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A Quantitative and Qualitative Assessment of Groundwater Resources in the Shourdasht Basin of Ghahavand

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A B S T R A C T

Nowadays, because of severe droughts, the drilling of new wells, the over-abstraction of groundwater resources, and inattention to resource planning and management, there is an urgent need for paying special attention to groundwater resources and their quantitative and qualitative assessment. The present research assesses the quantitative and qualitative status of groundwater behavior in the Shourdasht basin of Qahavand in Hamadan province, Iran. Quantitative and qualitative groundwater data were collected for the 2001-2016 period and the quantitative and qualitative groundwater maps of piezometric wells data were evaluated using the GIS-based interpolation method. According to the results of the annual Shourdasht hydrograph, an average of 1.7 m decline is observed in the groundwater in the study area. The calculation of hydrodynamic coefficient shows that the studied aquifer had the maximum water transmissibility rate of about 165.23 m/day in the northwestern part of the Shourdasht basin and the minimum transmissibility rate of 16.5 m/day in the north of the basin. The maximum and minimum specific yield coefficients were recorded in the eastern and northeastern parts of the plain, which were about 0.61 and 0.006, respectively. The results of the qualitative study of the area show that according to the Schuler diagram, drinking water quality is mainly within the acceptable to moderate range. Also, according to the Wilcox diagram, the samples are classified to have medium quality.

1. Introduction

Water tables or alluvial aquifers are known as the major sources of water for agricultural, drinking, and industrial purposes. Aquifers, including natural resources, have always drawn human attention to exploiting them. The over-abstraction of groundwater tables in many aquifers in Iran has caused a decline in groundwater level and has led to various problems such as the drying of wells and their destruction (Shamsi Sosahab and Taghi Sattari, 2014).

Extensive research has investigated the quantitative and qualitative changes in groundwater. Afzali and Shahedi (2014) studied the process of quantitative and qualitative changes in groundwater of Amol-Babol plain. The results indicated that the groundwater level was slightly reduced and the groundwater quality was improved in the study site. In a study on groundwater level decline using the geographic information system (GIS) in Mashhad plain, Ekrami et al. (2011) found that, on average, 60 cm of water level had declined each year. The results showed that the main factors responsible for the decline in groundwater level included droughts, over-abstraction, population growth, an increase in cultivation, and the drilling of a large number of wells. Hejazi Jahromi et al. (2013) investigated the trend of qualitative and quantitative groundwater and the raining status in a 30-year statistical period in the southern and southeastern plains of Fars province, Iran. The results showed that both the reduction of rainfall and excessive abstraction of groundwater, particularly in recent years, had decreased water quality. So, based on the water classification, the water in the selected plains was not suitable for irrigation. Samadi et al. (2015) investigated the trend of groundwater level changes in 31 piezometric stations on the monthly and annual scale in Urmia plain using the Mann-Kendall nonparametric test. The results showed that in all stations, groundwater level had a negative trend and this negative trend was significant ($p < 0.01$) in 56% of the stations. The examination of the line slope showed that the average groundwater level in the plain had been declining at a rate of 19 cm per year over the last decade.

Khajeh et al. (2014) evaluated the quantitative status of groundwater quality in the Parishan plain over an 18-year period using GIS. The results showed that the quantity and quality of groundwater decreased with an increase in droughts and a drop in the groundwater table. Ghazavi et al. (2016) studied the effects of changes in rainfall and groundwater abstraction on quantitative and qualitative changes in the aquifer in the Rafsanjan plain. To assess the annual fluctuations in the groundwater level, a plain

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hydrograph was prepared and the effect of precipitation and abstraction rate was analyzed on groundwater level changes in different years using a correlation relationship. The results showed that the groundwater level had been declining at a rate of about 0.8 m per year. Karimi and Haddad (2015) investigated quantitative and qualitative changes in groundwater resources of the MehVelat plain in Khorasan Razavi province, Iran. The results revealed that the water level decline was, on average, 1.35 meters per year. Rostamzadeh et al. (2014) evaluated the groundwater table of the Ardabil plain. piezometers water table and the changes in the water level were displayed during this period by fuzzy weighting technique and the interpolation methods, the results showed that most changes were related to a decline in groundwater level in the eastern and southeastern parts of the plain. Wang et al. (2016) investigated quantitative groundwater recharge in desert areas in northeast China. The results showed that the restricted groundwater aquifer in the study area was mainly rechargeable by leakage from the upper unconfined aquifer and lateral flow from the eastern and southern aquifers. Etebari et al. (2019) conducted a qualitative and quantitative assessment of the Sarayan watershed in northeastern Iran using GIS. The study involved a careful survey of water level and sampling of water quality (water table salinity) to create a conceptual model of the basin and subsequently perform various simulations to investigate different factors for long-term management of water resources in the area. Lezalia et al. (2018) used the ArcGIS model to estimate groundwater resources in the Middle East and North Africa based on saturated aquifer production saturation and effective porosity estimation. On the groundwater changes between 2003 and 2014, all MENA countries except Morocco have shown a decline in groundwater reserves. An assessment of quantity and quality of groundwater in the Kashan basin, Central Iran according to data from 53 wells revealed that the average water table was decreased by 7.93 meters between 1990 and 2006, indicating a decrease. The average water table is 0.496 meters per year. The comparison of groundwater quality showed that most water samples were not potable.

Ebadati and Khamisabadi (2014) investigated the quantitative and qualitative potential of groundwater mineral resources in Iran's Millard mineral water. The results emphasized the quantitative and quantitative reduction of rural water wells in the region due to two factors: geological features of the area and hydrochemical factors, which play a role in reducing water yield. Most of the qualitative changes were related to chemical conditions and lithological composition. Attai et al. (2016) analyzed the process of quantitative and qualitative changes in groundwater with regard to correlation coefficients in western Lake Urmia, Iran. The results showed that the correlation coefficients were significant in the evaluation of the time series trend. Also, an analysis of temporal variations in groundwater quality parameters revealed that the values of sodium absorption ratio were upward and other values were decreasing. Bing et al. (2012) investigated the hydrochemical properties and water quality assessment of surface and groundwater in the Songenen plain, northeast China. Water quality indices showed that shallow groundwater was suitable for irrigation and deep reservoir in upstream of water sources were suitable for drinking. Zeinali (2017) assessed the meteorological and hydrological impacts on the quantity and quality of groundwater in the Marand plain. The results of the Pearson correlation between meteorological drought and groundwater level were significant at a 1% confidence level. The chemical quality of groundwater showed that changes in water quality occurred in the plain extensively due to increased cultivation area and increased abstraction. Pourkhosravani (2016) analyzed the qualitative groundwater of the Urozuyeh plain using the GIS technique. The results showed that among the measured indices, the electrical conductivity and TDS in the selected samples were higher than the national standard of Iran. Almodadersi et al. (2019) analyzed qualitative groundwater quality indices based on the Schuler and Wilcox diagrams and the IDW and kriging models. Evaluations based on the 10-year average quality of water in the plain showed that, according to Schuler and Wilcox water quality criteria for drinking and agricultural purposes, the northern and southern parts of the plain had poor water quality compared to the center. Karami et al. (2019) studied the special effects of various climatic factors including temperature, precipitation, evapotranspiration, and transpiration on the quality of groundwater resources in the Varamin plain. The results indicated that these parameters were highly variable along the plain except for pH and the spatial distribution of the data was not normal and the frequency of pixels was less than the spatial average of the region. The correlation analysis showed that water quality was affected by climate factors. It should also be noted that the maximum temperature had the greatest effect. Aishah Ramadan (2012) showed that the Murzuq basin was experiencing a significant decline in water quantity due to its high abstraction. The results showed that the water level had decreased gradually over the past three decades, more than one meter measured in Wadi al Shati. The data also showed that the physical and chemical properties of water were affected by negative changes. Almodaresi et al. (2015) prepared a groundwater quality zoning map for drinking purposes using the Schuler model and GIS. The results showed that by moving from southwest to northeast of the plain, the quality of drinking water decreased. In terms of drinking water quality, about 30% of the study area was in good and acceptable condition. Also, about 57% of the study area had low-quality drinking water, i.e., poor quality water and completely unpleasant quality, and 13% of the drinking water quality map was dedicated to medium quality located in the central region.

The present research assesses the quantitative and qualitative status of groundwater behavior in the Shourdasht basin of Qahavand in Hamadan province using a GIS-based interpolation method. The contribution of this research is the application of GIS in quantitatively and qualitatively monitoring groundwater and facilitating large-scale analysis of data. Using this system, it is possible to devise more effective management plans in combination with other information, especially when faced with complex hydrogenation systems and groundwater.

2. Materials and Methods

2.1. Study Area

The aquifer of the study area is located in the eastern part of the Shourdasht basin, which is a part of the Razan-Qahavand and Komijan aquifer. The aquifer area in the study site is about 13821.6 hectares. The southwest and northwest elevations of the basin are aquifer recharging resources. Groundwater level isolines, fault position, and wells scattered in the area, as well as aquifer boundary and area (Figure 1), were determined by topographic maps.

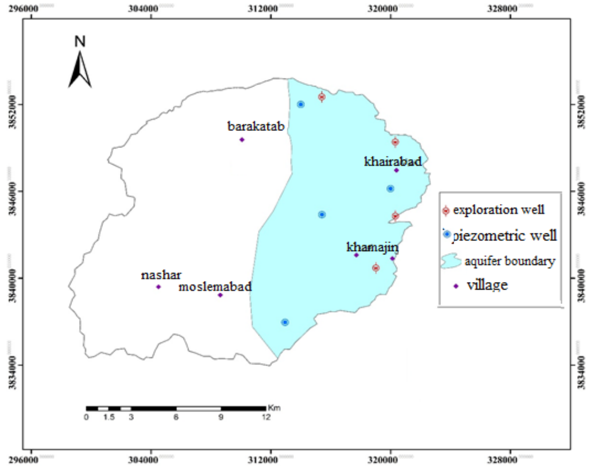

Fig. 1. The location of the Shourdasht aquifer

2.2. Research Methodology

First, the quantity and quality of the Parishan plain groundwater resources were obtained from Hamadan Regional Water Organization. Then, using GIS software, the basin boundary and digital and base maps including topographic, geological, hydrographic location maps were prepared. The years from 2001 to 2016 were selected as the study period. Five piezometric wells were used to control the quantitative changes in groundwater and four wells were employed to investigate the qualitative changes in groundwater well distributed in the study area. Quantitative and qualitative changes data were then entered into the GIS software. The data processing and analysis were performed in MS-Excel software. It was also used to provide quantitative and qualitative maps of the interpolation model of kriging by GIS. The Wilcox diagram was used to classify groundwater according to the type of agricultural use.

3. Results and Discussion

3.1. Quantitative Assessment of Groundwater Resources

3.1.1. Groundwater Level

According to the groundwater level statistics of piezometric wells in the study area (Table 1) and the use of kriging interpolation, the groundwater level curve shapes of the study area were prepared in the years 2001 and 2016 (Figures 2 and 3). According to the statistics of the year 2016, the underground water level is about 1700 meters on the northern side of the basin around the western part of Dashteh village, 1777 meters in the eastern part of the basin around the village of Khamajin, and about 1661 meters in the southern and central part of the basin around the village of Moslem Abad. The comparison of the groundwater level with the year 2001 reveals a lot of changes in the groundwater level, especially in the southern part of the aquifer between 2001 and 2016. Figure (2) shows the groundwater level based on water level statistics for the year 2001. Based on the comparison of this figure with Figure (3), the water level is about 50 m in the northern wells of the area, about 15 m in the eastern part of the region, and about 75 m in the southern part around Moselm Abad, indicating the largest decline in water level in the region.

3.1.2. Groundwater depth

Groundwater depth changes in 2001 and 2016 were prepared as presented in Figures (4) and (5)Using the water level statistics in the piezometer wells (Table 2).respectively the water table in the northern part of the plain west of the plain about 166 meters, in the eastern part near Khamajin village about 60 meters and in the southern part around Moslem Abad is about 155.8 meters according to the water table data for the year 2016 (Figures 4 and 5). The comparison of the water level of the piezometric stations of the study area in the year 2001 reveals that the water level was about 50 meters in the northern part, about 25 meters in the eastern part, and 75 meters in the southern part. Most declines are in the southern part of the basin around Moslem Abad.

3.1.3. Groundwater hydrograph of the study area

Based on the water level statistics in the wells, the hydrograph for the fifteen-year period (2001-2016) was prepared and shown in Figure 6. To draw the hydrograph, the annual water level values in the piezometric wells in the area were calculated for a 15-year period (2001-2016). In Arc GIS software, the affected area of each well was obtained by the Thiessen method. Based on the results of the number of surface changes per year (Table 3), it can be said that there is an average of 1.7 meters of water-level decline in the study area.

Table 1. Water level statistics of piezometric wells in the study area (m)

Station	Khemajin	Khairabad	Ghuzelche	Moslemabad	Gharb-dashteh
2001-2002	1786.8	1796.53	1763.56	1735.19	1707.86
2002-2003	1786.35	1796.65	1759.77	1713.383	1702.83
2003-2004	1785.56	1792.72	1760.9	1700.565	1691.79
2004-2005	1785.01	1791.66	1763.06	1702.231	1693.26
2005-2006	1786.63	1790.75	1762.92	1701.068	1692.26
2006-2007	1783.51	1788.87	1760.66	1697.009	1688.75
2007-2008	1786.63	1788.88	1762.75	1679.972	1676.1
2008-2009	1780.3	1788.6	1761.7	1673.809	1668.8
2009-2010	1779.95	1782.66	1759.57	1683.8	1678.3
2010-2011	1779.6	1782.2	1760.15	1680.6	1676.8
2011-2012	1778.8	1781.83	1759.85	1675.8	1667.9
2012-2013	1778.35	1781.23	1759.6	1673.2	1669
2013-2014	1777.85	1779.28	1758.2	1670.3	1670.6
2014-2015	1777.5	1778.6	1757.8	1669.1	1659.7
2015-2016	1776.85	1776.7	1757.85	1666.5	1659.73
2016-2017	1776.5	1775.95	1757.05	1661	1659.73

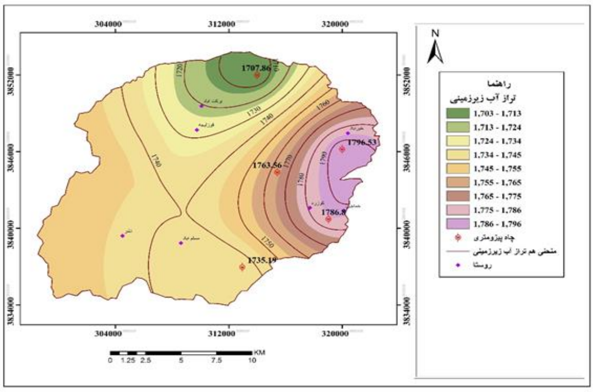

Fig. 2. Groundwater isoline map in 2001.

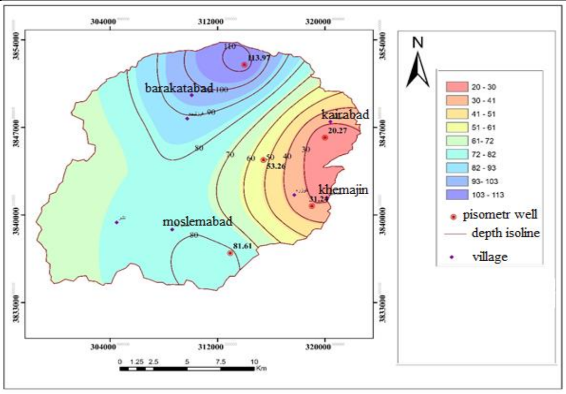

Fig. 4. Groundwater depth in 2001

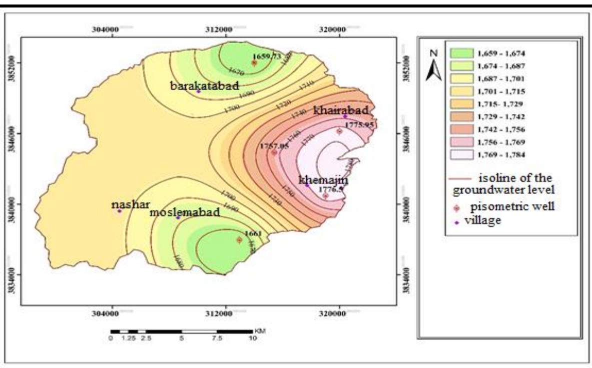

Fig. 3. Groundwater isoline map in 2016.

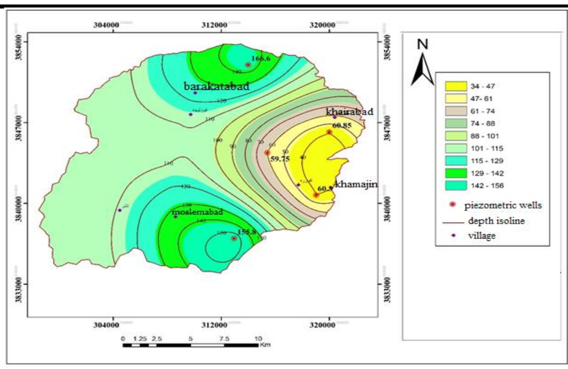

Fig. 5. Groundwater depth in 2016

Table 2. Water table statistics of piezometric wells in the study area (m)

Station	Khemajin	Khairabad	Ghuzelche	Moslemabad	Gharb-dashteh
2001-2002	31.24	20.27	53.26	81.61	113.97
2002-2003	30.65	22.35	57.03	92.07	113.97
2003-2004	31.26	26.08	55.9	6.36	125.06
2004-2005	31.79	25.16	53.76	107.92	123.56
2005-2006	32.17	26.05	53.88	109.57	126.56
2006-2007	33.29	27.93	56.16	115.33	128.05
2007-2008	32.17	27.92	56.05	131.35	137.75
2008-2009	36.5	28.6	55.1	132.59	162.7
2009-2010	36.85	36.16	57.23	133	168
2010-2011	37.2	36.6	56.65	136.2	138.5
2011-2012	38	36.97	56.95	161	162
2012-2013	38.65	35.57	57.6	163.6	168.9
2013-2014	38.95	37.52	58.6	166.5	167.8
2014-2015	39.3	38.6	59	167.7	166.6
2015-2016	39.95	60.1	58.95	152.3	166.6
2016-2017	60.3	60.85	59.75	155.8	166.6

Table 3. The water level of the studied basin

Statical years	Water level (m)	The amount of surface changes (m)
2001	1758.67	-0.22
2002	1758.17	-0.5
2003	1757.76	-0.61
2004	1757.69	-0.07
2005	1756.62	-1.07
2006	1752.97	-3.65
2007	1752.76	-0.23
2008	1769.8	-2.96
2009	1761.71	-8.09
2010	1760.58	-1.13
2011	1738.22	-2.36
2012	1737.78	-0.66
2013	1736.9	-0.88
2014	1736.26	-2.66
2015	1733.2	-1.06
2016	1732.36	-0.86

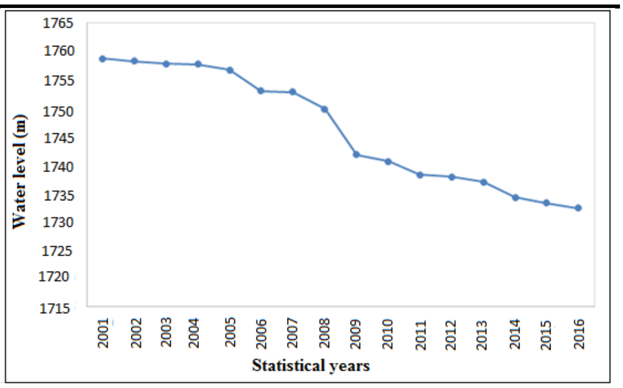

Fig. 6. The groundwater hydrograph of the study area

3.1.4. Hydrodynamic coefficients

3.1.4.1. Water transmissibility coefficient

The water transmissibility coefficient in an aquifer is the amount of water that crosses a unit area of the aquifer under a hydraulic gradient per unit time. If *K* is the hydraulic conductivity coefficient of the aquifer ingredients is and *b* is the thickness of the layer, the water transmissibility coefficient will be as follows (Alizade, 2008).

$$T=kb \quad (1)$$

An estimation table (Table 4) was used to estimate the hydraulic conductivity with respect to the exploration wells' alluvial gradation (Domenico and Schwartz, 1990).

Table 4. Unconsolidated sedimentary Materials

Material	Hydraulic Conductivity(m/s)
Gravel	$3*10^{-6}$ - $3*10^{-2}$
Coarse sand	$9*10^{-7}$ - $6*10^{-3}$
Medium sand	$9*10^{-7}$ - $5*10^{-6}$ to
Fine sand	$2*10^{-7}$- $2*10^{-6}$
Silt,loess	$1*10^{-9}$ - $2*10^{-5}$
Till	$1*10^{-12}$ - $2*10^{-6}$
Clay	$1*10^{-11}$ -$6.7*10^{-9}$ to
Weathered marine clay	$8*10^{-13}$- $2*10^{-9}$

3.1.4.2. Storage Coefficient

The storage coefficient or storage capacity, usually denoted by *S*, is the volume of water that has been removed or added to each unit of the aquifer as a result of lower or higher pressure levels. Lack of sufficient information regarding the calculation of hydrodynamic coefficients in the study area was attempted to calculate these coefficients based on the available data from the wells in the range. The Jacobean calculation formula was used to calculate the storage coefficient (Alizade, 2008).

$$S = yb(a + n\beta) \tag{2}$$

s = storage coefficient

n = aquifer porosity

b = aquifer thickness (m)

a = compressibility of aquifer materials (inverse of elastic modulus of aquifers)

β = compressibility of water (inverse of elastic modulus of water)

The total thickness of the alluvial was calculated based on the data obtained from the drilling logs of existing exploration stations in the study area.

3.1.4.3. Determination of the stored water volume

The stored water volume was calculated by the following formula:

"Storage coefficient× Saturation area thickness × Aquifer area = Storage volume"

Area: According to the creation of Thiessen polygon for exploration wells in the area, the area of each polygon was obtained using GIS software.

-Saturation section thickness: Based on data obtained from drilling logs of existing exploration stations in the study area, the total thickness of the alluvial and the water table were calculated.

The computational results of the aquifer hydrodynamic coefficients at the wells of the study area are presented in Table (5). The maximum transmissibility rate was calculated at about 165.23 m/day in the eastern part of the plain and the minimum was 16.5 in the northeast part of the plain. Maximum and minimum specific yield coefficients were recorded in eastern and northeastern parts of the plain at about 0.61 and 0.006, respectively.

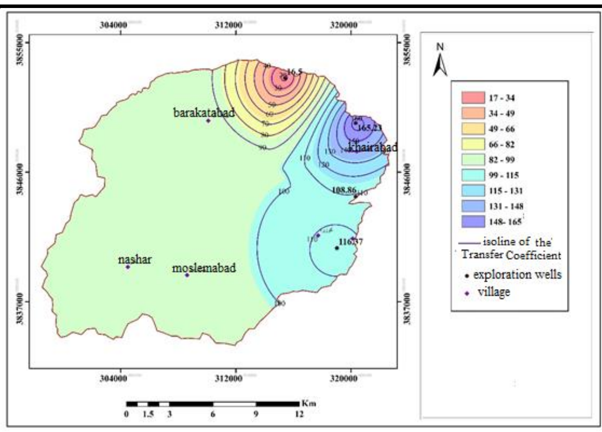

Fig. 7. The contour map of the study basin transfer coefficient

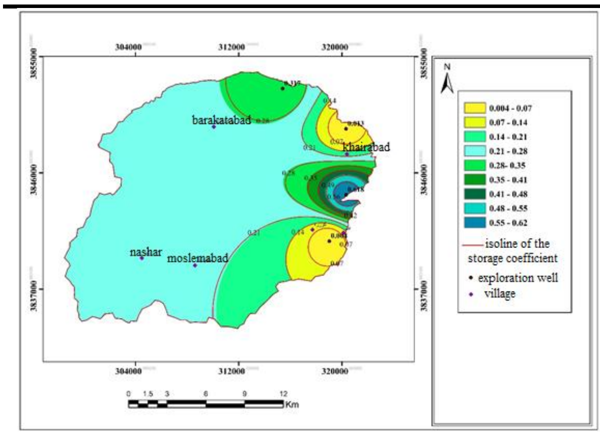

Fig. 8. The contour map of the basin storage coefficient of the study basin

3.2. Qualitative assessment of groundwater resources

The purpose of this study was to identify and evaluate the quality of groundwater and evaluate its water resources in terms of its potential uses in different sectors, including agriculture, drinking, and so on. Water quality was determined by several factors and indices, i.e., sulfate, sodium, calcium, carbonate, and bicarbonate, as well as SAR, TDS, EC, and pH values. The locations of the points where the samples were taken for the qualitative analysis of water resources are illustrated in Figure 9.

Table 5. The hydrodynamic coefficients of exploration wells in the study area

Exploration Well	Names	Utm_x	Utm- y	Storage coefficient	Transmissibility (m2/day)	Alluvium thickness (m)	Storage volume (million cubic meters)	Area(km2)	Saturation thickness
p1	Khairabad	320320	3869608	0.013	165.23	160	40.25	22.6	137
p2	Gharb dashteh	315611	3852525	0.317	16.5	130	270.12	26.3	32.4
p3	Khemajin	319026	3860716	0.006	116.37	85	5.58	28.49	49
P4	Janb kjairabad	320323	3866300	0.618	108.86	85	666.35	16.55	63

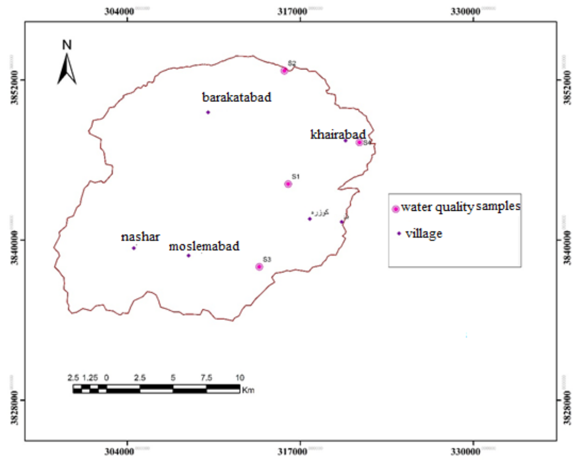

Fig. 9. The position of water quality samples in the study basin

3.2.1. **Classification of Drinking Water Quality based on Schuler Diagram**

The quality of drinking water is of particular importance, and drinking is one of the most urgent uses of water presented by Schuler. In this diagram, the element contents of water (Table 11) are linearly aligned on axes in terms of their quantities in one of the moderately good, acceptable, completely inappropriate, and completely inappropriate good ranges, and it is non-drinkable. According to the Schuler diagram for the studied basin, the range is generally from acceptable to moderate.

The water quality for drinking in terms of hardness is given in Table 12 and the percentages of each class of drinking water in Table 13. According to this classification, most of the elements in the studied samples fall within the acceptable and moderate range.

Table 12. Water quality in terms of hardness

Water quality based on total hardness	Total hardness	Temporary hardness	Permanent hardness	Abbreviation
Complete hardness	671.05	671.05	0	S1
Complete hardness	662.68	662.68	0	S2
Complete hardness	760.55	760.55	0	S3
Complete hardness	790.57	790.57	0	S4

Table 13. Percentage of each Schuler classes in the Total Area

Water classification	TDS	TH	Na	Cl	So	TDS
good	0	0	0	50	50	0
acceptable	25	25	75	25	50	25
moderate	75	75	25	25	0	75
Non-suitable	0	0	0	0	0	0
Totally unpleasant	0	0	0	0	0	0
Non-drinkable	0	0	0	0	0	0

3.2.2. Water quality classification for agriculture based on Willcox diagram

Irrigation is the most beneficial of all the various uses of water that cause the use and development of water. Water quality assessment for irrigation purposes should be carried out in conjunction with the multifaceted effects of soil, plant, and climate types. One of these classifications is the Wilcox Diagram presented in 1968. In this classification, there are two factors of electrical conductivity and SAR each of which is divided into four parts, ultimately dividing the water quality into 16 groups (Table 14). Equations for the lines dividing the Willcox diagram are as below:

Table 10. The location of the collected water samples and chemical properties in the study basin.

	X	Y	SAR	PH	EC	Total dissolved solids
S1	316095	3866205	39.07	7.2	2190	1667.3
S2	315806	3852698	30.13	7.3	1362	898.92
S3	313926	3837998	26.38	6.73	2050	1373.5
S4	321656	3867325	67.63	7.85	3117	2088.39

Table 11. Chemical components of water quality for the samples (Province regional Water organization)

MEq/l									
Water resource	Carbonate	bicarbonate	Cl	Sulfate	anions	Na	Mg	Ca	cations
S1	0	11.1	6.2	6.5	21.8	8.69	5.6	7.9	22.26
S2	0	7.7	2.5	3.06	13.26	6.02	3.5	5.8	13.36
S3	0	15	2.7	2.3	20	6.95	6.3	9	20.25
S4	0	11	10.5	8.6	30.1	16.5	6.2	9.7	30.6

$$S = 63.75-8.87 \text{Log } C \quad (3)$$
$$S = 31.31-6.66 \text{ Log } C \quad (4)$$
$$S = 18.87-6.66 \text{ Log } C \quad (5)$$

where *S* represents SAR and *c* denotes EC.

Table 14. Different water quality classes

Water quality class	Water class
The first group is very good waters where the EC is less than 250 μd/cm	C1S1
Good quality water	C2S1-C2S2-C1S2
moderate quality water	C3S3-C1S3-C2S3-C3S1-C3S2
Non-suitable water	C1S6-C2S6-C3S6-C6S6-C6S1-C6S2-C6S3

According to the Willcox diagram, the samples studied are classified by water quality for agriculture (Table 15). According to the water class classification table for agriculture, the study samples are of average quality (Table 16).

Table 15. Water quality for agriculture

Water Classes	Ec	S.A.R	Samples
C3-S1	2190	3.36	S1
C3-S1	1362	1.86	S2
C3-S1	2050	1.78	S3
C3-S2	3117	5.16	S6

Table 16. Percentage of each class of the Wilcox studied samples

C1				C2				C3				C6			
S1	S2	S3	S6	S1	S2	S3	S6	S1	S2	S3	S6	S1	S2	S3	S6
0	0	0	0	0	0	0	0	75	25	0	0	0	0	0	0

4. Conclusion

The increasing over-abstraction of groundwater resource abstraction has led to the decline of groundwater levels in many parts of the world, including Iran, leading to many aqueducts and other dry and saline water resources in groundwater aquifers. Continuing this trend also has other adverse consequences, such as a decrease in the quality of groundwater resources, higher abstraction costs, and the loss of underground reservoirs due to land subsidence. Most of Iran's underground water is extracted from alluvial sources and some of them can be replaced by artificial feeding methods. Using timely floods and applying flood propagation methods for artificial nutrition in addition to aquifer hydration also reduces flood damage and soil conservation. The results of the survey of water-level statistics during the 15-year statistical period (2001-2016) show that the water level is about 10 m in the northern wells of the area, more than 15 m in the eastern part of the area, and about 65 m in the southern part around Moselm Abad. This evidence indicating the largest drop in water levels in the area, which may be due to the wells being congested and untreated groundwater abstraction. Based on hydrographs for the 15-year statistical period (2001-2016), the results show that there is, on average, a 1.7-meter drop in annual water level in the study area, given the trend that exists. The region's aquifer will decline further from the east. The most appropriate way to compensate for the decrease in reservoir volume, especially in the eastern part of the plain, is to use artificial feeding along with a ban on increased abstraction. The results of the qualitative part show that according to the Schuler diagram for drinking water quality, it is mainly in the acceptable to moderate range. Also, according to the Willcox diagram, water samples are classified as medium quality. Finally, it can be concluded that the results of the study of geohydrological parameters in the studied basin are applicable like hydrodynamic coefficients and water quality parameters, and they can be used to locate proper artificial recharges.

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