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Physical and chemical characteristics of drinking water quality in rural areas of north Iran by geographic information system (GIS)

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Abstract
Background and purpose: Babol city in the central part of Mazandaran province, with more than 577 villages. The only source of drinking water for the residents of these villages is groundwater. Therefore, evaluating the quality of these resources is important. The aim of this study is qualitative evaluation of the drinking water in the villages of Babol city.
Materials and Methods: This research was a cross - sectional. 56 samples from 28 wells were selected randomly Five qualitative parameters (EC, Na^+, $NO3^-$, $NH4^+$ and TDS) was tested in two seasons of low rainfall and high rainfall. A comparative analysis with Arc GIS software model 16 was performed.
Results: In this study, electrical conductivity with a mean of 625±120 microsiemens/cm and a minimum of 450 to a maximum of 950 microsiemens/cm, Sodium with a mean of 70±20 mg/l and at least 7.6 to a maximum of 100 mg/l, Nitrate with an average of 10.3±4.3 mg/l and at least 7.4 to a maximum of 16.3 mg/l, Ammonium ion with mean 0.14±0.1 mg/l and the minimum 0.01 to a maximum of 0.27 mg/l, and total dissolved solids with a mean of 387±43 mg/l and Varies from a minimum of 261 to a maximum of 410 mg/l.
Conclusion: The results showed parameters values are less than the recommended amount of world health organization guideline. Utilization management and protection of groundwater should be regarded as a basic principle used in planning of Babol Township.

Keywords: Drinking Water, Chemical and Physical Characteristics, GIS.

1. Introduction

Continuous monitoring of various aspects of drinking water quality, particularly chemical parameters is one of the most important requirements of human communities in maintaining and improving consumer health [1-2]. On the other hand, drinking, industrial and agricultural applications of water will determine the required water quality [3-5]. Therefore, standards set by the competent authorities and organizations differ for various water uses [6]. With the development of industries and agricultural activities, the chemical quality of water resources is at risk of various contaminations [7-9]. Population growth and increasing exploitation of groundwater resources and mismanagement have led to reduced quantity and quality of groundwater resources [4, 10, 11].

Mapping drinking water quality changes may be an important step in the proper utilization of water resources [12-13]. There are many studies on the quality of groundwater in Iran and throughout the world [14-17]. Rahmani and Shariat measured nitrate and total dissolved solid (TDS) levels in the groundwater resources of Hamedan Plain using geo-based information system (GIS). They found that nitrate level was higher in most southern regions and in agricultural and horticultural lands of Hamedan [6]. Rezazadeh *et al.* investigated groundwater contamination using GIS and found that the quality of drinking water wells in Mashhad Plain is good to average in the central areas toward the west. In contrast, the quality of drinking water in the northeast was poor [7]. Salari *et al.* examined the chemical quality of the water springs in Bam using GIS. According to their results, upstream springs had a higher water quality than those in downstream areas due to the impact of geological formations on groundwater resources [8].

The aim of the present study was the qualitative evaluation of groundwater resources in rural areas of Babol using GIS in dry and rainy seasons in 2014. The results were compared with World Health Organization (WHO) standards.

2. Materials and Methods

Babol Plain with an area of 1578 km^2 and more than 577 villages has a rural population of over 230,973 people. Drinking water resources of the villages of Babol include 45 wells (single and joint). In this study, the qualitative change zonings of sodium (Na^+), nitrate (NO_3^-), ammonia (NH_4^+), total dissolved solids (TDS) and electrical conductivity (EC) in drinking water resources of rural areas of Babol were evaluated using geographic information system (Arc GIS) of Model 16. Of 43 wells in operation during dry and rainy seasons in 2014, 28 wells were randomly selected and 112 water samples (in both summer and winter, with repetition) were collected. Polyethylene bottles of 1000 ml were used as containers. The bottles were first rinsed with water at the desired water resource and were then filled up to 900 ml to provide enough space for shaking the bottle and completing the mixing of contents. 2 ml of concentrated sulfuric acid as a preservative agent was added to prevent possible reactions in the water samples. The samples were transferred to the laboratory in a dark environment while maintain cold chain under standard conditions within 6 h. The water samples were analyzed in the Water and Wastewater Laboratory of Department of Environmental Health, Babol University of Medical Sciences based on the standard method [9]. Maps with a scale of 1: 25,000 were used to map the urban area. The results were compared with World Health Organization standards. After the analysis of water samples, the data were entered into Excel and the water quality zoning of water resources was drawn with Arc GIS. The results were analyzed by t-test with the help of SPSS 19.

3. Results

The following figures show the qualitative maps and distribution of above parameters (EC, TDS, Na^+, NH_4^+ and NO_3^-) in selected groundwater resources in rural areas of Babol.

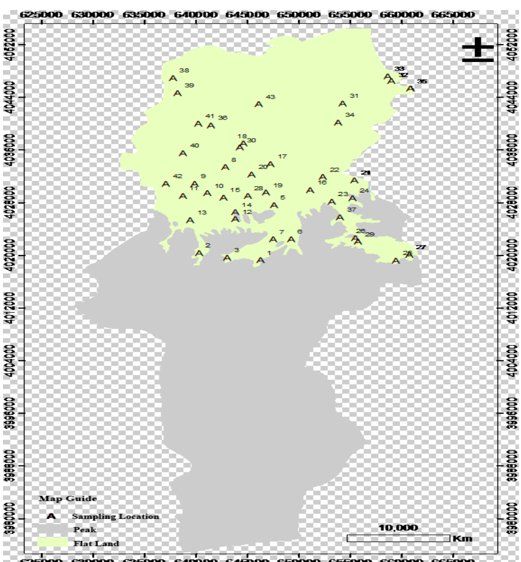

Fig 1: The location of groundwater wells in the rural areas of Babol

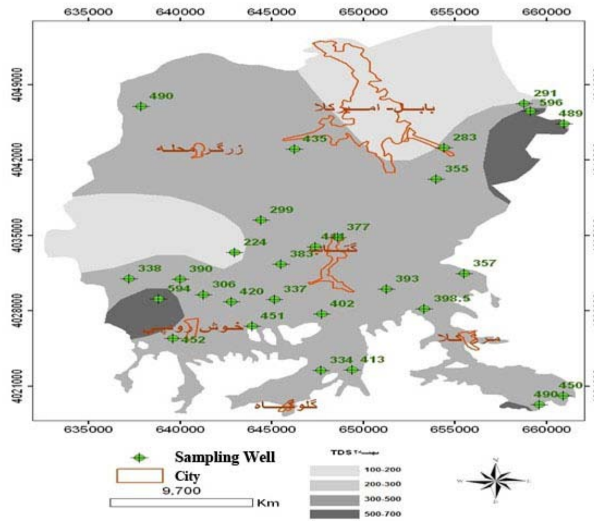

Fig 2: Total dissolved solids (TDS) zoning in the dry season

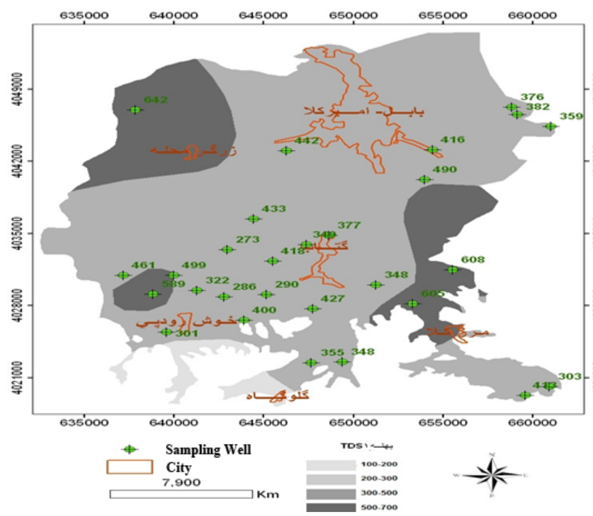

Fig 3: Total dissolved solids (TDS) zoning in the rainy season

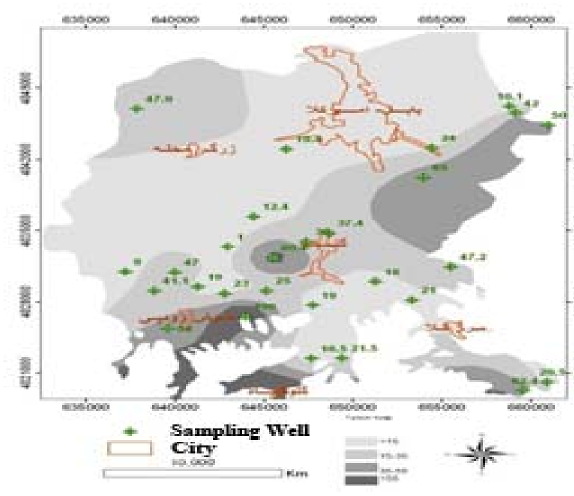

Fig 4: Sodium zoning in the dry season

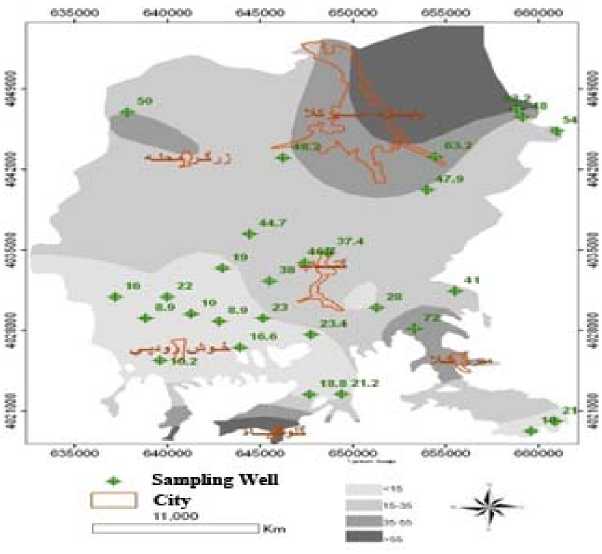

Fig 5: Sodium zoning in the rainy season

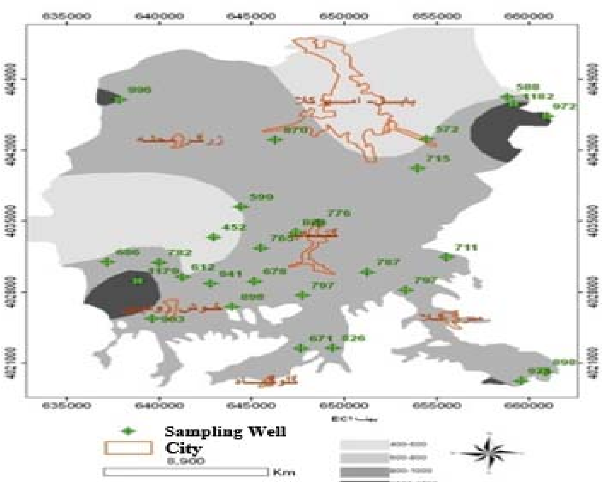

Fig 6: Electrical conductivity (EC) zoning in the dry season

Fig 7: Electrical conductivity (EC) zoning in the rainy season

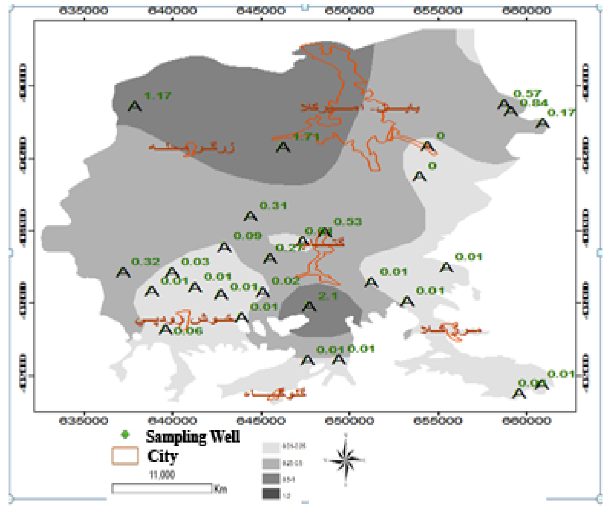

Fig 8: Ammonia zoning in the dry season

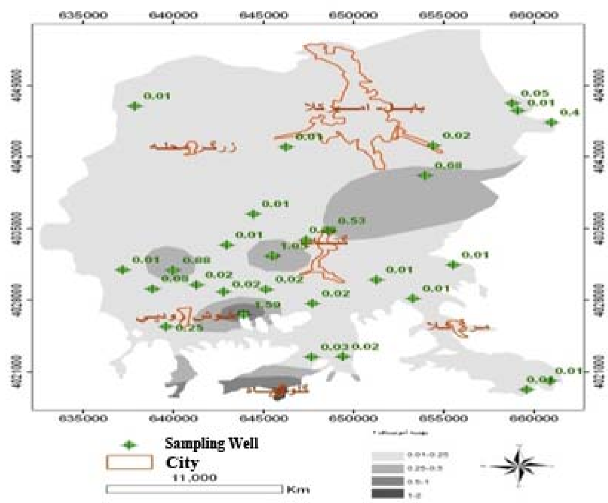

Fig 9: Ammonia zoning in the rainy season

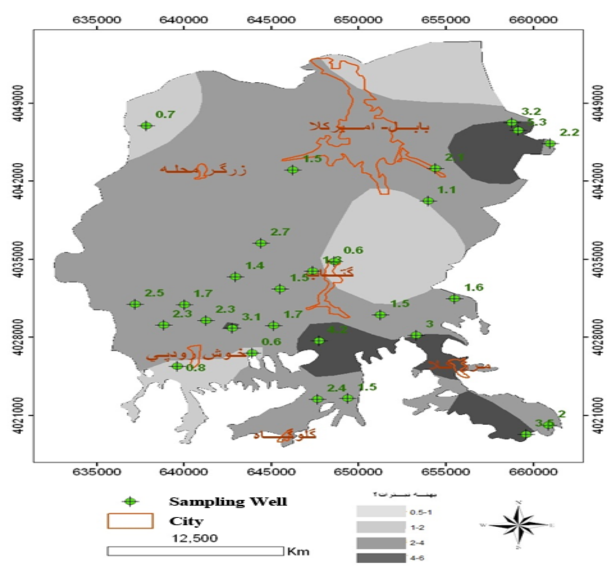

Fig 10: Nitrate zoning in the dry season

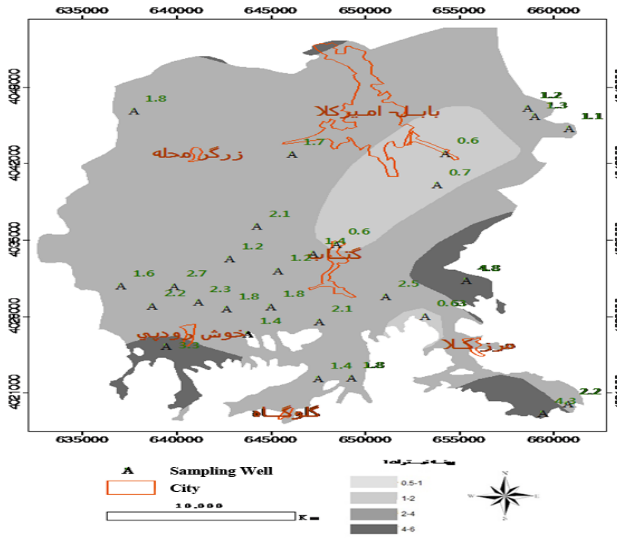

Fig 11: Nitrate zoning in the rainy season

4. Discussion

Figures 2 and 3 show the distribution maps of total dissolved solids (TDS). As can be seen, the mean values of TDS in the dry and rainy seasons are 443±75.7 and 395±65.6 mg/l, respectively. Obviously, TDS is higher in the dry season which is consistent with the results of Dianati *et al*. who examined Sari water resources [15]. According to Figures 4 and 5, the average concentration of sodium in the dry and rainy seasons is 35± 6.3 and 23.5±4.6 mg/l, respectively. Average sodium concentration is inversely related to rainfall so that it is higher in the dry season [14]. As can be seen in Figures 6 and 7, the average electrical conductivity in dry and rainy seasons is 835±78.7 and 697±88.8 mg/l, respectively [16]. According to Figures 8 and 9 (distribution maps), the ammonia level in the dry and rainy seasons is 0.11±0.05 and 0.15±0.1, respectively. Due to drinking water wells in the downstream of farmlands and the use of agricultural fertilizers, the concentration of ammonia increases in the spring. As shown in Figures 10, and 11, nitrate level in the dry and rainy seasons is 1.85±0.4 and 2.54±0.7 mg/l, respectively. This is consistent with the results of Yousefi *et al.* [17]. Nitrate is accumulated in the soil during summer and fall as a result of favorable weather conditions for microorganisms and decomposition of organic matter and the lack of rain. With the onset of the rainy season in late fall and winter, leaching occurs so that the highest concentration is observed in late winter which is consistent with the results of Zazouli *et al.* [18]. Nitrate level is increased in the agricultural season, i.e. in spring and this could possibly be caused by the use of agricultural fertilizers. This is consistent with the results of Yousefi *et al.* [17]. Babiker *et al.* evaluated the quality of groundwater resources in Japan. They found that ammonia and nitrate levels were increased due to the use of fertilizers in rice farmlands. This is consistent with the results of the present study [19]. Kumar *et al.* measured ammonia level to examine the quality of groundwater resources in India [20]. Fytianos *et al.* evaluated nitrate level in drinking water of rural areas by GIS. They found that ammonia and nitrate levels were increased due to the use of fertilizers in farmlands. This is in good agreement with what was found in this study [21]. Nikolaidis and Mandalos examined the impact of agricultural activities on water quality in northern Greece using GIS. They found that the nitrate level in agricultural areas with higher rates of fertilizer consumption is higher [22]. Ehsani *et al.* evaluated nitrate concentration in Hamedan Plain groundwater resources using GIS and found that most regions with high nitrate levels were located in the south with irrigated and horticultural cultivation [23].

According to the results and water quality standards, the concentration of ions in the groundwater of rural areas is in standard range. In rural areas of Babol, wastewater is disposed traditionally using absorbing wells. Accordingly, in addition to continuous monitoring of the quality of water resources, the development of agricultural activities in the vicinity of such water resources should be avoided.

5. Acknowledgment

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