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Quantity investigation of groundwater in Ghaemshahr-Jouibar aquifer

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Abstract

Nowadays groundwater of Ghaemshahr-Jouibar aquifer is decreasing very rapidly. Thus this research was done with the aim of analyzing the changes of water level in Ghaemshahr-Jouibar aquifer using GIS and comparing the results in the considered period. For studying the changes of water level, data of 40 wells were gathered in years 1996-2012. The results showed that in some years the level of water was close to the ground and in other years the level of groundwater was so far from the earth ground. According to the annual hydrograph there are three increasing periods with the recorded numbers for water level in the aquifer 0.13, 1.73 and 0.76 respectively in years 1996-1997, 2002-2004 and 2008-2012. The most increasing of water level was related to years 2002-2004. In average the level of water was decreased 0.92 (without considering the increasing years).

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Introduction

Although water resources are renewable but the water demands are increasing six times in the recent years while the population is increasing just 3 times in comparison with the former years (Rahmani, 2010). According to the serious limitation of water resources, continuing the current trend leads us to a hard water shortage in 20 years in the future. Ghaemshahr-Jouibar aquifer is located in Talar basin. In the recent years to much groundwater exploration caused water level decreasing and great quality changes in the groundwater resources. In this regard studying groundwater level changes in the aquifer becomes very important. The aim of this study is to investigate the changes in the quantity of water with GIS and creating annual hydrograph from considered years.

GIS has been used by so many researches in the field of water resources (Babiker *et al*, 2004; Giordano *et al,* 2000; Rahman *et al*, 2004; Sharma *et al,* 1991; Gustafsson 1993). Portoghese *et al* (2005) Simultaneously with GIS developing used DREASTIC model as a kind of quality model in order to analyze the quality changes of groundwater in an area which is located in Japan. He in this research investigated karst resources in northern parts of China. Nas and Berktay (2006) has acknowledged the ability of GIS in the investigation of groundwater in south of Italy using the same method. Dixon (2005) used GIS for creating quality changes of groundwater in the study area. Han (2006) used GIS as suitable software for investigation of groundwater resources in hard formations. They studied karst formations in northern part of China. Akbari *et al.* (2009) with GIS zonated the decreasing of groundwater level and showed that the level of water is decreasing up to 30 meters in western and central parts of Mashhad province. During 20 years about 12.1 meters and averagely about 60 centimeters, the level of water was decreased. Dehghani *et al.* (2009) in Ghazvin aquifer reached to the point that fuzzy Neural systems with 98 percent correlation coefficient and the least error has the most accuracy in groundwater estimation of participle points of aquifer in comparison with Geo-statistics methods and ANN. Izadi (2008) revealed that the model with combined data with common influences have the best results for groundwater level prediction. Sokoti *et al*, (2011) in their research used the combination of GS and ARCVIEW 8 with GIS. They showed that in Orumie basin, the results of Kriging method would be more accurate with circular empirical semi-changing mode and the correlation coefficient of the model would be 0.938. Lashgari *et al,* (2012) in their research using GIS recognized that krishnamourti method is more consistent with results of Shirvan wells investigations. They explained that this is possible because of using more data in the investigations. The results of Pourtabari (2010) showed that the ability of GIS in order to simulate and predict the attitudes of groundwater level changes in comparison with statistic neural models. The results of Zehtabian (2004) showed that using groundwater for irrigation must be done with more attention. He released that in the study area there is about 9354 hectares of the land separated in terms of groundwater level from other parts because of low water level about 3 meters lower in comparison with other parts. Kelin *et al,* (2005) investigated the groundwater level in northern part of China and with Kriging method created the zonation map for the area. This research was done with the aim of simulation and prediction of groundwater level changes of Ghaemshahr-Jouibar aquifer with GIS and comparing the results of years 1996-2012.

Materials and methods

Study area

Talar basin is part of Caspian Sea basin that is located between Albourz altitudes and Caspian Sea (see figure1). Talar basin covers a surface of 3385 km² and its aquifer is about 899 km². The Talar basin is fall between 52˚ 35′ 10′′ to 53˚ 24′ 7′′ longitude and 35˚ 54′ 0′′ to 36˚ 47′ 0′′ latitude. The main cities located in Talar basin are Sari, Ghaemshahr and Jouibar. The area has experienced intensive human activities including agricultural and industrial and tourism. According to Rahmani (2010) different sources of pollution are identified including main cities, geological formations and mining activities.

Mining from rivers and variability of precipitation in time are two factors that limit the water resources. Since water in wells is of good quality and is available, people use it for daily needs. But, due to increasing in population, and as a result of indiscriminate extraction of groundwater, the slope of water table became reverse allowing salty water of sea entering into the aquifer. Location of wells in Talar aquifer demonstrated in figure 1.

Methodology

In order to investigate the situation of groundwater level changes of Ghaemshahr-Jouibar aquifer data collected from the Water Organization of Mazandaran's province (WOMP) in years 1996-2012. Figure 2 shows the location of quantity wells in Ghaemshahr-Jouibar aquifer.

Sampling from groundwater from the area is done for every year by Water Organization of Mazandaran's province (WOMP) in dry and wet seasons. The samples are transformed to the central laboratory in the Mazandaran province. Basically quality and quantity factors have great fluctuations in every study area and it is not possible to consider these data constant in a period. Thus in this research, in order to investigate the spatial and temporal changes of groundwater level of Ghaemshahr-Jouibar aquifer, quantity data with a proper format were entered to the ArcGIS 10.1 environment. Then with choosing the best method of zonation for the area and the kind of data, necessary maps and diagrams were drawn. Finally according to the maps and diagrams, total view of the groundwater level of the study area was obtained.

Results

According to the data collected from the WOMP, annual hydrograph and maps created by GIS the results are determined as below:

1-the changes of groundwater level (for free aquifers) and piezometric level (for under pressure aquifers) in the different statistical periods.

2-determination of the value of water level fluctuations in the study area.

3-determination of the most and the least amount of value which are recorded.

4-the amount of fluctuations of groundwater resources volume.

Fig. 1. Geographical location of Talar basin.

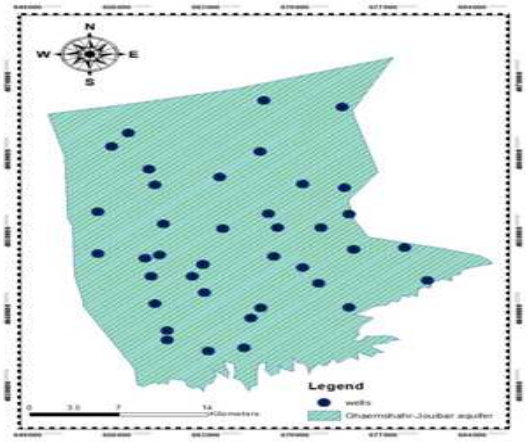

Fig. 2. Quantity wells location in Ghaemshahr-Jouibar aquifer.

WOMP

In order to demonstrate groundwater fluctuations, a unit hydrograph for the aquifer has been created. To generate annual unit hydrograph, monthly data were transformed to annual. Monthly data of 42 piezometric wells for 16 years commencing from 1996 to 2011 were used. Then by using the Thiessen polygon method the amount of precipitation for total basin was interpolated using GIS.

Figure 2 shows the annual unit hydrograph. This figure demonstrates groundwater table fluctuation in Talar aquifer during 1996 to 2011.

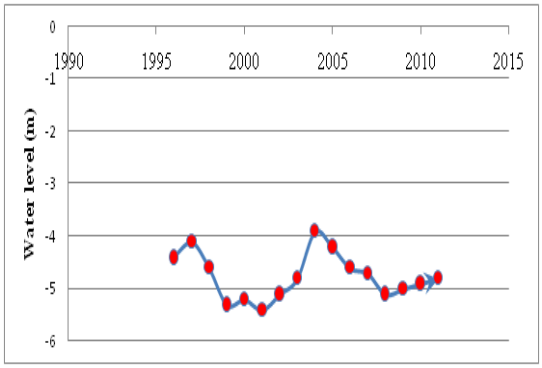

Fig. 3. Annual unit hydrograph of Talar aquifer.

Annual hydrograph

As shown in figure 3 it can be recognized that in some years the level of water was close to the earth ground and in other years it was so far and it means that the level of groundwater is decreasing.

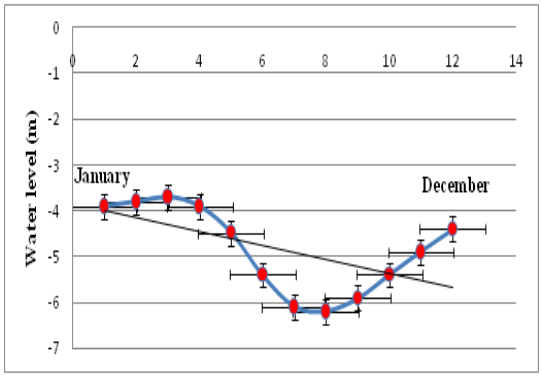

Fig. 4. Monthly unit hydrograph of Ghaemshahr-jouibar aquifer.

The first period from 1998-1999 the level of groundwater was decreased from 4.23 to 5.29, it means that the amount of decreasing in this period was about 1.06 meters.

The second period is recorded in years 2004 to 2008 in which the level of groundwater is decreased from 3.47 to 5.17 meters beyond the ground. It means that the level of water is decreased about 1.7 meters.

The most decreasing occurred in the second period in years 2004-2008.

According to the annual hydrograph there are three increasing period in the level of groundwater in years 2006-2007, 2002-2004 and finally in 2008-2012. The numbers recorded for these periods were 0.13, 1.73 and 0.76 meters respectively. The most increasing was related to years 2002-2004. Averagely the level of groundwater was decreased about 0.92 meters.

Maps created by GIS

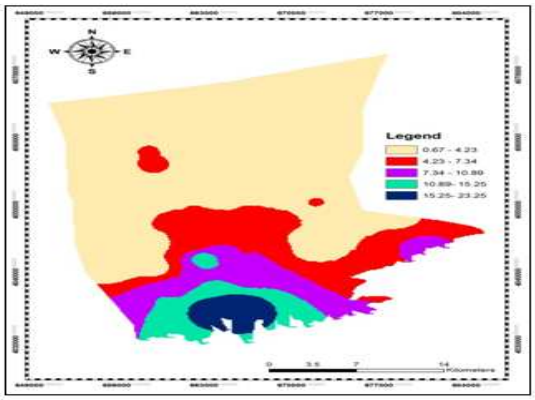

Fig. 5a. Groundwater table maps of Talar aquifer. a) mean annual water level.

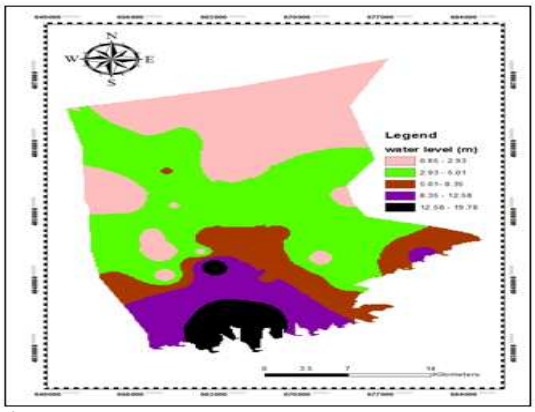

Fig. 5b. Groundwater table maps of Talar aquifer. b) Water level for the year 1996.

Monthly unit hydrograph

As shown in figure 4 there is just one period recongnized for the area. In this period there is a decreasing trend from April to September. After this period there is an increasing trend in the level of groundwater from October to March. Rahmani (2010) said that this happens because of decreasing the level

of groundwater simultaneously with the time of starting the plants growing and this trend can be seen until September. After the growing period pass and increasing the amount of percipitation in fall and winter the amount of water level would be increased.
Groundwater level maps.

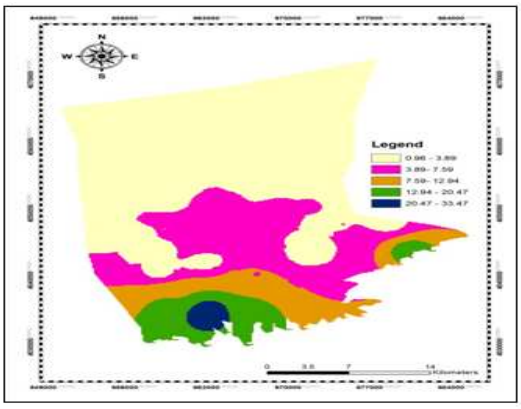

Fig. 5c. Groundwater table maps of Talar aquifer. c) water level for the year 2011.

Groundwater table was mapped based on water level data from piezometric wells. By overlying derived map in different years, spatial variation and trend of groundwater level in Talar aquifer is identified. Maximum water levels correspond to the upper parts of the aquifer with 34 meters and the minimum corresponds to the lower parts of Caspian Sea with 25 m (see figure 5.a, and 5.b and 5.c). This trend is stable until 1991. Since 1991 to 1992 the water level in downward parts of the aquifer has increased about 2.45 m and changed from -25 meters to -22.65 m. Annual average of groundwater level data for the investigated period and 2011 were used for creating annual average and 2011 groundwater level map in Talar aquifer. To show the spatial pattern of groundwater fluctuations, a water table map was generated based on mean annual water level and water level for 2011. Interpolation has made based on observed data in 42 piezometric wells in Talar aquifer and using Kriging interpolation technique embedded in ILWIS GIS software. Based on figure 5, it is evident that water level in the northern part of aquifer is higher than other parts. Also it is illustrated that water level during the period of 1996 to 2011 has moderately unchanged in the southern part of aquifer. This trend is the same up to 2011 for the rest of aquifer.

Conclusion

Rahmani (2010) in his research showed that based on the groundwater table maps of Ghaemshahr-Jouibar aquifer in years 1985-1991. According to his results there are two increasing and decreasing of groundwater level until year 2008. In another word the first period of increasing trend is occurred in years 1992-1996 and another increasing trend is occurred in years 2002-2006. In this research unit hydrograph showed two decreasing and three increasing period in groundwater level. The first period was from 1997-1998 in which the level of water was decreased from -4.23 to -5.29. In another word the level of groundwater was decreased about 1.06 meters. The second period was recorded from 2004 to 2008. It means that in this period the level of groundwater was decreased about 1.7 meters from -3.47 to -5.17. The most decreasing trend was recorded in years 2004 to 2008. Based on the annual hydrograph three increasing periods in years 1996-1997, 2002-2004 and 2008-2012 were recorded. The records for these periods were 0.13, 1.73 and 0.76 meters respectively. The most increasing was recorded in years 2002 to 2004. Averagely the level of groundwater was decreased about 0.92 meters. While Rahmani (2010) illustrated that in the same period there are just two increasing and two decreasing periods in the same area. The reason of this result is that the periods investigated in the same area were different with each other. Rahmani (2010) said that the only reason for increasing the level of groundwater in the Ghaemshahr- Jouibar aquifer is that most of the wells in the aquifer are semi-deep and the level of groundwater in the plain is too much. Thus these areas can be recharged through the precipitation and also because of wet climate determined in the study area this kind of recharging for the aquifer is even more than the needs. On other hand the water harvesting in the area is lower than other parts and another reason can be the low slope of the earth ground which let the rain to infiltrate in to the soil.

The other reasons for increasing the level of groundwater level in Ghaemshahr- Jouibar aquifer is existence of two rivers Talar and Siahrood. The water of the wells is recharges by these two rivers when there is a water shortage in the area. Also there are some ponds that are filled with water when there is a wet year. These ponds have enough water until the end of the summer. Some of these ponds have enough amount of water even in the whole days of the year.

The results of this study is opposite to the results of Mahdavi (1995), Zahmatkesh *et al* (2001), Zehtabian (2002), Sadeghi *et al*, (2006) and Rahnama *et al,* (2009). The reason for this difference is because of studying different periods. They also just mentioned decreasing trend in their areas.

Based on Rahmani (2010) until year 2009 there is a meaningful relationship between absolute precipitation and altitude data of groundwater level of Ghaemshahr- Jouibar aquifer. But among annual average precipitation data with one or two year's difference and the level of groundwater there is not any meaning full relationship.

In this research also there was a meaning full relationship between precipitation and the level of groundwater. These two results are consistent in this term. Rahmani (2010) explained the reason for the increasing of water level and said that high amount of precipitation and low slope of earth ground. This result is opposite to the results of Sadeghi *et al,* (2006).

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