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Assessment of chemical quality of drinking water in rural areas of Babol, Northern Iran

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Abstract

Background: This study evaluated the quality of drinking water in rural areas of the city of Babol in terms of chemical parameters (iron, manganese, nitrite, and nitrate) and compared it with the Iranian and the World Health Organization (WHO) standards to determine the trend.

Methods: This cross-sectional study monitored chemical test results for the years 2011-2014 of samples collected from rural water and wastewater from Babol Company. A total of 375 samples from 71 drinking water wells were investigated.

Results: Results for the maximum, mean, and minimum levels of each parameter across rural sectors over 4 years were compared and analyzed against Iranian and the WHO standards. The results showed that during the four years of monitoring, the average iron concentration in Laleh Abad (0.5 ± 0.06 mg/L), Gatab (0.398 ± 0.42 mg/L), and Central (0.307 ± 0.23 mg/L) exceeded the standard concentration. Overall, the average concentrations of iron, manganese, nitrite, and nitrate in all areas during the years 2011-2014 were 0.239 ± 0.15 mg/L, 0.132 ± 0.95 mg/L, 0.008 ± 0.012 mg/L, and 2.201 ± 0.73 mg/L, respectively.

Conclusion: In general, statistical analyses showed that the average concentrations of nitrite and nitrate were below the allowable limit, which is desirable. The mean concentrations of iron and manganese (Mn^{+2}) in the water of some areas of the county during this period were higher than the allowed limit. This is an adverse finding that may be attributable to the improper locations of the water wells.

Keywords: Drinking water, Chemical quality, Babol, Northern Iran

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Introduction

The chemical properties of groundwater are important and determinate factors used in domestic, irrigation, and industrial purposes with contexts (1). Water quality and its appropriateness for use can be determined by taste, smell, color, and concentration of organic or mineral substances. Importantly, pollutants in water can affect the quality and, thus, human health (2,3).

The existence of unexpected chemical compounds, even in small amounts, leads to the poisoning of humans or animals if levels are higher than amounts stipulated by international standards (4). The quality of groundwater is typically characterized through various physical and chemical features. These parameters vary widely according to different types of pollution, seasonal changes, groundwater extraction, and other changes. Based on water analyses, most drinking water resources in northern Iran are very hard, indicating poor quality. Therefore, a constant monitoring and control of groundwater pollution is required (5,6).

Drinking water can be quantified using parameters such as pH, electrical conductivity, total dissolved solids, turbidity, free residual chlorine, alkalinity, hardness, chloride, calcium, magnesium, iron nitrite, sulfate, fluoride, and phosphate. Concentrations of some parameters that are too high or too low can have adverse effects on human health (7-11). It is believed that groundwater is cleaner and freer of contamination than surface water. However, the long-term discharge of industrial wastewater, domestic sewage, and wet waste has caused groundwater to become polluted and cause health problems. Hence, the need for groundwater conservation and quality management have always existed (12). If chemical impurities in drinking water exceed recommended standard ranges over the long-term, irreversible damage and human diseases, including digestive disorders or methemoglobinemia, may occur (13).

Distinctive ecological features cause rural environments in Iran to have various spatial structures. Factors such as weather, climate, terrain, and the physical conditions of land, water resources, and other natural factors have been very effective in the formation and establishment of settlements in rural areas.

The non-homogeneous distribution of rural areas in terms of geographical distribution and the distance between residential units has created some difficulty in supply, distribution, and water quality monitoring (14). Babol is located in Mazandaran province and has six rural sectors: Gatab, Eastern Bandpei, Western Bandpie, Central, Laleh Abad, and BabolKenar. Most of the water in these parts is supplied from groundwater.

The current research evaluated the quality of drinking water in rural areas of Babol by measuring chemical parameters and comparing them with the standards of Iran and the World Health Organization (WHO).

Materials and Methods

Study population

Babol is located in the center of Mazandaran province at a latitude of 36°31'44.71"N and a longitude of 52°40'14.57"E. Babol has an area of 1578 km^2 and has more than 510 villages with a total population of over 230 973 people (15).

Project method

This research evaluated the chemical quality parameters of drinking water from wells in six rural areas during the period 2011-2014. The chemical parameters iron, manganese, nitrite, and nitrate were investigated and compared with the WHO standard guidelines (the mean and standard deviation of data, etc.) in six rural areas during 2011-2014.

This cross-sectional study collected chemical test results from the years 2011 to 2014 from 71 drinking water wells in six areas (Figure 1).

Sample collection

A total of 375 water samples from groundwater drinking water wells of Babol city in Mazandaran province, northern Iran were randomly collected from six areas (Central, Western Bandpei, Eastern Bandpei, Babolkenar, Gatab, and Laleh Abad) during 2011 to 2014. All samples were collected in 1000 ml polythene bottles and carried to the laboratory. The total number of samples in 2011 2012, 2013, and 2014 were 84, 99, 93, and 99, respectively.

In Central, Western Bandpei, Eastern Bandpei, BabolKenar, Gatab, and Laleh Abad, different numbers of samples were taken, as shown in Figure 2.

Sample analyses

All samples were analyzed according to the Standard Methods for the Examination of Water and Wastewater, 22nd Edition (16). HACH-DR 2000 UV-Vis Spectrophotometer and USA colorimeter (Methods 8039 and 8507) at 500 and 507 nm were applied for the measurement of nitrite and nitrate, respectively. The standard solution method and blank preparation were prepared according to the Standard Methods for the Examination of Water and Wastewater. Measurements of iron and manganese in all samples were taken in 25 mL cells on a Hach, DR 2000 spectrophotometer.

Statistical analysis

Statistical analyses were performed on the collected data using Excel software.

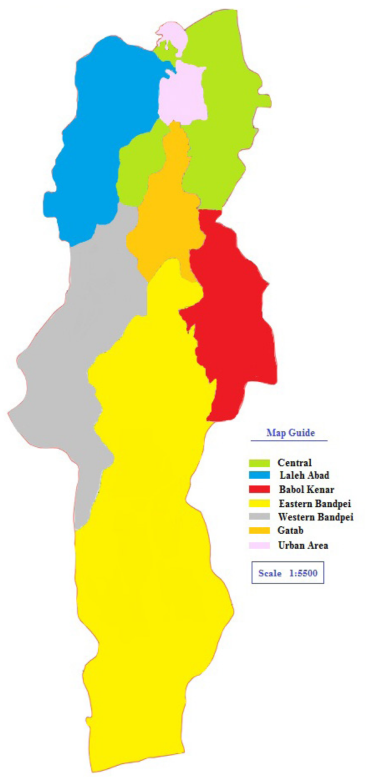

Figure 1. Geographical location of study areas.

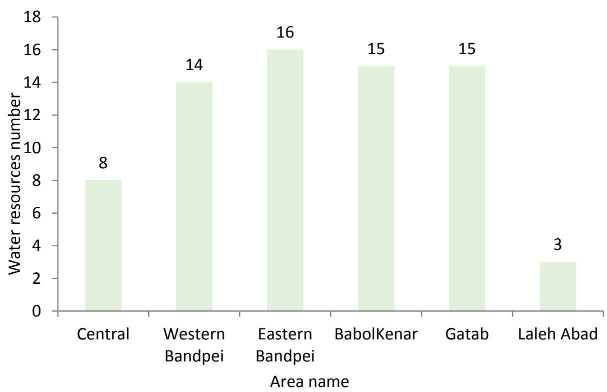

Figure 2. Number of Water Resources Evaluated in Rural Areas.

Results

For each rural area, chemical variables of water quality, i.e. iron, manganese, nitrite, and nitrate, which are all independent and quantitative variables, were studied (Table 1).

As seen in Table 1 and Figure 3, during 2011-2014, Laleh Abad, Gatab, and Central generally had maximum amounts of iron (0.5 ± 0.06 mg/L, 0.398 ± 0.42 mg/L, and 0.307 ± 0.23 mg/L, respectively), which were greater than the Iranian national and WHO standards. This may be due to the inappropriate placement of the wells. Since the standard limitations of these components were not based on consumer health, this cation poses no threat for regional water. However, it may be important to the aesthetics of the samples. In other sections, the amount of iron ions was desirable. Overall, the average concentrations of ions of iron, manganese, nitrite, and nitrate in all studied locations during 2011-2014 were within permissible levels and equal to 0.239 ± 0.15, 0.132 ± 0.95, 0.008 ± 0.012, and 2.201 ± 0.73 mg/L, respectively.

As Table 1 indicates, the results showed that the mean concentrations of water quality parameters in some cases were higher than Iran's national allowable limits. Assessing the water quality parameters in the selected cities revealed that the mean concentrations of nitrite and nitrate in all of the studied areas were within allowed limits, but the mean concentrations of iron and manganese (Mn^{+2}) in the water of Central, Gatab, and Laleh Abad exceeded the national allowable limits. Also, the mean concentration of Manganese (Mn^{+2}) in water (0.132 ± 0.95) in all of the studied areas exceeded Iran's national standard limits and the WHO guidelines.

Discussion

The results of Seth et al on drinking water of the Ashanti area in Ghana in 2014 showed that the level of chemical concentration was generally at the level allowed by the WHO guidelines, but in some aquifers, the results showed Iran high levels above the limit (0.3 mg/L) that the results of these studies were adapted to this research (16).

In a national survey, the US Environmental Protection Agency (EPA) reported about 1.2% and 2.4% of the community and rural domestic drinking water wells (respectively) had nitrate levels higher than the health advisory level. Also, this report indicated that about 1.5 million people are covered by rural domestic drinking water wells and that another 3 million people are covered by community water wells that exceed health advisory levels for nitrate (18,22).

Another research in the United States showed that in the seven states of California, Pennsylvania, New York, Illinois, Wisconsin, Minnesota, and Iowa, more than 100 000 rural residents were exposed to nitrate levels higher than the federal standard (19,22).

About 18% of rural domestic drinking water wells in Iowa had a higher level of nitrate concentration (above 10 ppm) than the allowed limit (20). In another report, pollutant resources of nitrate such as fertilizer, sewage sludge, and animal manure were the main causes of increasing nitrate in groundwater drinking water wells. Also, well waters without the influence of these pollution resources contained nitrate levels of less than 3 ppm (21,22).

Rainfall events can transfer nitrogen from lands utilized for crops into groundwater. Denitrification, sewage treatment plants, private septic systems, animal manure, legume crops, and atmospheric deposition can be important in the polluting of groundwater drinking water wells (22,23).

The findings of Mohammadi et al from their research on the quality of groundwater drinking water resources in rural areas of Babol indicate that some parameters such as nitrite, nitrate, sulfate, chloride, calcium, sodium, conductivity, and pH are at desirable levels. Other measured parameters, such as turbidity, fluoride, iron, and hardness, were not in the desirable range (14).

Generally, the results showed that the average concentrations of iron, manganese, nitrite, and nitrate ions in rural areas of Babol during 2011-2014 were within desirable ranges compared to the Iranian national and WHO standards (Table 1).

The results further showed that the number of iron ions in

Table 1. Results of water chemical analysis in rural areas of Babol, 2011-2014

Area	Fe^2 (mg/L)	Mn^2 (mg/L)	NO_2^- (mg/L)	NO_3^- (mg/L)
Central	0.317±0.307	0.220±0.180	0.015±0.009	1.807±0.647
Western Bandpei	0.112±0.105	0.122±0.090	0.014±0.008	2.475±0.950
Eastern Bandpei	0.060±0.056	0.046±0.040	0.008±0.004	2.262±0.767
Babolkenar	0.065 ± 0.043	0.055±0.041	0.003 ±0.004	2.937±1.216
Gatab	0.420±0.398	0.150±0.142	0.030±0.015	2.247±1.185
Laleh Abad	0.063±0.502	0.237±0.037	0.001 ±0.005	1.475±0.488
Mean of whole parts	0.239±0.168	0.946±0.132	0.012±0.007	2.200±0.778
Iran national standards 1053 (desirable, allowed)	0.3	0.4	3	50
WHO Guidelines	0.3	0.5	3	50

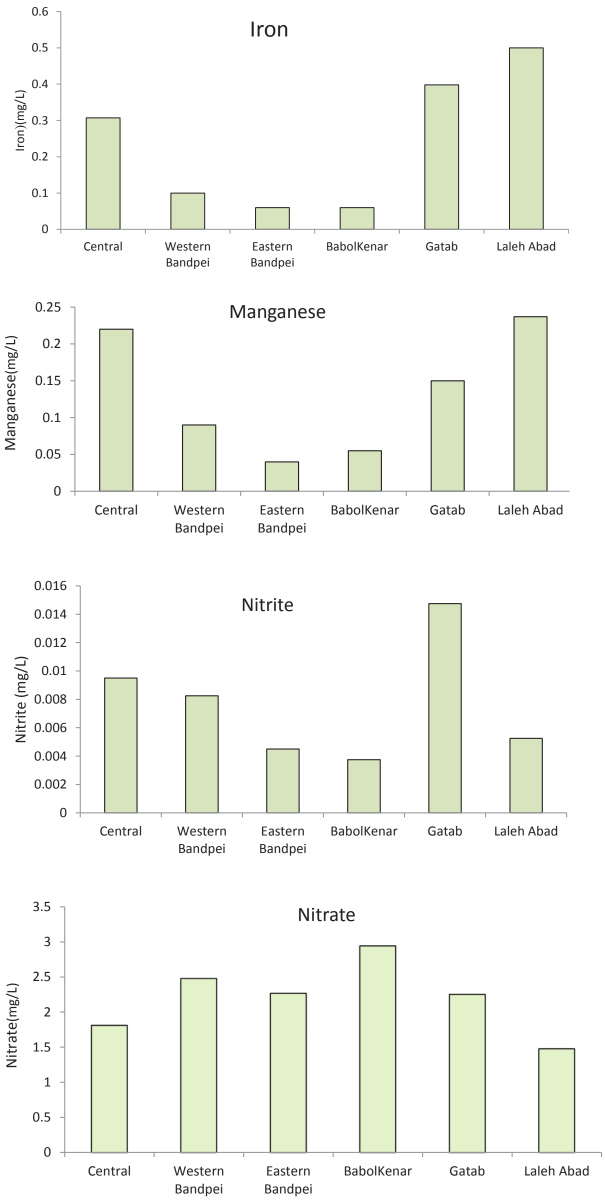

Figure 3. Average concentrations of iron, manganese, nitrite, and nitrate ions in rural parts of Babol during 2011-2014.

some parts during the 4 years were higher, possibly due to the inappropriate locations of water wells. This element is not very harmful, but in terms of the physical properties of water (color, taste, and smell), it is very good (Figure 3). In large amounts, however, it makes the water taste bitter and unpleasant. Even a small amount of iron can cause the accumulation of sediment in the water supply networks. Such a sediment is not suitable for the consumer and could cause the growth of iron bacteria, and that could explain why water quality is reduced through the production of sludge or noxious smells.

Conclusion

Statistical analysis indicated that the mean concentrations of some parameters (nitrite and nitrate) were below the Iranian national standard limits and the WHO guidelines, which is desirable. The mean concentrations of some parameters (iron and manganese) of water in some areas of the county, however, were higher than the limit, which may be due to the improper location of water wells and the improper control of discharges into the groundwater. The authors of this study recommended to the authorities of the water and wastewater corporation that a master plan for monitoring of water quality parameters and the discharges to the water resources be devised.

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Ethical issues

None applicable.

Competing interests

The authors affirm that this article is the original work of the authors and that the authors have no conflicts of interest to declare.

Authors' contributions

All authors were involved in all stages of the study. On behalf of the co-authors, the corresponding author bears full responsibility for this submission.

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