinfecting water significantly reduces water borne diseases (10). Factors affecting the efficiency of the disinfection process include type and concentration of the microorganism, type and concentration of disinfectant, contact time of the disinfectant, and chemical quality of the water (3). Chlorine is used for disinfection in many water treatment plants. For effective disinfection, residual chlorine must be at least 0.2 mg/l (5). Many compounds including inorganic and organic nitrogen, iron, manganese, and hydrogen sulfide interfere with disinfection (10). In water treatment processes, chlorine is used as a solution of liquid chlorine. These chlorine compounds produce hypochlorous acid (HClO) and hypochlorite ion (ClO^-) in water. Free residual chlorine in water is called to the HClO. The ratio of HOCL and OCL^- concentrations is dependent on the pH and temperatures of water (4). Although pH has no direct effect on consumer health, does affect water quality. There is no guideline for health effects caused by pH (11).

This study investigated concentrations of iron, manganese, turbidity, free chlorine residual, and pH in the water distribution networks and resources of Qom city and compared the results with standards.

Methods

The present descriptive-cross sectional study was conducted in the summer of 2012 year. Scopes of the study were (*a*) groundwater (60 wells), (*b*) reservoirs (10 tanks), and (*c*) water distribution network (33 points) of Qom city. One sample was collected monthly from each source. Total number of samples was 309 and sampling was performed in duplicate. The parameters of iron, manganese, turbidity, free chlorine residual, and the pH were measured. All measurements were performed according to the standard methods for examining water and wastewater (12). Turbidity and pH were measured using a turbidity meter (model AQVALITIC) and a pH meter (model RTCO), respectively. (Fe) and (Mn) were determined using a DR2000 spectrophotometer (Hach company, USA). The N,N-diethyl-p-phenylenediamine (DPD) method was used to measure free chlorine residual. Data were analyzed with SPSS version 16 software. Post hoc Tests (Tukey HSD and the Tamhane) were performed, and the results were compared with drinking water standards.

Results

The average values of measured parameters in groundwater, reservoirs, and water distribution networks of Qom are shown in Table 1.

The average concentrations of Fe and Mn in wells, reservoirs, and water distribution networks are presented in Figures 1, 2, and 3. The values of most measured parameters were similar among the different sources (wells, reservoirs, and distribution network).

Variation trends of the studied parameters in wells are shown in Figure 4.

The variation trends of studied parameters in the reservoirs are shown in Figure 5.

The variation trends of the studied parameters in the distribution network are shown in Figure 6.

Discussion

The average concentrations of iron in groundwater, reservoirs, and distribution networks were 0.09, 0.07, and 0.07 mg/l, respectively. No significant difference ($P > 0.05$) was observed among the iron levels in groundwater, reservoirs, and the water distribution network. An iron concentration of 0.3 (mg/l) in drinking water is recommended by the Institute of Standards and Industrial Research of Iran (13). In the national secondary drinking water regulations, the Environmental Protection Agency (EPA) recommends the level of 0.3 mg/l as the maximum contaminant level (MCL) of iron in drinking water (14). Therefore, the amount of iron in groundwater, reservoirs, and the distribution network of Qom was at a desirable level. Maximum iron concentrations in all places was observed in July.

The average manganese concentrations in groundwater, reservoirs, and distribution networks were 0.15, 0.09, and 0.1 mg/l, respectively, which show no significant difference ($P > 0.05$). According to Iranian drinking water standards, optimum and maximum manganese concentration limits in drinking water are 0.1 and 0.4 mg/l, respectively (13). According to the secondary standard of the EPA, the maximum contaminate level of manganese is 0.05 mg/l

Table 1. Average values of parameters in wells, reservoirs, and the water distribution network of Qom

Parameter	Samples Location		
	Distribution Network	Reservoirs	Wells
Iron (mg/l)	0.07	0.07	0.09
Manganese (mg/l)	0.1	0.09	0.15
Turbidity (NTU)	0.52	0.6	0.58
Free Chlorine Residual (mg/l)	1.06	1.74	-
pH	7.5	7.7	7.4

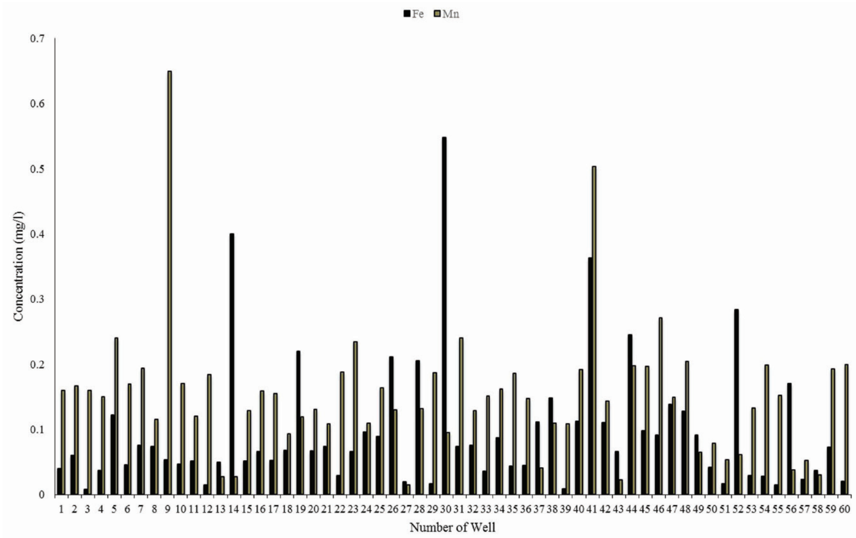

Figure 1. Average concentrations of Fe and Mn in wells.

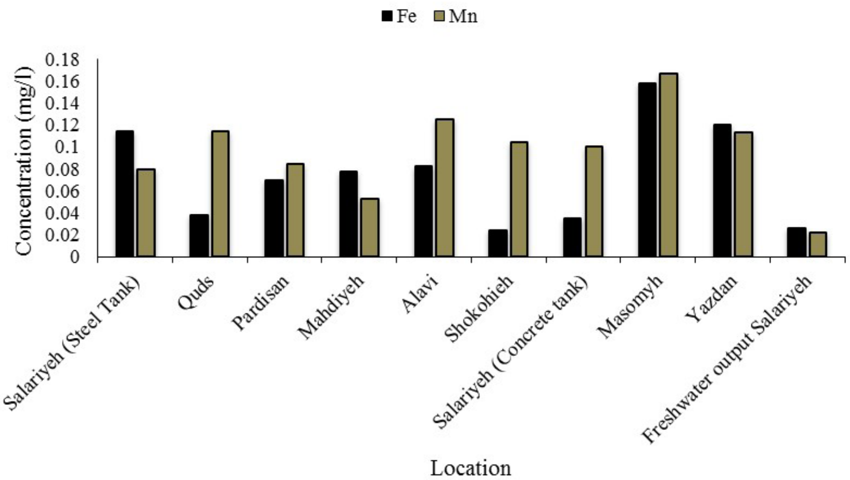

Figure 2. Average concentrations of Fe and Mn in reservoirs.

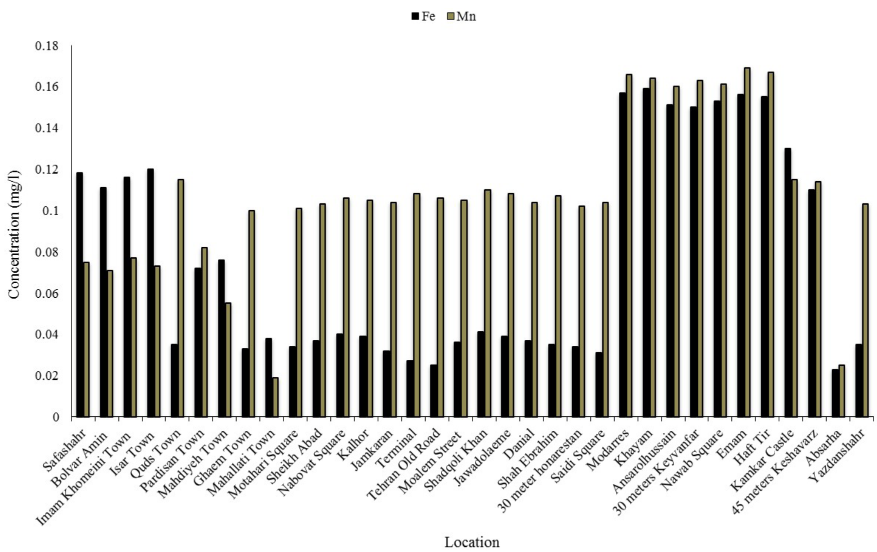

Figure 3. Average concentrations of Fe and Mn in distribution network.

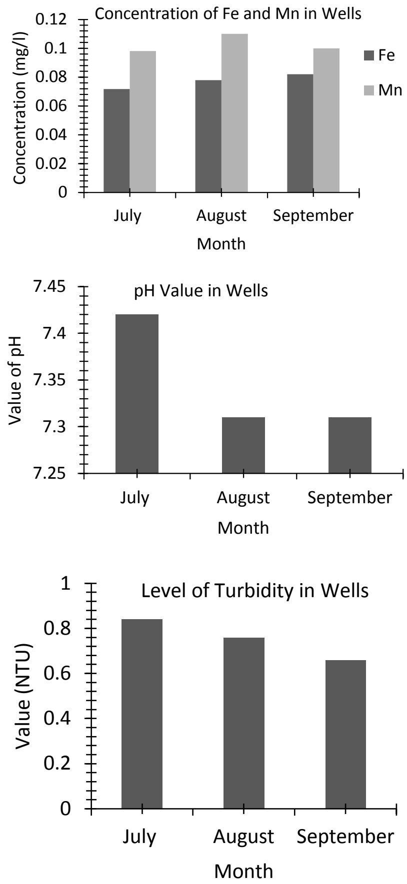

Figure 4. Variation trends of studied parameters in wells.

(14). Based on Iranian drinking water standards, the average manganese concentrations in Qom's water resources and distribution system were with in permissible levels, while according to the national secondary drinking water regulations of the EPA, they were higher than permissible limits. Such concentrations were observed in all investigated places in July.

Average turbidity levels in groundwater, reservoirs, and distribution networks were 0.58, 0.6, and 0.52 NTU, respectively, which showed no significant difference (P > 0.05). According to Iranian drinking water standards, the desired value and permissible value of turbidity are ≤1 and 5 NTU, respectively (13). According to the EPA, turbidity must never be higher than 5 NTU (14). The turbidity values in the water sources and distribution network in Qom were less than the value recommended by Iranian and EPA standards. The turbidity concentration was higher in July than in other months, possibly because precipitation was greater in spring.

The average concentrations of free chlorine residual in water reservoirs and distribution networks were 1.74 and 1.06 mg/l, respectively, which showed no significant difference (P > 0.05). According to the national standards, the minimum allowable level of free chlorine residual is 0.5 mg/l in pH values below 8 (13). In the Qom reservoirs and water distribution networks, the values of free chlorine residual were with in allowable levels.

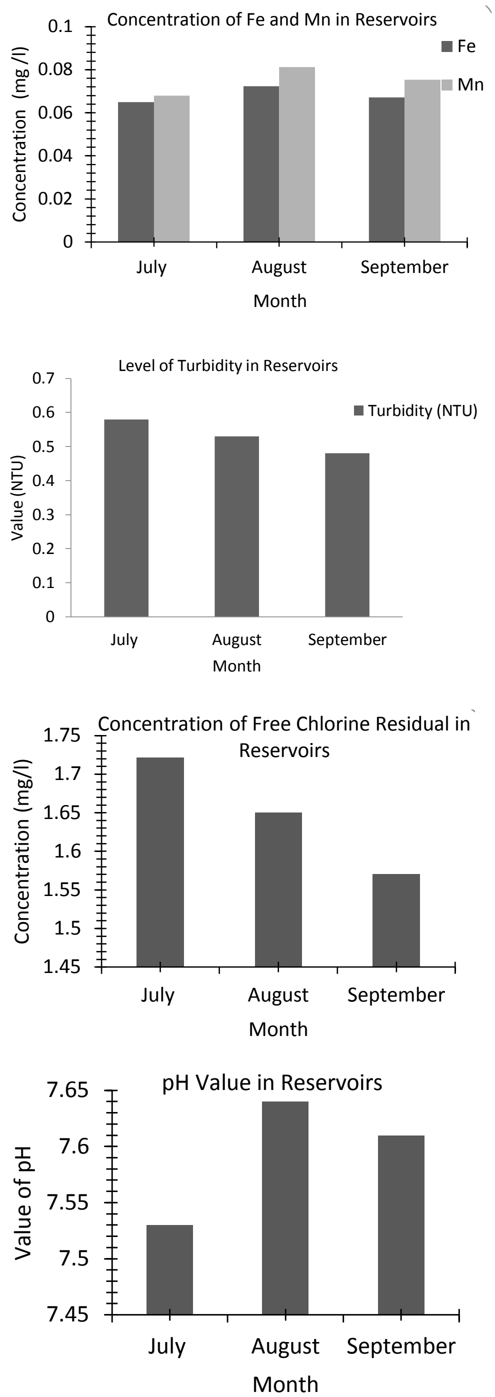

Figure 5. Variation trends of studied parameters in reservoirs.

The average pH values in groundwater, reservoirs, and distribution network were 7.4, 7.7, and 7.5, respectively, which showed no significant difference (P > 0.05). According to Iranian standards, the allowable and optimum pH values are 6.5-9.2 and 7-8.5, respectively (13). The EPA recommends a maximum permissible pH range between 6.5-8.5 (14). Therefore, the pH values of Qom water resources and water distribution networks were with in the desirable range.

The physical, chemical, and microbial qualities of water

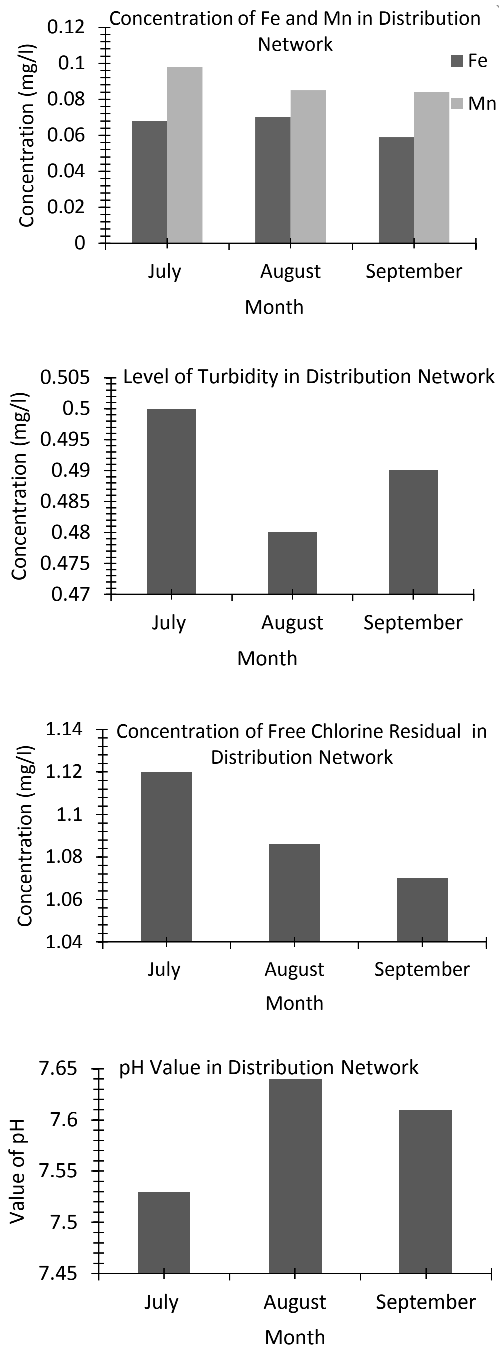

Figure 6. Variation trends of the studied parameters in distribution network

in desalination units in Qom were investigated by Yari et al (15). Iron and manganese concentrations in the inlets and outlets of desalination units were with in permissible limits (15). Mazloomi et al (16) determined the physical and chemical quality of water at the Ilam water treatment plants. The average concentrations of Fe and Mn were 0.07 and 0.01 mg/l, respectively. The amounts of turbidity and pH were 1.04 NTU and 8.12, respectively (16). The chemical quality of drinking water was investigated by Rajaei et al (2) in the rural regions of Ghaen and Birjand. The average concentrations of iron and manganese were 0.04 mg/l and 0.02 mg/l, respectively. The average pH and turbidity values were 7.83 and 0.19 NTU, respectively (2). Dindarloo et al (1) assessed the quality of drinking water in Bandar Abbas. The amounts of iron in surface and groundwater sources were 0.1 mg/l and 0.082 mg/l, respectively (1). Groundwater contamination in the Kerman area was investigated by Hassanzadeh et al (17). The average Mn value in 43 wells equaled 0.026 mg/l. In addition, the level of pH in well water was 7.28 (17). Nasrolahi Omran et al (18) reviewed the physical and chemical quality of drinking water in Gorgan city. The annual mean of pH was 7.2, and the annual average turbidity was 0.95 NTU. In the present study, the iron, manganese, turbidity, and pH levels were found to be below the standard in agreement with the above-mentioned studies.

Conclusion

The study results showed that the values of iron, manganese, turbidity, free chlorine residual, and pH in the groundwater, reservoirs and water distribution networks of Qom city were with in permissible limits (national standards and EPA), which showed no significant difference ($P > 0.05$). Only average concentrations of Mn were higher than the EPA permissible limits (it was second the recommended standard).

It is possible that, with carry-on the current water resources management, the concentration of manganese in water will exceed the recommended limits in the future. Therefore, in order to avoid a probable increase in Mn, water resources must be continuously monitored. In addition, Mn-producing resources in the region must be identified, and a management strategy for controlling manganese in water recourses is necessary.

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Ethical issue

The authors certify that all data collected during the study is presented in this manuscript, and no data from this study has been or will be published separately.

Competing interests

The authors declare that they have no competing interests.

Authors's contributions

MF, RAT, GM, ASM and MA designed the study. MA, HJM, MSTM, and GM performed the literature search and wrote the manuscript. All authors participated in data acquisition, analysis, and interpretation. All authors critically reviewed, refined, and approved the manuscript.

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