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Determining the Critical Points of Underground Drinking Water Sources in Central Areas of Golestan Province in Terms of Magnesium and Sulfate

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ABSTRACT

Background and objective: In accordance with the national document to improve water quality, access to safe and adequate drinking water is one of the critical needs of the Iranian people. The development of urbanization, industry and agriculture and the reduced level of available water have made the drinking water supplies face the threat of pollution. This study aimed to determine the critical points of underground drinking water sources quality at central areas of Golestan Province in terms of magnesium and sulfate.

Method: In order to conduct this cross-sectional study with descriptive approach among 29 deep wells studied in the management of water and wastewater for drinking water in rural areas of Aliabad Katoul- Golestan Province- Iran the number of 116 samples were taken in 2012 and the level of magnesium and sulfate concentration was determined. For statistical analysis at the significance level of 95 percent the pps18software and for zoning the GIS software were used.

Results: Among the total samples under study in 6.8 and 40.52% of the samples the sulfate and magnesium concentration was higher than the allowed maximum range in drinking water. However in the test results of 5-year period (2008-2012) the amount of sulfate and magnesium was higher than the allowed maximum range in 7.58 and 38.18% of the samples. Pearson correlation test showed that there was no significant correlation between the levels of magnesium and sulfate and precipitation, evaporation, wells' depth, static level and the difference between the static level and the dynamic water level in the samples under study. However there was a significant relationship between the level of sulfate and the distance with the water supply and the nearest water resources of the river, as with increasing the distance between the well and river, the sulfate levels increased. Also there was no significant correlation between the concentrations of magnesium recorded each period and the amount of rainfall, evaporation, the distance between the distance with the water supply from the nearest water resources, wells' depth and the static level of the well during the same period. However, there was a negative significant correlation between magnesium concentrations and the difference between the static and dynamic levels of water as the difference between the static and dynamic levels is reduced the concentration of magnesium is increased.

Conclusion: The results of zoning using GIS indicated that the increased concentrations of sulfate and magnesium in drinking water sources in areas with good vegetation cover, fertile soil and active agriculture is due to the use of agricultural pesticides containing sulfur, such as Maneb, Mancozeb, Magnesium fertilizers containing magnesium sulfate and Micro fertalizers in the form of powder and liquid used in farm fields and gardens area.

KEY WORDS: Drinking water, sulfate, Magnesium, GIS

INTRODUCTION

The rapid growth of industry and the increasing development of agriculture for the production of various types of food besides the indiscriminate application of groundwater resources cause the increase in the concentration of some pollutants in recent years (1). Normally, drinking water contains a wide variety of chemical solutions such as Magnesium and sulfate some of which can affect cellular metabolism and metabolism of human body cells (2). However, the existence of these combinations higher than the recommended amounts in water can have adverse effects on human health (3). Sulfate penetrates the underground water resources through different sources such as dissolution of mineral deposits containing sulfate, the influence of sea water, tannery plants' wastewater and pulp production (4). The concentration of sulfate in natural waters is about 50 mg per liter which is increased in case of pollution spill through wastewaters. WHO established the minimum and maximum permissible limit of sulfate in

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drinking water as 250 And 400 mg /L (5). The sulfate in the water can be produced by the sulfur oxidizing bacteria in water and by creating a dark slime layer makes the water opaque, clog the plumbing system and turn the color of the clothes (6). From the medical point of view sulfate can cause diarrhea which leads to dehydration particularly in children (7). Laxative effect of sulfate is mainly due to osmotic activity of sulfate salt remaining in the intestines. This laxative effect depends of the amount of sulfate and other active osmotic materials such as magnesium, sodium and sugar in the intestines. People with kidney disease may be more sensitive to side effects of high sulfate because the additional sulfate is excreted through the kidneys (8). In humans, the long term laxative effects of water with high concentrations of sulfate (chronic effect) are less than short-term and acute exposure. It is not made clear that how long this adjustment in human body lasts but it probably occurs during the next 7-10 days. The effects of chronic exposure to sulfate are within the range 361 to 1488 mg per liter and the threshold of acute toxicity is 450 mg per liter (9).

Magnesium is also one of the conventional materials of water that forms water-soluble salts. High concentration of magnesium in household water is not acceptable due to the formation of plaques in vessels, as well as laxative effect especially if coupled with large amounts of sulfate (10). The World Health Organization suggests the level of magnesium equivalent to 30 mg per liter for sulfate more than 250 mg per liter and the maximum allowable concentration of 50 mg per liter if the sulfate concentration is less than suggested (5). Excessive magnesium in humans is due to the increased amount caused through the oral use or kidney disorders. The side effects of increase in medium amount of magnesium are low blood pressure, dizziness and drowsiness. And large amounts of magnesium can change the balance and activity of intracellular ions, especially calcium ions, which directly affects nerve and muscle functions (8). The results of studies showed that relatively high amounts of magnesium is the reason of almost half of colon cancer in humans but their relationship is unknown (11). However, studies on animals suggest that magnesium reduces the incidence of sarcoma (a malignant tumor) in some tumors of nickel and cadmium and its compounds are not considerably toxic to the environment (12). The case-control study of Chiu Et al. (2003) in Taiwan on the possible association between ovarian cancer risk and calcium and magnesium levels in drinking water sources of the city found that from1986 to 2000, that all eligible registered deaths (933 residents of Taiwan) were compared with other factors of death and the levels of calcium and magnesium in drinking water of the residents were determined. The control group consisted of people who had died for other causes and they were compared in terms of gender, year of birth and death. In this comparison the control group used water with Magnesium levels below 7.3 mg/lit and the first experimental group used water with Magnesium levels between 7.3-13.4 mg/lit. The results of this study indicated no significant correlation between levels of calcium in drinking water and ovarian cancer but the Magnesium intake of drinking water may have a protective effect against the death risk of ovarian cancer (13).

Golestan Province in northern Iran is one of the most beautiful green areas with an area of 22 thousand square kilometers located in the south eastern part of the Caspian see basin in the north limited by Turkmenistan, in the south limited by Semnan province, in the east limited by the North Khorasan province and in the west limited by Mazandaran Province (Figure 1). Golestan Province has two different climate so that the south of the province is a mountainous region covered with dense forests and in the north of the province there is a desert low land with a temperature quite different from the south. The annual average rainfall in the south of the province is 700 mm and in the north of the province is 200 mm with an average of 450 mm, which is higher than the average rainfall in the country (250 mm). The value of average annual evaporation in the north side of the province is 2000 mm and in the south it is 800 mm. (14, 15) (Golestan Regional Water Co., 2012). Since Golestan province is one of the important areas of the country for sustainable development in agriculture and tourism industries, protecting the groundwater resources is crucial (16). So the purpose of the present study is to determine the levels of magnesium and sulfate in underground drinking water in Golestan province, identify areas of risk and crisis to manage and plan in order to prevent pollution of drinking water sources and to determine the factors influencing the increase in the concentration of magnesium and sulfate in water resources.

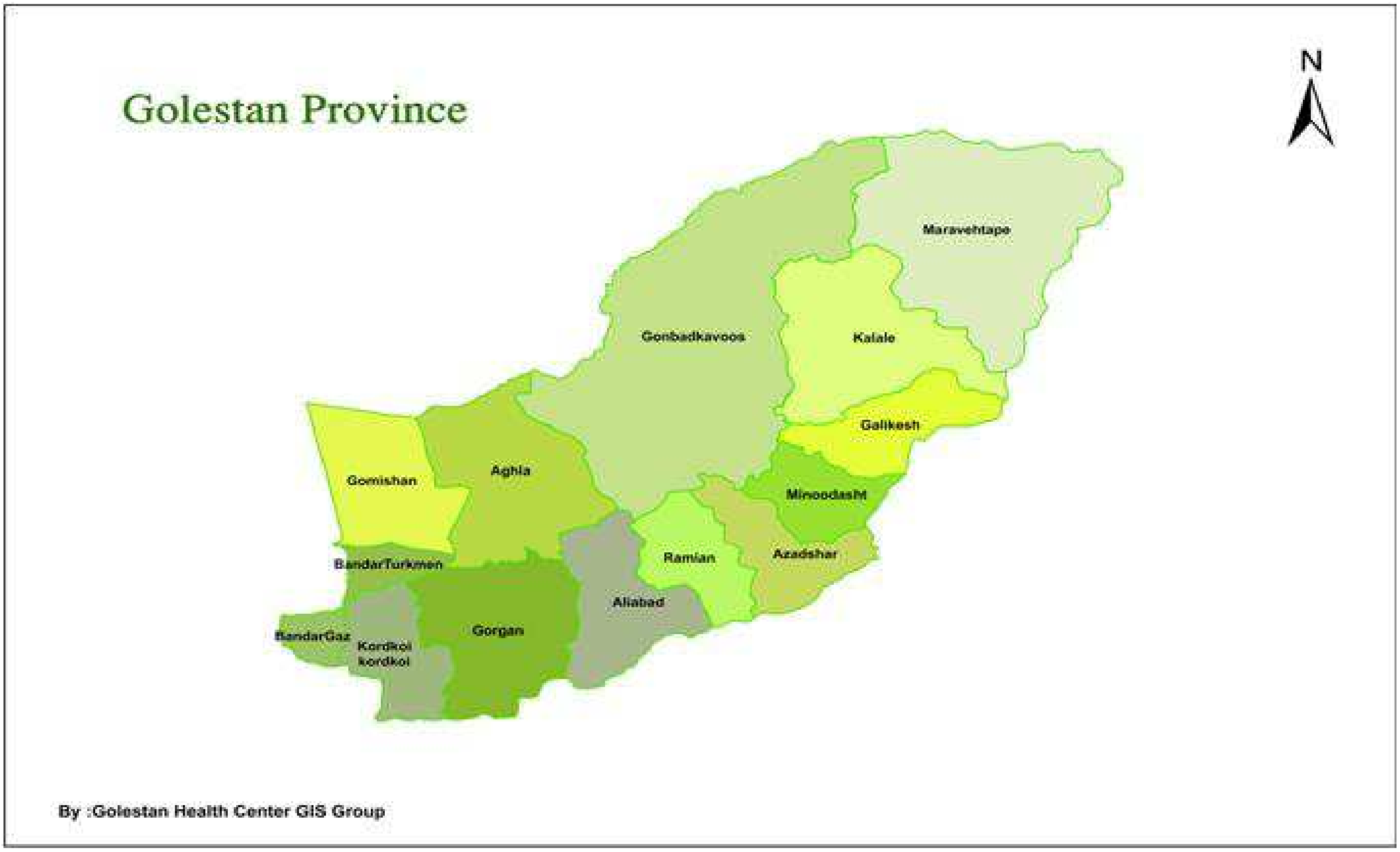


Figure 1: Geographic location of Golestan Province

METHOD

For this cross-sectional study 29 deep wells in Aliabad Katoul city with 36°54′30″N 54°52′08″E coordinates were selected (Table 1). Sampling was performed seasonally 4 times during 2012 as census of all 29 active deep wells providing the drinking water of the rural areas by standard method and immediately the concentration of sulfate was determined by the spectrophotometry device model DR2800 and then the concentration of magnesium ions was determined by titration (17) in the water quality control laboratory of Golestan province Rural Water and Wastewater Company. For comparison and to determine changes in the values of magnesium and sulfate values of water resources the results of the Golestan Province Rural Water and Wastewater Company during 2008-2012 were used. For data analysis SPSS18 software was used, the independent t tests, Pearson correlation coefficient and ANOVA were used to plot the qualitative maps and to determine the zoning GIS software was devised.

Table 1 - Geographical location of the wells under study

Row	Well Name	Drilling location coordinates (UTM)			Static level (m)	Dynamic level (m)	Dubai obtained L / s	Depth m
		Z	Y	X				
1	Kordabad	186	4085879	313341	37	55	7	100
2	Mahdi Abad	161	4088402	313565	55	75	10	170
3	Amir Abad Sorkh Mahalle	152	4089422	314233	60	85	8	90
4	Hakim Abad	104	4092554	314146	32	50	10	200
5	Masoum Abad	88	4095019	314853	25	45	10	220
6	Haji Kalate	87	4095853	312247	12	35	9	200
7	Sangdovin	68	4096536	309478	30	52	10	230
8	Kouchak Nazari Khani	44	4100991	311770	24	55	8	190
9	Bodraq Ane Galdi	44	4101951	30994 3	22	37	6	207
10	Kosar – Oudak Doji	45	4101269	308127	24	38	7	220
11	Katoul Farm	62	4097388	302129	22	45	12	150
12	Savari Kelate (1)	66	4095085	299142	22	45	12	150
13	Savari Kelate (2)	70	4094284	297006	35	45	5	180
14	Boluk Ghulam (Kosar)	90	4092998	2973 78	21	44	12	210
15	Shirang Olia	186	4085879	313341	40	60	15	250
16	Pichak Mahalleh	94	4092098	297233	30	50	7	90
17	Ahmedabad (1)	101	4092355	298035	25	40	6	120
18	Ahmedabad (2)	111	4091336	298177	40	55	7	205
19	Jahan bini	105	4090740	300187	45	65	18	198
20	Shirang sofla	131	4090144	300252	45	65	15	200
21	Shirang Olia	100	4092079	305504	22	45	5	100
22	Shuja Abad	118	4091665	309669	15	35	20	180
23	Bagher Abad (1)	126	4089372	310170	35	55	15	150
24	Bagher Abad (2)	154	4088338	312055	40	60	30	200
25	Rahmat Abad	118	4090137	306254	90	105	9	200
26	Abbas Abad	146	4087113	307313	40	60	15	200
27	Mohammad Abad	288	4083585	301316	60	80	20	200
28	Qara Blaq	267	4083949	301506	40	65	15	180
29	Erfan Abad	268	4004150	302622	160	175	5 of 5	200

RESULTS

Among all 116 samples collected in 2012 the concentration of sulfate and magnesium ions was 8 (6.9%), and 47 (40.52%) higher than the allowed level in the samples of drinking water respectively. However the amount of sulfate and magnesium ions in the 5-year period test (2008-2012) was higher than the allowed range. During this period the average concentration of sulfate in Aliabad Katoul's water resources was 152/11 ±12/64 (127.67-172.48) mg per liter. One way ANOVA to compare the concentrations of sulfate and magnesium is the wells shoed that there was no significant difference in the sulfate concentration of the well under study ($\alpha = 0.748$) however in terms of magnesium concentration the difference was significant ($\alpha = 0.006$). The independent t test indicated that there was no significant difference between the average concentration between the first half and second half in terms of sulfate ($\alpha = 0.796$) And magnesium ($\alpha = 0.175$)

In addition, Pearson correlation test showed that there was no significant difference between the levels of sulfate and precipitation ($\alpha = 0.724$), evaporation ($\alpha = 0.717$), the depth of the well ($\alpha = 0.788$), static level of the well ($\alpha = 0.405$) and the difference between static and dynamic water levels ($\alpha = 0.133$). However there was a significant relationship between the levels of sulfate and the distance with the water supply and the nearest water resources of the river ($\alpha = 0.019$), as with increasing the distance between the well and river, the sulfate levels increased. Pearson correlation test showed that was no significant difference between the concentrations of magnesium in each registered time and precipitation ($\alpha = 0.781$), evaporation ($\alpha = 0.214$), the distance with the water supply and the nearest water resources of the river ($\alpha = 0.101$), the depth of the well ($\alpha = 0.69$) and the static level of the well ($\alpha = 0.543$) during the same period. However there was a significant negative correlation between the magnesium concentration and the difference between static and dynamic water levels ($\alpha = 0.015$), the difference between the static and dynamic levels was reduced the concentration of magnesium was increased. Results of sulfate and magnesium concentrations in any water sources in Aliabad city (2012) are presented in terms of qualitative maps in Figures 1 to 8. (GIS) qualitative maps of water sources in Aliabad city in terms of sulfate concentrations in difference seasons of the year 2012

Quality maps (GIS) Based on the concentration of sulfate in drinking water sources in rural city Aliabad season 2012

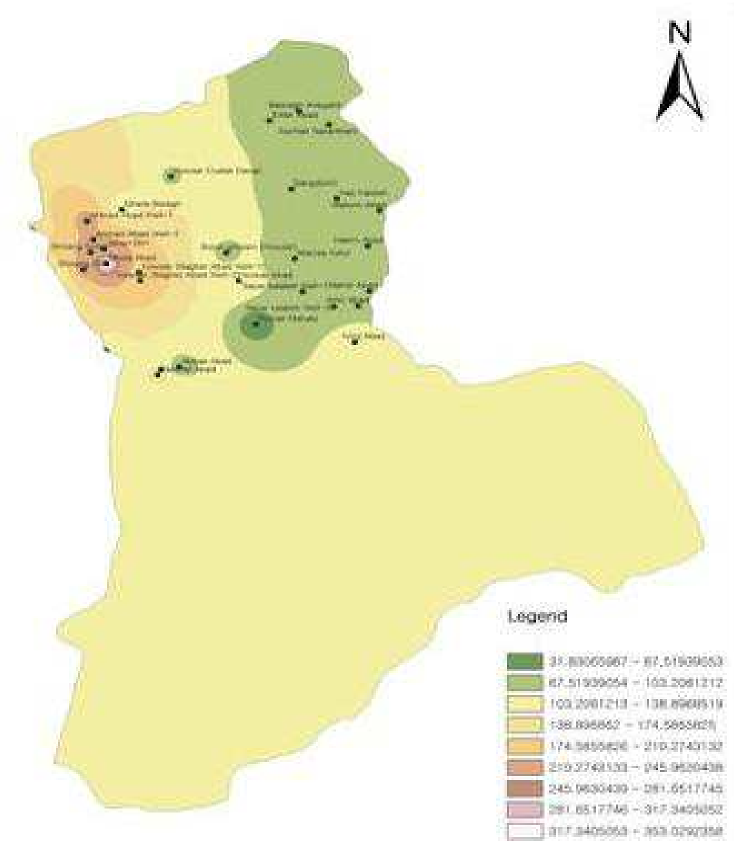


Figure2- The qualitative map of sulfate concentrations in summer -2012

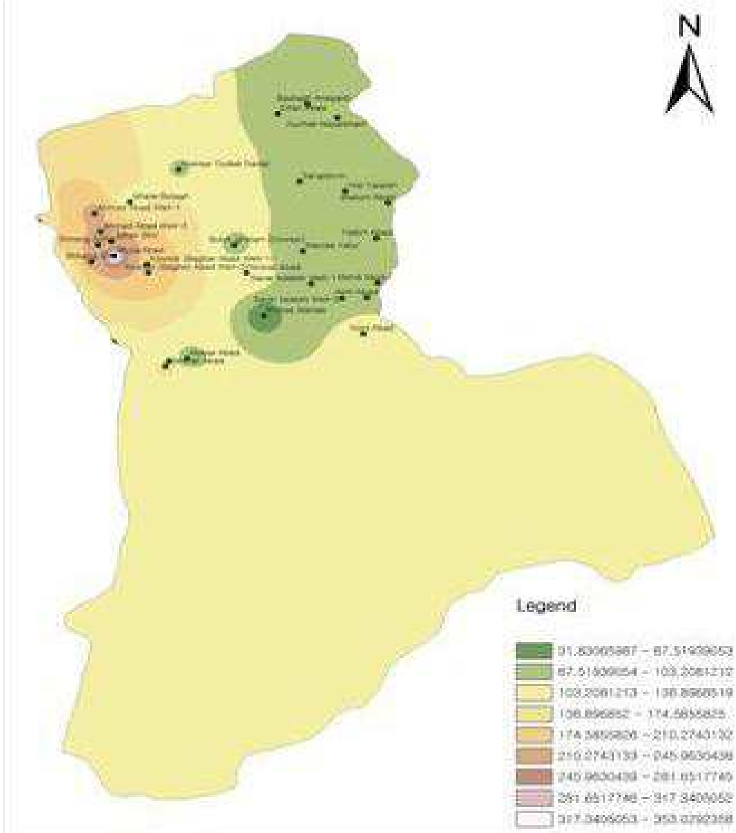


Figure 1- The qualitative map of sulfate concentrations in spring -2012

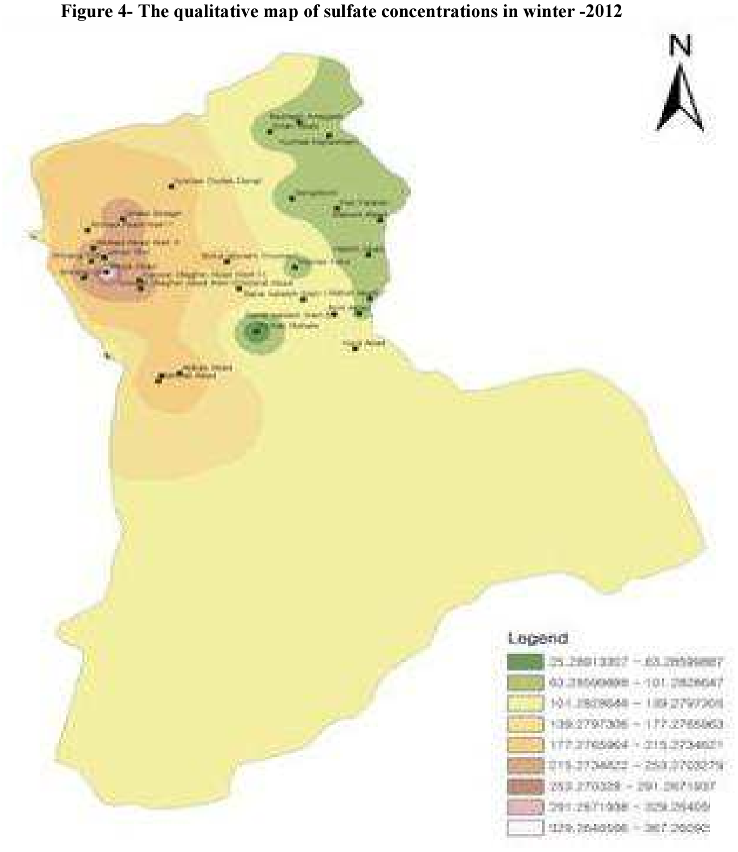


Figure 4- The qualitative map of sulfate concentrations in winter -2012

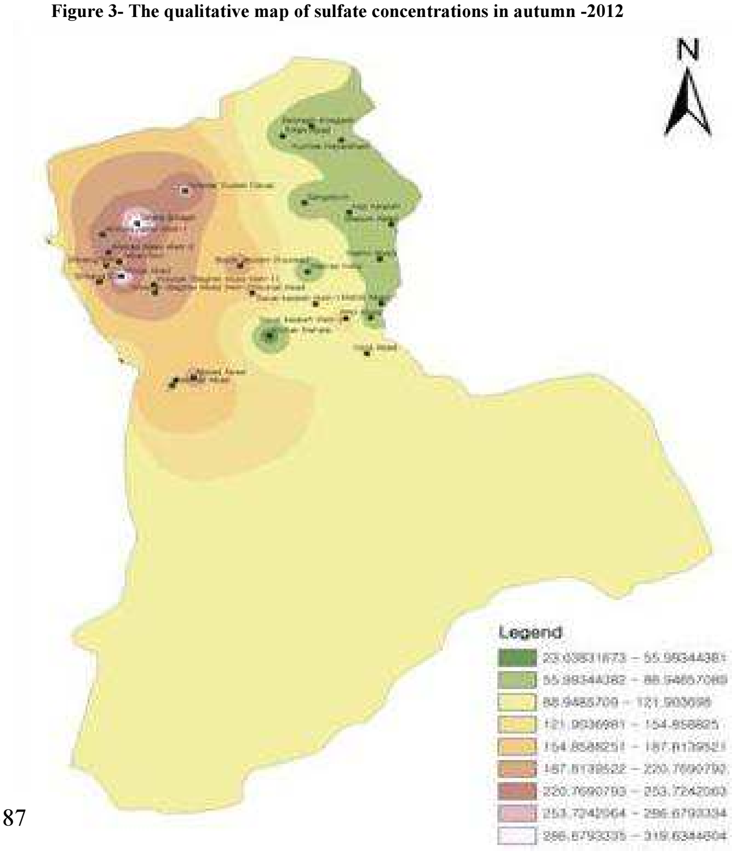


Figure 3- The qualitative map of sulfate concentrations in autumn -2012

(GIS) qualitative maps of water sources in Aliabad city in terms of magnesium concentrations in difference seasons of the year 2012

Figure 6- The qualitative map of magnesium concentrations in summer -2012

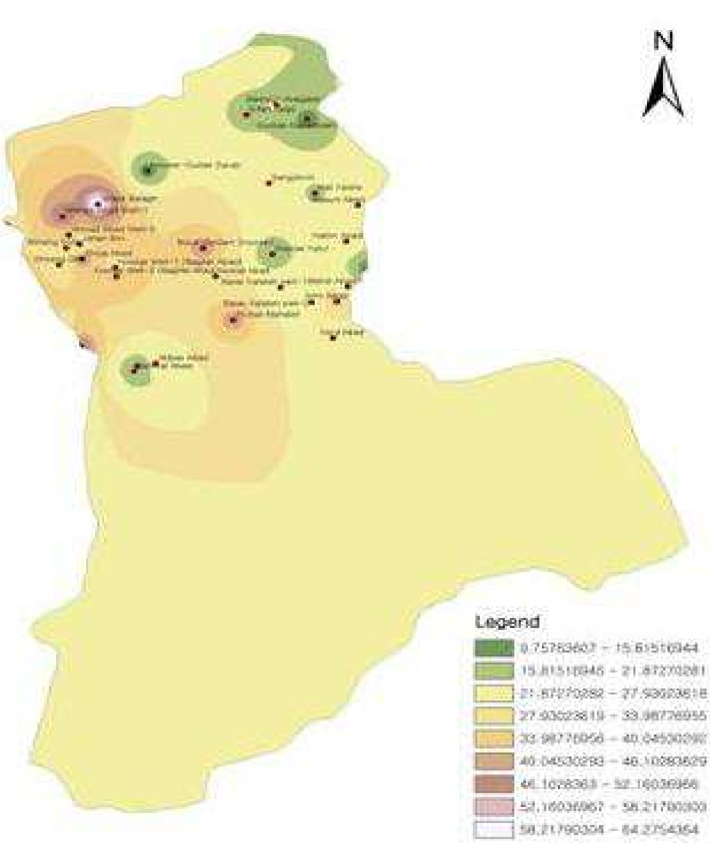


Figure 5- The qualitative map of magnesium concentrations in spring -2012

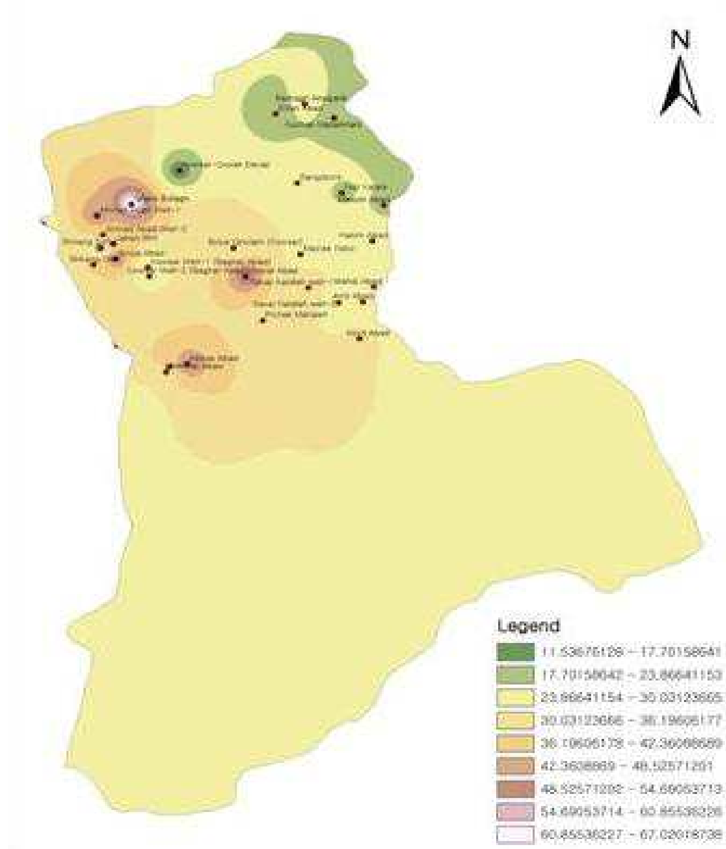


Figure 8- The qualitative map of magnesium concentrations in winter -2012

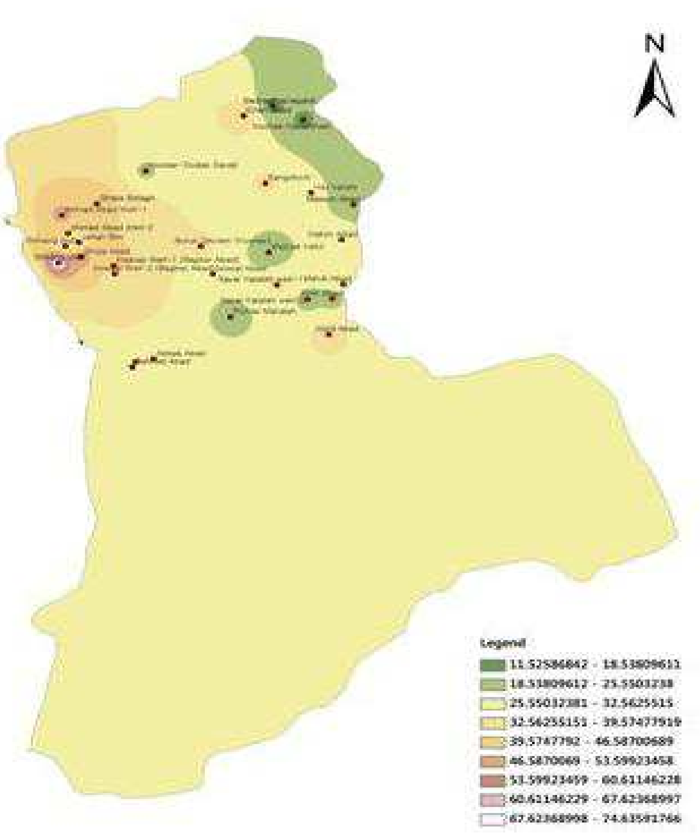
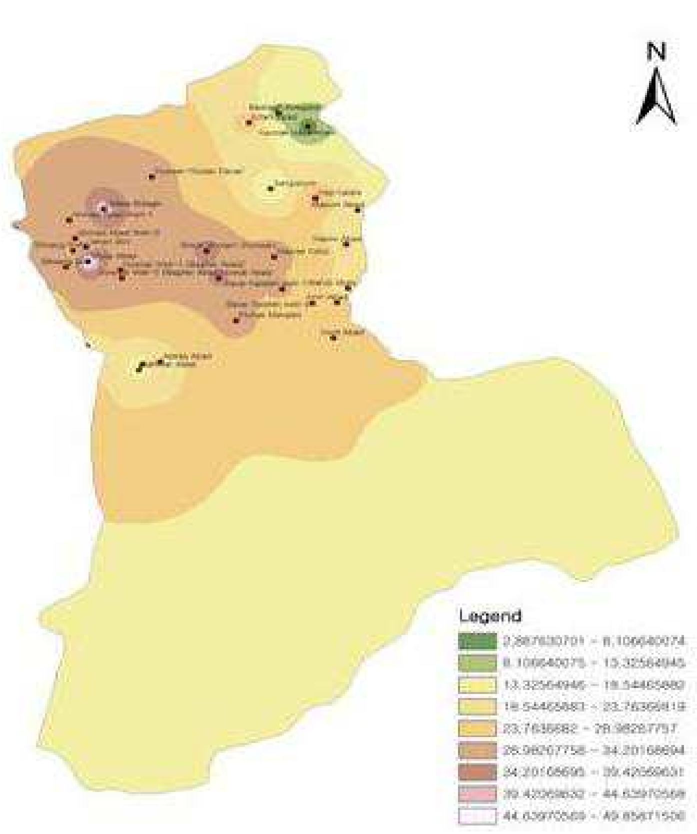


Figure 7- The qualitative map of magnesium concentrations in autumn -2012



CONCLUSION

Sulfate

The results showed that the mean concentration of sulfate in drinking water supplies of Aliabad was 137, 172, 154 and 158 mg per liter in the spring, summer, autumn and winter of 2012. Zoning Results with GIS showed that in the spring in the basins of Zaringol and Kaboud-Val Rivers that flow from south to north Aliabad the sulfate concentration was standard but in some parts of Mohammadabad River in the north-west of the city, the concentration of sulfate in drinking areas was higher than other areas (Figure 1). Zoning in summer showed that the distribution of sulfate with increasing trend was spread in the wider areas of the region. So that in the summer in Zaringol basin the concentration of sulfate was at the standard level but it was not suitable in Oudak Doji well in the river basin Kaboud- Val and Qare Bolaq and Shoja Abad well in the river basin Mohammadabad River Basin(Figure 2). Although the concentration of sulfate had a decreasing trend in the autumn, but in Zaringol basin the concentration of sulfate was good but the concentration of sulfate in the water wells Qare Bolaq and Shoja Abad well in the river basin Mohammadabad was upper than the desired level and lower than the allowed level but since the magnesium concentration is over 30 mg per liter, so the sulfate concentration is considered higher than the allowed range (Figure 3). In winter, the concentration of sulfate with an insignificant increase compared to the autumn did not change significantly (Figure 4). Zoning sulfate concentrations showed that the state of water resources in the Northeast and in Zaringol Basin had good circumstances but the sulfate concentration in water wells Qare Bolaq and Shoja Abad in Mohammadabad was above the optimal level and below the limit, but since the magnesium concentration is over 30 mg per liter, so the sulfate concentration is considered higher than the allowed range.

Magnesium

The results showed that the mean concentration of magnesium in drinking water supplies of Aliabad was32, 29, 27 and 32.6 mg per liter in the spring, summer, autumn and winter of 2012. Zoning Results with GIS showed that in the spring in the basin of Zaringol only Kordabad well was inappropriate and above the allowed range while in Kaboud-Val River the wells of Pichak Mahalle, Nosratabad, Savari Kelate (I) and Bluk Qolam and in Mohammadabad River Basin the concentration of magnesium in wells Mohammadabad, Ahmadabad (I), Jahanbini, Shirang Olia, Rahmat Abad, Abbasabad, Shoja Abad and Qare Bolaq was higher than the allowed range (Figure 1). Although the concentration of magnesium was reduced in the summer but the magnesium concentration level was beyond the limit in 9 wells. So that the level of magnesium in Amirabad well in Zaringol basin and the wells of Pichak Mahalle, Nosratabad and Bluk Qolam in Kaboud-Val River and in Mohammadabad Basin the wells of Ahmadabad I and II, Shoja Abad, Bagher Abad II and Qare Bolaq was higher than the allowed limit (Figure 2). In the autumn in the north-west of the city the concentration of magnesium in drinking water sources is higher than the rest of the areas. The decreasing trend of magnesium concentration in drinking water supplies continued to until the autumn but in this season the concentration of magnesium was higher than the limit in 10 wells. Zoning the results showed that in all water resources of Zaringol River magnesium concentration was standard while the magnesium concentration in the Kaboud-Val River in the wells Pichak Mahalle, Nosratabad, Bluk Qolam, Katul farm and Oudak Doji and in the Mohammadabad River Basin in Ahmadabad II, Shoja Abad, Jahanbini, Bagher Abad I and Qare Bolaq was higher than the allowed limit. Zoning the results showed that despite a decrease in the average magnesium in the city its distribution was spread in an extended area (Figure 3). In winter due to increased rainfall we are faced with a general reduced magnesium concentration but still in 14 wells the concentration of magnesium was higher than the limit. So that in Zaringol River the wells of Kord Abad and Sangdovin and in the Kaboud-Val River the wells Savari Kelate (I) and Bluk Qolam and in Mohammadabad River Basin in the wells of Ahmadabad I and II, Shoja Abad, Shirang Sofla, Shirang Olia, Rahmat Abad and Qare Bolaq had magnesium concentration above the limit (Figure 4).

Observing the geology, land use and topography maps as well as the information obtained from the chemical analysis in the area under study in GIS environment indicated that the reason of the vulnerability of underground waters is probably the land use especially in indiscriminate use of chemical fertilizers and pesticides in a the area of agriculture. That is because in the region due to relatively mild weather conditions and relative appropriate humidity, as well as good precipitation different types of agricultural activities include planting rice, wheat, barley, cotton, soybean, canola, lettuce, beans, strawberries, tomatoes and cucumbers in the region. Moqadas et al. (2012) reported that due to the wide variety of crops cultivated in the area at least twice a year, using chemical fertilizers and pesticides is very current (14). However, to obtain more detailed information about the impact of agricultural activities more objective studies are required. Nas (2010) suggested that according to geological data, land use, topography and chemical composition of water, it seems that the main ions such as sulfate and chloride and agricultural activities seem to be the main pollutants in this area (18). Also the sudden increase in the concentration of sulphate ions in some wells under study may be the result of the spill of household and industrial wastewaters, runoff penetration into groundwater and lack of qualified space of the wells (19). North and north-western parts of the study area were among the vulnerable areas against pollutions such as urban and rural wastewater, absorbing wells and agricultural activities due to high underground water levels. Ayoubi (2011) showed that the lack of appropriate waste landfill and the absence of sewage collection systems in urban and rural centers have led to the vulnerability of the underground water resources (20).

Zoning results by GIS indicated that due to the location of drinking water sources in northern side of Aliabad City with fertile soil and rich vegetation, the concentrations of magnesium and sulfate are increased in some wells. High sulfate levels may be due to soil type of the region, the use of agricultural pesticides containing sulfur, such as Tiraman, Maneb, Mancozeb, Ferbam, Zineb, Magnesium fertilizers and organic and micro fertilizers in the form of powder and liquid in the agricultural fields. So the best method to maintain the groundwater resources' quality is to identify sources of pollution and prevent water pollution. Creating a database for groundwater and the required spatial data to determine the most vulnerable areas can lead to the economic saving in monitoring operations and increase efficiency in the management of groundwater resources. Therefore, in accordance with the document of national water, the development of the program for the protection of water resources in Iran especially in the northern part of the country is crucial.

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