Original Article

Investigating Changes in Groundwater Level in Kashan Plain

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Abstract

Aims: Management of water resources, especially groundwater in arid and semiarid regions, is of particular importance. Various natural and human factors in recent decades have created critical conditions for these resources. Therefore, this study was conducted to investigate changes in groundwater levels over the past 28 years. **Materials and Methods:** To conduct this research, statistics related to 64 piezometer wells were studied during the years 1990–2018, and the effect of rainfall and extraction from groundwater resources was interpreted and analyzed. **Results:** The results of the study showed that according to the hydrograph of 64 piezometer wells in Kashan plain, the groundwater level has a downward trend and has decreased by 15.29 m during 28 years. The annual drop was 0.54 m. An increasing peak of water table was also observed. Moreover, the water level has decreased slightly in some years and has not decreased in some years. **Conclusion:** The study shows that uncontrolled harvesting in the long run has had a more significant impact than rainfall on groundwater resources. Moreover, water abstraction has occurred on average in the southern and southeastern parts of the plain, which can be due to the concentration of agricultural lands in this area. To reduce this trend, strong management strategies should be adopted and appropriate to the situation.

Keywords: Fall, groundwater, water consumption, water harvesting

Introduction

In recent years, population growth and the expansion of industry and agriculture have increased the need for proper management of available resources.[1] Groundwater is one of the most important natural resources for the economic and social development of communities and provides almost 20% of the total water consumption in the world and it is the only safe source for many areas for which the development and operation of surface water are not economically feasible.[2,3] In arid and semiarid regions due to rainfall occur only in a short period of the year and high evapotranspiration, surface water resources are not a reliable source of water supply and as a result in these areas rely more on groundwater resources.[4,5] Excessive pumping from groundwater aquifers has caused water levels to drop and aquifers to become depleted.[6] Improper abstraction of groundwater has caused land subsidence, which as a problem and danger, threatens the communities living in it in the world. More than 150 cities in the world are exposed to this phenomenon.[7,8] For example, in the past 60 years in Mexico City, this phenomenon has caused the ground level to drop up to 5 m in some places due to falling water levels.[6] Similar problems exist in Arizona,[9] Calcutta in India,[10] Bangkok in Thailand,[11] and major plains in Uzbekistan and Azerbaijan.[12] Furthermore, in Iran, the highest land subsidence rate of 30 cm/year is related to Rafsanjan and Kashmar plains. Moreover, the lowest subsidence rate of 3.4 cm/year belongs to the plains of Qom and Kashan.[13] In recent years, the problem of falling groundwater levels has been reported in most plains of Iran, which can be referred to the Shamsabad plain of Qom,[14] Sirjan plain,[15] and Firoozabad plain.[16]

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Kashan city has a desert and dry climate due to its proximity to the desert and distance from the seas and is one of the least rainy areas in Iran, and excessive exploitation of groundwater despite poor water potential has caused irreparable damage to Kashan plain. Due to the importance of groundwater in the region, this study was conducted from 1990 to 2018, the results of which can be used in planning reliable water supply and also in managing water resources and preventing the phenomenon of subsidence and its consequences.

Materials and Methods

Kashan plain with an area of 1570 km^2 in the foothills of the Karkas Mountains and the central desert of Iran and located between longitudes 51°, 54 min and 51°, 5 min and latitudes 33°, 45 min and 34°, 23 min. Kashan plain is a narrow valley along the northwest-southeast. The width of this valley is about 20 km, which is limited to the Qom plain in the north, to the heights adjacent to the Natanz region in the south, to the heights from the west, and to the salt lake area from the east [Figure 1]. Annual rainfall in the region varies from 75 mm on the shores of Salt Lake to more than 300 mm in the southwestern heights of Kashan and the average rainfall of Kashan plain is 125 mm. About 47.6% of the annual rainfall falls in winter and 32% of the annual rainfall in spring. The maximum absolute annual temperature of 46°C belongs to July and August, and the minimum annual absolute temperature of − 12°C belongs to January. Geologically, the aquifer of Kashan plain includes sediments of the fourth geological period. Construction and extraction of groundwater from Kashan plain, since 1942 with the construction of the first well and now about 2900 wells have been registered, continues.

First, a license was established to communicate with the Isfahan Regional Water Organization and to study the trend of groundwater level changes, statistics related to 64 piezometer wells in the study area, which were measured monthly by experts of Isfahan Province Water Affairs Department from 1990 to 2018, were obtained and analyzed, and by drawing a graph whose X-axis is the months of the year and its Y-axis is the groundwater level, a 28-year hydrograph was plotted to gain an overview of the change process. Due to the fact that the changes in groundwater level of each aquifer depend on the amount of water entering and leaving the aquifer, so to show the effect of rainfall on groundwater level fluctuations, a monthly rainfall diagram was drawn for the years 1990–2018. Then, the data were extracted, categorized, and presented by tables and graphs and the results of the study were interpreted, analyzed, and evaluated. The present study with code of ethics IR.KAUMS.NUHEPM.REC.1398.063 was approved by the Vice Chancellor for Research of Kashan University of Medical Sciences, which thanks the efforts of this Vice Chancellor.

Results

The results of the study showed that according to the hydrograph of 64 piezometer wells in Kashan plain, the groundwater level has a downward trend and has dropped 15.29 m in 28 years. So that the average annual drop was 0.54 m. Moreover, an increasing peak of water table is seen in the years 2012–2013 [Figure 2].

The results of the study show that the highest drop is in 1991–1992 that the water level has decreased by 205 cm and the lowest drop is in 1999–2000 that the water level has decreased by 3 cm. Furthermore, in the years 2007–2008, 1992–1993, and 2013–2014, there is no water drop and the groundwater level has increased by 19 cm, 2 cm, and 5 cm, respectively. The highest increase is related to the years 2007–2008. The amount of groundwater level fluctuations based on unit hydrograph is reported in Table 1.

The results of the study show that the highest rainfall in 1995 is 254.3 mm with an average monthly rainfall of 21.11 mm, and the lowest rainfall in 2016 is 80.5 mm with an average monthly rainfall of 6.75 mm, which is also plotted. The years 1991, 1995, 2002 have also been reported as a wet year that rainfall has increased compared to other years. Total annual rainfall and average monthly rainfall over 28 years are presented in Table 2.

Discussion

The results of the study showed that based on the hydrograph unit of Kashan plain, the groundwater level has been decreasing

Table 1: Groundwater level fluctuations values from 1990-2018

Years	Groundwater drop (cm)
1990-1991	−40
1991-1992	−205
1992-1993	2
1993-1994	−90
1994-1995	−44
1995-1996	−29
1996-1997	−82
1997-1998	−32
1998-1999	−68
1999-2000	−3
2000-2001	−34
2001-2002	−34
2002-2003	−52
2003-2004	−49
2004-2005	−42
2005-2006	−49
2006-2007	−43
2007-2008	19
2008-2009	−55
2009-2010	−107
2010-2011	−50
2011-2012	−51
2012-2013	−107
2013-2014	5
2014-2015	−35
2015-2016	−80
2016-2017	−80
2017-2018	−40

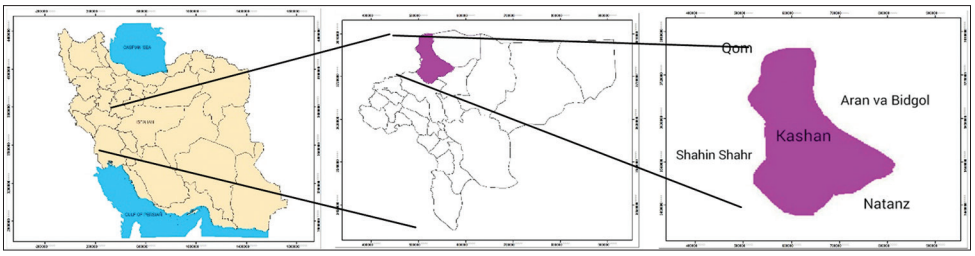

Figure 1: Geographical location of the study area

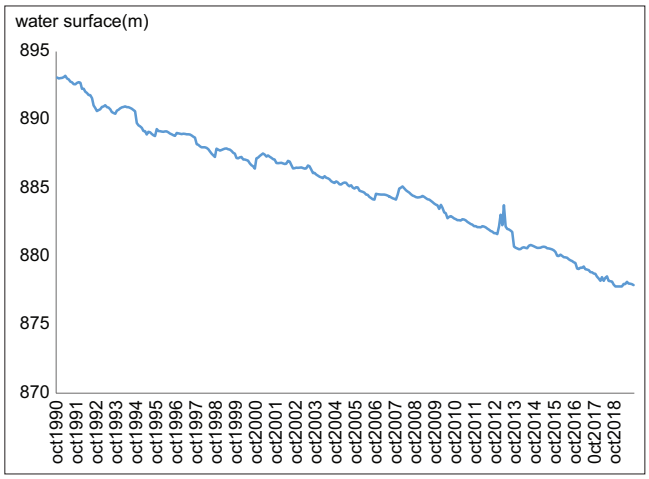

Figure 2: Hydrograph of Kashan plain from October 1990 to October 2018

for 28 years and has decreased by 15.29 m, and the drop is more in the south of the plain and decreases to the north of the plain, this may be due to the fact that the areas near the edge of the desert, which are located in the north of the plain, have the lowest harvest due to poor water quality, and due to the concentration of agricultural lands in the south and southeast of the plain, these areas have more decline. According to the results of the study, an increasing peak in the water level hydrograph occurred in 2013–2012, which is probably due to good rainfall this year, but despite the good rainfall and wet season in 1992–1992, the groundwater level has dropped a lot which shows that the uncontrolled abstraction from the groundwater level was so high that the resulting rainfall had a small effect on reducing the drop and the reason for this decrease can be over-harvesting of these resources, increasing the area under cultivation. There is a large number of harvesting wells or digging unauthorized wells and increasing water demand in various sectors of agriculture, industry, drinking, and health which is consistent with the results of some researchers.[17-19] The results of the study show that uncontrolled abstraction of groundwater in the long run has a more significant effect than rainfall on the surface of groundwater resources with the results of some researchers.[5,20,21] This decrease causes subsidence and salinization toward freshwater, which is consistent with the results of some researchers.[22-24] Improper abstraction of groundwater poses a serious risk of salinization of water and soil resources. According to studies, improper abstraction from the aquifer has increased the salinity of groundwater.[25]

Table 2: Rainfall values from 1369 to 1397 (mm)

Years	Total annual rainfall (mm)	Average monthly rainfall (mm)
1990	98	8.16
1991	249.5	20.79
1992	191.5	15.95
1993	130	10.83
1994	129	10.75
1995	253.4	21.11
1996	61.5	5.12
1997	192.5	16.04
1998	147	12.25
1999	70.3	5.85
2000	199	16.58
2001	201.8	16.81
2002	219	18.25
2003	184	15.33
2004	10.75	129
2005	11.75	141
2006	8.75	105
2007	7.41	89
2008	18.83	226
2009	9.08	109
2010	13.16	158
2011	12.75	153
2012	12.33	148
2013	19.25	231
2014	11.87	142.5
2015	7.16	86
2016	6.7	80.5
2017	5.45	65.4
2018	15.68	188.2

Salt water causes diseases in living things and also causes cell dehydration of plants. Metabolic processes such as reduced photosynthesis, reduced growth, reduced germination, leaf burn are the primary responses of the plant to water salinity.[26,27] Most of the groundwater resources are used in agriculture, urban and industrial uses, and the use of these resources is increasing. The entry of pollutants and municipal and industrial waste, petroleum products, heavy metal pollution, organic and inorganic pesticides, and chemical fertilizers has created many problems for these resources. Kashan plain and its water resources have not been safe from this problem. In this regard, we must pay attention to how water resources are polluted. Because these water resources, in addition to being used in

the agricultural sector, are responsible for supplying drinking water to the region, so paying attention to this issue in arid and semi-arid regions is of particular importance.

Conclusion

Due to the fact that Kashan plain is one of the critical plains of the country and its main sources are groundwater if the process of excessive and unprincipled harvesting continues, it will face something beyond the crisis. As a result, to reduce the downward trend of groundwater resources in this plain, stronger management strategies should be adopted and appropriate to the conditions these include preventing the cultivation of new lands and using new irrigation methods instead of traditional and flooding methods to prevent the drilling of illegal wells.

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Conflicts of interest

There are no conflicts of interest.

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