Original Article

# Salinity Variation in Kashan Plain Groundwater Resources

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## Abstract

**Aims:** The trend of withdrawal from groundwater resources in Kashan plain has been increased during the recent 40 years. For example, the number of deep wells has been increased from 67 in 1965 to 927 in 2003. As a result, the well discharges and water quality have been diminishing. Hence, this research was aimed to study the salinity variation modeling in Kashan plain groundwater resource. **Materials and Methods:** This descriptive research was done based on recorded data for some wells in Kashan plain. First, the data from 112 wells were considered then, 16 wells with more complete data were selected for analysis. Total dissolved solids (TDSs) were considered as the salinity index. **Results:** The results showed that, in Kashan plain, the mean of salinity has been increased from 1190 mg/L to more than 1400 mg/L during 7 years. Although the salinity has been somewhat less after each annual precipitation, the trend is upward. Minimum and maximum of TDS were identified taken samples from wells number 27 and 47, respectively. Maximum rate of salinity was found in wells number 53 and 55, while the minimum was related to well number 54. **Conclusions:** The groundwater salinity in Kashan plain has an upward trend. The groundwater salinity can be related to some major factors such as distance from Salt Lake, less annual precipitation, and more withdrawal from the aquifer in the recent decades. Since the later can be managed withdrawal, especially for agricultural activities have to be minimized as the most effective way for prevention of the groundwater quality degradation.

**Keywords:** Groundwater, Kashan, salinity, total dissolved solids

## Introduction

Groundwater is the main source of water supply for drinking and agricultural use, especially in arid and semi-arid regions.[1] Although in Iran, the groundwater ratio is about 30% of all resources currently, the withdrawal from groundwater resource is more than 50%.[2,3] On the other hand, the population growth, urbanization, industrialization, and agriculture development led to more water demand, especially in the arid and tropical regions. Since the groundwater resource is the main source of water supply in Kashan plain since the 40 past years. The withdrawal from groundwater tables in the plain has been intensified, and the number of certified deep wells has been increased from 67 wells in 1965 to 924 in 2003.[4] During recent centuries, all over the world, especially in the Third World countries, water quality has been degraded due to natural processes and human activities, and recently the fresh water sources are threatened by the phenomenon of salinity.[5,6] The gradual increase in the salinity of under exploitation groundwater is a serious beginning for land salinity and degradation.[7,8]

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According to geographical location, Iran is ranked as fifth arid and semi-arid climate in Asia.[8] In recent years, the drop in wells' water level in the most plain areas has been detected by exploiters such as farmers or experts in urban and rural water and wastewater companies, and it concluded that the quality of water resources has been affected by intensified withdrawals.[9] The progression of saline groundwater to freshwater tables is one of the serious threats to these valuable resources.[10-12] This phenomenon occurs due to excessive withdrawal of fresh groundwater and leads to the pressure imbalance between fresh and saline water, causing annual damage to fresh groundwater resources.[13-16]

Torabi study (1999) on Kashan plain groundwater showed that the average subsidence of the water table has been about

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16 m during 1965–1997 and the average electrical conductivity increased from 3.4 to 6.9 ds/m.[17]

The study of Valipoor *et al*. (2008) on Shams-Abad in Qom Province shows that, during the past 47 years, the agricultural lands' area in the region has been increased by about 9.5 times, which has been led to an increase of groundwater consumption and dropping of water level also, increasing groundwater salinity.[18] A case study of Kashan plain by Ghazavi *et al*. (2015) shows that water quality in the most parts of the plain is not suitable for drinking, and based on Papier diagram, water type is NaCl.[19] Miranzadeh *et al*. in their study on quality of drinking water in villages of Kashan claimed that the most important causes for increasing salinity of the water resources in the region are dipping the wells' violations of permitted discharge, as well as too much pumping from deep wells.[20] In another report, Mirzavand *et al*. declared that the amount of EC is increased along the pathway of groundwater flow from supply areas to the desert outline.[21] Rise of Electrical-Conductivity of water samples in 1994 has been related to the more backflow of saline water to the fresh water table, while before 1983, the groundwater flow was toward the desert.[17,22] Land subsidence is a phenomenon which occurs due to several natural geological factors or human activity such as excessive withdrawal from aquifers. Physical and chemical properties of groundwater are not constant, and changing over time and place. On the other hand, the proper management of groundwater resources, both quantitatively and qualitatively, requires a good understanding of the local and temporal changes in the water level and salinity of groundwater. Hence, update data are required to good manage of resources.[23-27]

Considering the excessive bring out of groundwater in Kashan plain, further studies on the quality changes are particularly required in terms of salinity. Therefore, in this research, salinity changes in groundwater of Kashan plain were studied.

## Materials and Methods

### The study area

Kashan plain which situated in south of Salt Lake in the center of Iran is an important natural and economical area in Isfahan province. Its altitude is averagely about 970 m. It is classified as arid and warm climate. In this plain, the annual precipitation is <130 mm, while the annual potential evaporation is 2700 mm. Kashan and Aran-Bidgol cities have been located in this plain. Agriculture is the main occupation of the people from the past. Textile, carpet, automotive, and metals industries have been established in the recent decades, due to the increasing population, water demand has been increased sharply. Arid climate, low precipitation, high potential evaporation as well as increasing water demand because population growth, agricultural and industrial development, have been led to the groundwater table decline and diminished water quality in this plain.

### Research method

#### *Method*

This research is a descriptive study which has been performed using data from 2006 to 2013 regarding the water quality of some wells in Kashan plain. In this research, the data of 112 wells were received from Kashan Water and Wastewater Company. Only the data of 16 wells were available in a complete and regular form that was analyzed.

In this work, variation of Total Dissolved Solids (TDSs) has been considered as an important indicator of water salinity variation. The position of the wells is shown in Map 1.

## Results

The results show that the total amount of dissolved solids in the 16 well water samples has been increasing so that the average value of dissolved solids in these wells during the 8 years has been increased from 1190 mg/L to more than 1400 mg/L [Figure 1].

Figure 1 shows that subsequent of the increase in annually precipitation, the salinity of well water ' is reduced. However, an ascending trend is observed in the mean of salinity over the time [Figure 2]. According to the given data, among the under research wells, the well No. 27 showed the lowest salinity and the well No. 47 the highest.

While the highest ratios of salinization were detected in wells No. 53 and 55, the lowest ratio of increasing dissolved solids was in the well No. 54 [Figures 3-5].

## Discussion

Study of groundwater salinity in Kashan plain indicates that salinization of the water is ascending all the time. Furthermore, salinity increasing is reckonable almost in all over the plain. On the other hand, according to Figure 1, with increasing precipitation in 2012 and 2013, the salinity of the groundwater resources has been reduced to some extent. Notice to location of the wells shows that as we move toward the Salt Lake, the


**Map 1:** Location of studied wells

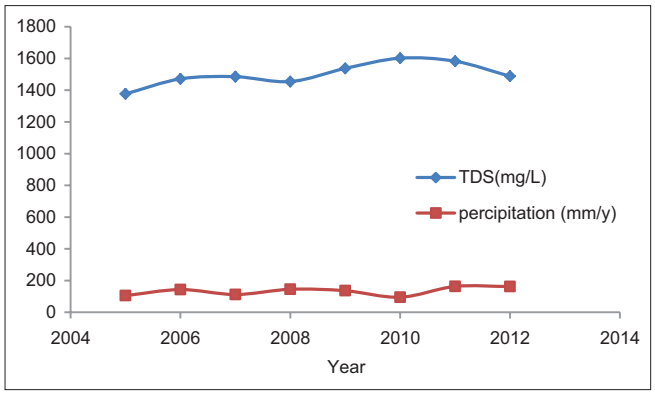


**Figure 1:** Average salinity of wells' water in Kashan plain in comparison with average annual precipitation during 2006–2013

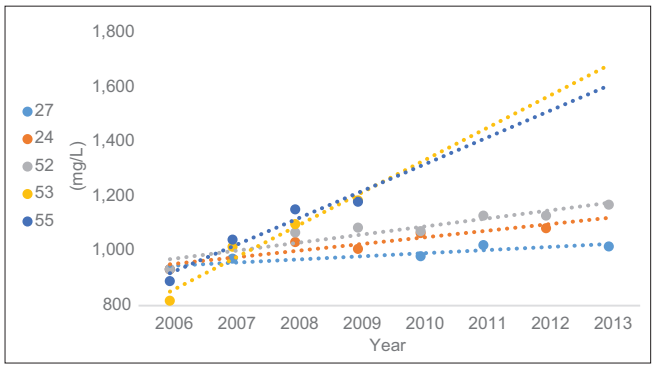


**Figure 3:** Changes in water salinity in several wells in Kashan plain during 2006–2013

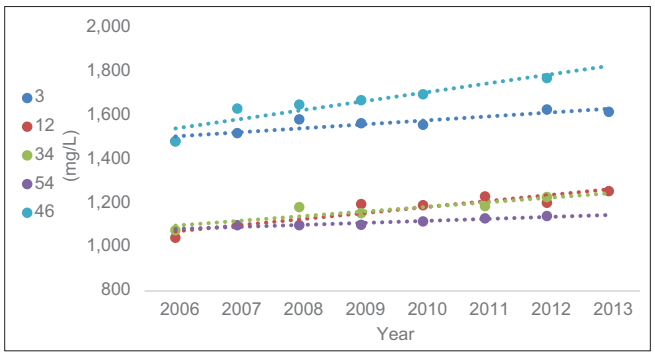


**Figure 5:** Changes in water salinity in several wells in Kashan plain during 2006–2013

average salinity of the water increases too. These results are in compatible with the studies of Valipor and Miranzadeh.[18,21]

Recently, in many parts of Iran, groundwater salinity has been increased in parallel to groundwater level drop resulted from more withdrawal from water tables, for example, Abadeh *et al*. study in Ziyadabad district, Sirjan in east south of Iran achieved similar results in agreement with our findings.[28]

According to Huang *et al*. study in a coastal aquifer, in addition to the geological characteristics of the aquifer and precipitation, the amount of groundwater exploitation affects its salinity.[29]

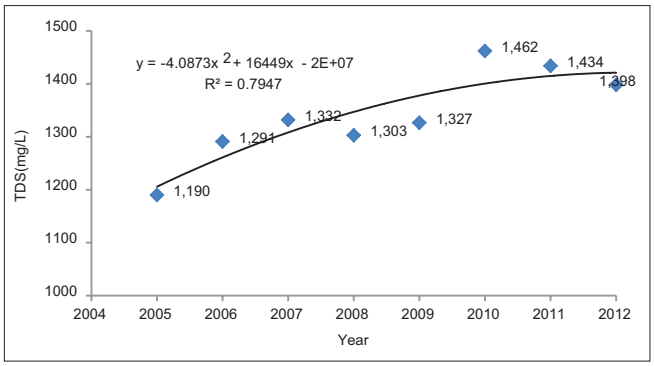


**Figure 2:** Changes in the average salinity of studied wells' water in Kashan plain during 2006–2013

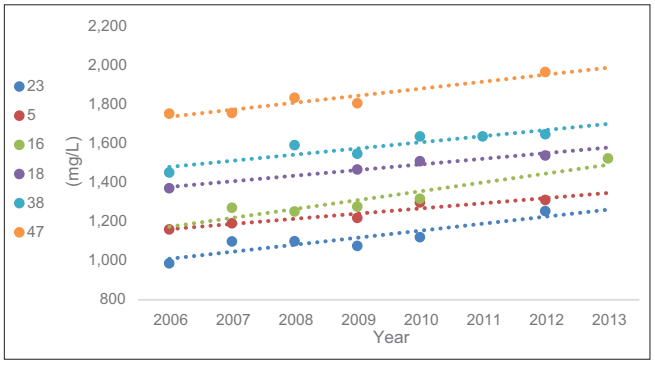


**Figure 4:** Changes in water salinity in several wells in Kashan plain during 2006–2013

A reverse relationship with low correlation coefficient has been found between annual precipitation and salinity level in groundwater which is compatible with our findings.[30-32] The trend of groundwater salinization in north of Kashan plain was investigated by Torabi. He declared that the average electrical conductivity of groundwater had been increased from about 1350 to 6930 mmhos/cm, during 1965–1997 and the land subsidence stated about 13 m for the same period.[17] Furthermore, our finding is well-matched to Karami *et al*. study in 2011 on water salinity changes in Sarab plain. They stated that groundwater salinity level in Sarab plain has been increased during a 10-year period. The minimum salinity has been stated for foothills surrounding the plain while the salinity increased toward the center and the west of the plain.[33] In addition to prolonged drought, excessive withdrawal and proximity to the Salt Lake that contribute to changes in the salinity of groundwater in Kashan plain different geological formations has been caused some spatial variations too.

Land subsidence has been acquired in Kashan plain as like many other plains of Iran which is one of the most harmful effects of excessive consumption of groundwater.[23-25]

## Conclusions

Our study showed that groundwater salinization in Kashan plain has an upward trend which can relate to more withdrawal from the water table in the recent decades. Since it can lead

to numerous socioeconomical and economical crises, it seems that reducing of water demand is the best way to prevent the salinization of groundwater in this plain. Because the main consumer of groundwater in the plain is agricultural activities, water demand management in the agricultural sector has become a priority.

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## Conflicts of interest

There are no conflicts of interest.



## References

1. Bouchaou L, Michelot JL, Qurtobi M, Zine N, Gaye CB, Aggarwal PK, *et al*. Origin and residence time of groundwater in the Tadla basin (Morocco) using multiple isotopic and geochemical tools. J Hydrol 2009;379:323-38.
2. Karami F. The study of salinity changes of groundwater sources in Sarab plain. Tabriz Univ Geogr 2012;16:101-22.
3. Ebrahimi M, Kazemi H, Ehtashemi M, Rockaway TD. Assessment of groundwater quantity and quality and saltwater intrusion in the Damghan basin, Iran. Chem Erde Geochem 2016;76:227-41.
4. Jahanshahi R, Zare M. Hydrochemical investigations for delineating salt-water intrusion into the coastal aquifer of Maharlou Lake, Iran. J Afr Earth Sci 2016;121 Suppl C: 16-29.
5. Kusimi JM, Kusimi BA. The hydrochemistry of water resources in selected mining communities in Tarkwa. J Geochem Explor 2012;112:252-61.
6. Li J, Wang Y, Xie X, Su C. Hierarchical cluster analysis of arsenic and fluoride enrichments in groundwater from the Datong basin, Northern China. J Geochem Explor 2012;118:77-89.
7. Lagnika M, Ibikounle M, Boutin C, Sakiti EN. Groundwater biodiversity and water quality of wells in the Southern region of Benin. Comptes Rendus Chimie 2016;19:798-806.
8. Jamshidzadeh Z, Mirbagheri SA. Evaluation of groundwater quantity and quality in the Kashan Basin, Central Iran. Desalination 2011;270:23-30.
9. Mahmoodzadeh D, Ketabchi H, Ataie-Ashtiani B, Simmons CT. Conceptualization of a fresh groundwater lens influenced by climate change: A modeling study of an arid-region island in the Persian Gulf, Iran. J Hydrol 2014;519:399-413.
10. Kut KM, Sarswat A, Srivastava A, Pittman CU Jr., Mohan D. A review of fluoride in African groundwater and local remediation methods. Groundwater Sustain Dev 2016;2-3:190-212.
11. Gautam SK, Maharana C, Sharma D, Singh AK, Tripathi JK, Singh SK. Evaluation of groundwater quality in the Chotanagpur plateau region of the Subarnarekha river basin, Jharkhand State, India. Sustain Water Q Ecol 2015;6:57-74.
12. Nguyen TT, Kawamura A, Tong TN, Nakagawa N, Amaguchi H, Gilbuena R Jr. Hydrogeochemical characteristics of groundwater from the two main aquifers in the Red River Delta, Vietnam. J Asian Earth Sci 2014;93:180-92.
13. Ojha CS, Singh VP, Adrian DD. Assessment of the role of slit as a safety valve in failure of levees. Int J Sediment Res 2008;23:361-75.
14. Osinowo OO. Water quality assessment of the Asata River catchment area in Enugu Metropolis, Southeast Nigeria. J Afr Earth Sci 2016;121:247-54.
15. Seckin G, Yilmaz T, Sari B, Ersu CB. Groundwater hydrochemistry at the Mediterranean coastal plains – The case of Silifke, Turkey. Desalination 2010;253:164-9.
16. Kalantari N, Heidari MJ, Rahimi M. Finding and managing potential finding juicy crisis: A case study of Zideon Plain, Khouzestan Province. Engineering Geology 2009;3:591-614.
17. Torabi A. Investigating trend of groundwater susanation in the North of Kashan Plain. Desert 1999;4:1-22.
18. Valipoor M, Karimian E, Malakoti M, Khoshgoftarmanesh A. The trend of salinity development and degradation of agricultural lands in the Shams Abad area of Qom province. Water Soil Sci (Sci Technol Agric Nat Resour) 2008;12:683-91.
19. Ghazavi R, Yaghob Y, Abbasali V, Sadatinejad SJ. Location of Suitable Fields for Storing Heavenly Deserts Using GIS (Case study of Kashan plain). Persian Geography Papers; 2014. p. 85-96.
20. Miranzadeh M, Mesdaghinia M, Heydari M, Yonosian M, Naddafi K, Mahvi AH. Investigation of chemical quality and chlorination of drinking water in villages of Kashan. Health system research. 2010;6(Suppl):889-97.
21. Mirzavand M, Ghasemiyeh H, Sadatinejad SJ, Akbari M. Comparison of artificial neural network models and multivariate regression in estimation of groundwater quality changes (Case Study: Kashan Aquifer). Water Soil Knowl (Agric Knowl) 2015;25:207-20.
22. Zarei M, Sedehi F, Raeisi E. Hydrogeochemical characterization of major factors affecting the quality of groundwater in Southern Iran, Janah Plain. Chem Erde Geochem 2014;74:671-80.
23. Re V, Sacchi E, Allais E. The use of nitrate isotopes to identify contamination sources in the Bou-Areg Aquifer (Morocco). Proc Earth Planet Sci 2013;7:729-32.
24. Sako A, Bamba O, Gordio A. Hydrogeochemical processes controlling groundwater quality around Bomboré gold mineralized zone, Central Burkina Faso. J Geochem Explor 2016;170:58-71.
25. Ghazifard A, Moslehi A, Safaei H, Roostaei M. Effects of groundwater withdrawal on land subsidence in Kashan Plain, Iran. Bull Eng Geol Environ 2016;75:1157-68.
26. Dieng NM, Orban P, Otten J, Stumpp C, Faye S, Dassargues A. Temporal changes in groundwater quality of the Saloum coastal aquifer. J Hydrol Reg Stud 2017;9:163-82.
27. Farid I, Zouari K, Rigane A, Beji R. Origin of the groundwater salinity and geochemical processes in detrital and carbonate aquifers: Case of Chougafiya basin (Central Tunisia). J Hydrol 2015;530:508-32.
28. Abadeh M, OUNAGH M, Mosaedi A, Zainoldini A. The study of effects of water table drawdown on the salinity of groundwater in Zeydabad area, Sirjan. J Agricultural Sciences and Natural Resources 2006;13:18-27.
29. Huang G, Sun J, Zhang Y, Chen Z, Liu F. Impact of anthropogenic and natural processes on the evolution of groundwater chemistry in a rapidly urbanized coastal area, South China. Sci Total Environ 2013;463-464:209-21.
30. Machiwal D, Jha MK. Identifying sources of groundwater contamination in a hard-rock aquifer system using multivariate statistical analyses and GIS-based geostatistical modeling techniques. J Hydrol Regional Stud 2015;4:80-110.
31. Madioune DH, Faye S, Orban P, Brouyère S, Dassargues A, Mudry J, *et al*. Application of isotopic tracers as a tool for understanding hydrodynamic behavior of the highly exploited Diass aquifer system (Senegal). J Hydrol 2014;511:443-59.
32. Chongo M, Wibroe J, Staal-Thomsen K, Moses M, Nyambe IA, Larsen F, *et al*. The use of Time Domain Electromagnetic method and continuous vertical electrical sounding to map groundwater salinity in the Barotse sub-basin, Zambia. Phys Chem Earth Parts A B C 2011;36:798-805.
33. Karami F, Kazemi H. Spatial monitoring of groundwater salinity in drought and wetland index (Case: Tabriz plain). Geogr Dev 2012;10:79-94.