Available online at http://www.csjonline.org/

The Caspian Sea Journal
ISSN: 1578-7899

Volume 10, Issue 1, Supplement 4 (2016) 538-548

The Assessment of Groundwater Resources for Irrigation by Water Quality Indices (Case Study, Ghazvin Plain, Northwest of Iran)

Homayoun Moghimi
Geology Department, Payam-e Noor University, Tehran- Iran,
Email: homayounmoghimi@pnu.ac.ir

ABSTRACT– In this paper, groundwater quality index of Ghazvin plain for agricultural applications was used by examining statistics of 42 exploitation wells chemical analysis, in two water years, 2003-2004, and 2013-2014, as two average periods. Chemical analysis included the major anions and cations, pH, EC, TDS measurements and agricultural parameters such as SAR, % Na, etc. calculated from chemical equations. Parameters were compared with existing standards and then quality indices were calculated. In this study, impact of hydro-climate factors, human activities, geology and chemical reactions between water and rock on quality and quality index of groundwater was evaluated. According to the results, about 23 percent reduction in rainfall led to reduce water recharge and penetration into the aquifer. Indiscriminate withdrawal of groundwater also has caused a drop in water table and has reduced volume of the aquifer and hydraulic gradient. As a result of chemical reactions and dissolution of halide and gypsum sediments, as well as weathering, density is increased. This has caused movement of brine in the outer area of the plain towards the middle sections. A combination of these factors indicates that water quality index in the water year 2003-2004 had relatively worse situation than water year 20013-20014. Due to the importance of Ghazvin Plain in terms of industrial and agricultural applications, this is necessary that water resource managers (surface and groundwater) deal more seriously to protect these resources with firmly proper implementation of the laws. Otherwise, there will be no water for consumption in the not too distant future.
Keywords: Ghazvin plain, WQI-WHO, iso-quality index map, Wilcox zoning map

Introduction

Water as a renewable resource is the key element of sustainable development. Now the future of water in the world, and particularly in Iran is very critical. In recent decades with the increase in the population, water demand in different sectors (agricultural, industrial, and drinking water) has put a lot of pressure on groundwater resources (Khanduzy,2005). Due to The geographical location of Ghazvin Plain and its economic and social importance, it has had always high water demand. Locating in a semi-arid to arid region, low rainfall with heterogeneous distribution and high evaporation has caused water shortages in the region. Due to the shortage of freshwater resources shortage, indiscriminate withdrawal of surface water and groundwater resources in the past forty years and on the other hand, due to population growth, industries and increasing the cultivated lands, large amounts of pollution sources (natural and synthetic) are mixed with the water. These factors could reveal the importance and sensitivity of environmental issues that directly affect socio-economic status, more than ever. Several methods have been proposed in different parts of the world to assess the quality of water resources (surface and groundwater) and impact of these factors. Water quality index is a very useful tool to determine water quality conditions for different uses and needs to have basic water data and its related issues, like the other methods (WHO,2008). Water quality index is used for drinking and agricultural uses to determine its suitability with different indices. In this regard, the water quality index was proposed by Horton (1965) for the first time and then very useful and supplementary equations were proposed by Brown et al. (1970) for development of quality index. In this method, by giving weight to each of the measured parameters and providing cumulative function, water quality parameters would be measurable. Quality index assessments could be summarized in three stages; optimal selection of sampling location, statistics standardization, and finally, section of parameters aggregation method. Studies have been conducted on water quality index that could be mentioned as follows:

Judavi and Zare (2009) conducted a study on introduction of groundwater quality index (GQI) to assess the groundwater quality for drinking water purposes in Feizabad plain (KhorasanRazavi). They showed that the index is very efficient for evaluating groundwater quality for drinking uses and changes in its location via GIS. The results obtained from these changes are due to the aquifer geological characteristics and impact of the bedrock and entrance of desert saline waters. Rezaei et al. (2010) conducted a study entitled "Examination of changes in location of some water quality indices of Gilan province's groundwater using geo-statistics." The results showed that SAR of groundwater is good in the entire province, but EC is low in central areas to east adjacent sea and it can put at risk stability of rice in these areas. Yusefzadeh et al., (2013) conducted a study entitled "An assessment of Khurram Rood river water quality in Khorramabad using the Water Quality Index (NSFWQI) and zoning it using the geographic information system (GIS)" and they showed that NSFWQI is a good index to determine effects of pollutants on the river. The mean values of the studied index at various stations provide good conditions for decision-making about monitoring and control of the river water pollution and its effective use in various applications. Shweta Tyagi et al. (2013) studied concepts of water quality parameters for water quality assessment. They compared different methods of qualitative indices and presented their advantages and disadvantages. They finally suggested that in addition to carefully selection of the method, one can evaluate the desired method using qualitative indices and calculate vulnerability of waters from the proposed equations. In addition, they provided methods and equations to researchers so that they can invent and develop their selected or preferred method according to available data and environmental conditions. Dashtibarmaki (2014) conducted a study entitled "Evaluation of Groundwater Quality Index (GQI) in the Lenjanat aquifer using Geographic Information System" and prepared land use map of the region by quality index mapping. Accordingly, along the Zayande Rood River which covers the rice paddies quality reached the lowest level and showed that the optimum index factor method enables us to select the best combination of parameters for groundwater quality variability. Salehi et al. (2014) examined quality of groundwater for drinking and agriculture, and selection of the most appropriate spatial interpolation method (Case study: West of the Marivan city), The results showed that the groundwater is within the acceptable range in terms of quality for drinking and in appropriate range in terms of quality for irrigation. Also different interpolation methods, the locally method estimator for SO4 parameter, concentration of dissolved solids and salinity, radial functions for parameters Na and SAR, common estimator method for cl, and simple kriging method for toughness parameter had the most appropriate annual estimation. Abesi et al. (2012) studied on development of groundwater quality index in Ghazvin province. Qualitative indices were analyzed using simple multivariate method and condition and distribution of the index were evaluated by drawing Iso-index maps near the mineral waters. Assessment showed that the groundwater quality parameters were close to the mineral waters qualitative parameters and thus the maps showed very important points in terms of planning and management of water resources. Research objectives included study of effective factors including geological formations, hydro-climate, and human activities on groundwater uses of Ghazvin plain and assessment of changes in the quality indices in terms of agriculture and comparing the results with the multivariate statistical methods and then drawing thematic and spatial maps to determine status of the Ghazvin plain qualitative indices.

Geography and Geology of The Study Area

Ghazvin is located between 49° -10´ to 50° -40´ E and 35°- 20´ to 36° -30´ N. According to longitude and latitude, Ghazvin basin has an area of 9376 km^2, but the case study was the alluvial plain with an area of about 5534 km^2. Quaternary sediments covered most of the plain. The minimum and maximum elevations above sea level are respectively 1100 and 2971 meters. This region is adjacent to Shah Rood basin in the north, Abharrood, and Kharrud basins in the west, Shoorchay, Qarebolagh, and Qarechay Rivers in the south, and Kordan and Karaj basins in the east (Fig.1).

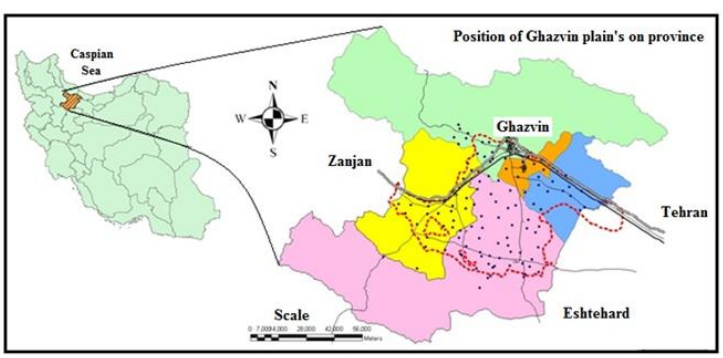

Figure1. Geographical location and exploitation wells in the Ghazvin plain

According to the meteorological statistics, the 10-year average temperature was about 17°C, the average actual evapotranspiration was about 185 mm, and the average precipitation was 309.4 mm. In water years 2003-2004 and 2013-2014 the averages were measured respectively 360.5 and 280 mm. As you can see, rainfall dropped by about 22.5% and this reduction is one of the most important factors in the groundwater qualitative and quantitative changes (IMO, 2015). Geographical location and elevation changes in the case study area have caused different climatic diversities. Accordingly, large parts of the area have cold arid conditions and marginal sectors have semi-arid -cold climate and humid climate prevails in northern sections. About 71 percent of the rainfall in the case study area converts to evaporation, 7 percent to transpiration, and the rest converts to the runoff. Ghazvin plain unit hydrograph in the interval of 2003-2013 shows that the water table has dropped by about 1.7 m and an average of about 37.1 m decline per year is observed in groundwater level at this interval. According to the inventories conducted by the Regional Water Organization of Ghazvin (2009), from 1966 to 2008, the amount of harvest is increased four times (from 400 to 1644.25 MCM). About %86 of this amount belongs to agriculture and the rest of it belongs to drinking (%6.4), industry (%2.1), and other purposes. The importance of Ghazvin plain in terms of agriculture, industry, and urbanization has caused a rapid population growth over the past 40 years. This issue has caused improper harvests and along with drought, human activities (urban, rural, and industrial sewages) and pollutants have put a great pressure on aquifer in terms of quantity and quality.According to the type of alluvial deposits in the feeding area (north-north west), that are commonly coarse grains, fans are formed with a thickness of 300 meters. To the discharge area (south east) the grains become finer and their thickness is decreased. In such circumstances, a significant aquifer is composed of good groundwater resources. In general, in Ghazvin Plain fan lands, groundwater depth is over 100 meters that is decreased to less than 15 meters toward the coastal plain. Groundwater flow in the plain is directed from the north west-west to the south east-east in accordance with the plain topographic slope (Fig.2, right). In terms of geology, Pre-Cambrian to Neogene outcrops can be seen in the Ghazvin plain basin heights and the plain is covered by Quaternary sediments mostly. In northern highlands (west to east) limestone, dolomite and marl deposits can be seen in abundance but the Ghazvin plain is mostly formed of Quaternary alluvial sediments including terraces and old and new fans, clay-silty pans with salt (Qc, Qt1, Qt2, Qms, Qsc) and gypsum (discharge area) sediments, upper red formation including conglomerate, gypsum marl, marl, and sandstone that occur in the southern region of Ghazvin plain and reduces quality of groundwater resources (Miocene-Pliocene) (Ms) along with volcanic activities (tuff, andesite, basalt) shale, Karaj formation limestone (Eocene, Ek) and plutonic such as granite and granodiorite masses (after Eocene) (Fig.2, left).

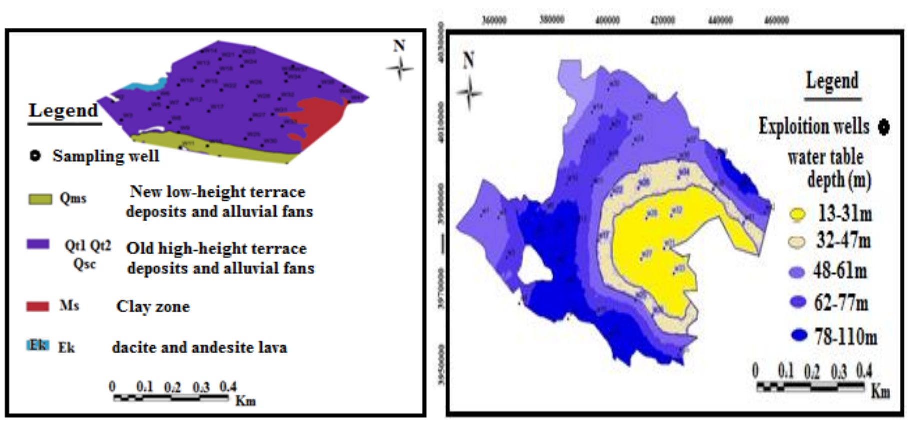

Figure2 .Map of the groundwater depth (right) and geological map of Ghazvin Plain (left)

Materials and Methods

In this study, in addition to geological, hydro-geochemistry and hydro-climate data, chemical analysis of water samples obtained from 42 exploitation wells in water years 2003-2004 and 2013-2014 were used and evaluated based on average of the water years. Analysis of water samples includes measurement of concentrations of main cations and anions and the parameters such as EC, T.D.S, ph. Hardness, alkalinity and irrigation parameters including sodium adsorption ratio (SAR), sodium percentage (%Na), residual sodium carbonate (RSC), soluble sodium percentage (SSP) magnesium hazard (MH), the Kelly index (KI) and permeability index (PI) were calculated through chemical relationships. Analyses were tested based on the methods described by Iran Industrial Standards Institute (2009), Ministry of Energy (1988) and WHO (2008) (Table1) and the standard values of the parameters were a combination of different standards (Table2). In table3, descriptive statistics of the minimum, maximum, and average parameters are provided.

Table 1 .The method of measuring elements and substances in groundwater

Method	**Elements and materials**	**Method**	**Elements and materials**
Portable field device	**EC,TDS**	**Atomic absorption spectrometry**	**Magnesium, sodium and potassium**
Portable field device	**pH**	**Titration**	**Bicarbonate and chloride**
Titration method	**Calcium hardness, alkalinity**	**spectrophotometer**	**Sulfate**

Table 2. Classification of the defined standards for the study area to determine type of water used for agriculture

Classification	**Standard**	**P**	**Classification**	**Standard**	**P**
Very good-good	**>20**	**%Na**	**C1(low)excellent**	**<250**	**EC((µS/cm)**
Good-allowed	**20-40**	**(Wilcox, 1955)**	**C2(medium) good**	**250-750**	**(Todd, Meys, 2005)**
Allowed-doubtful	**40-60**		**C3(high)allowed**	**750-2250**	
Doubtful-unsuitable	**60-80**		**C4(very high) unsuitable**	**2250-5000**	
Unsuitable	**>80**		**C5(very high) unsuitable**	**>5000**	
Suitable	**>1.25**	**RSC**	**S1(low) excellent**	**<10**	**SAR**
At the limit	**1.25-2.5**	**(Richards,**	**S2(medium)good**	**10-18**	**(Todd& Meys2005,**
Unsuitable	**<2.5**	**1954)**	**S3(doubtful)**	**18-26**	**Richards,1954)**
			S4(unsuitable)	**>26**	
Good	**<25**	**PI(%)**	**Suitable for drinking**	**>500**	**TDS(mg/l)**
Suitable	**25-75**	**(Doneen,1964)**	**Acceptable for drinking**	**500-1000**	**(Todd, Meys, 2005)**
unsuitable	**>75**		**Useful for irrigation**	**1000-3000**	
			Unsuitable for drinking andirrigation	**>3000**	
Suitable	**>1**	**KI**	**Good**	**0-40**	**SSP**
Unsuitable	**<1**	**(Kelly, et al**	**Acceptable**	**40-60**	**(Wilcox,1955)**
		1940)	**Doubtful**	**60-80**	
			unsuitable	**>80**	
			Suitable	**>50**	**MH (%)**
			Unsuitable	**<50**	**(Wilcox,1955)**

Table 3. Statistical information of chemical analysis of selected sources in Ghazvin plain (amount of element and, TDS (mg/l) and EC (μS/cm) for water years 2003-04 and 2013-14) (Regional Water Authority of Ghazvin 2015)

P		Min	Max	Mean		Min	Max	Mean
EC	(2013-14)	432	6523	1657.5	(2003-04)	358	4256	1526
TDS		257	4090	1035.5		230	2724	976.6
pH		7.3	8.1	7.67		7.25	9.68	8.23
Ca		11.2	307.2	80.4		10.6	211.4	66.1
Mg		9	198.4	49.7		4.32	84.9	35.7
Na		23	1030.4	188.5		23.7	530.8	198.5
K		0.78	9.36	2.15		0.78	25.3	3.36
HCO3		89	486.7	241.8		97.6	372.1	223.4
Cl		20.9	1605.3	255.3		10.6	1150.2	221.1
SO4		19.6	919.6	252.1		12.4	772.8	227.4
TH		74.4	1227.8	405.8		44.2	791	312.5
Alk		24.9	1039.7	208.2		73.8	340	199.7
SAR		0.64	12.5	3.95		0.74	9.78	5.03
%Na		17.6	73.5	49.6		21.6	87	58.2
RSC		-20.1	2.94	-4.2		-14.3	3.77	-2.62
KI		0.2	2.76	1.12		0.27	6.65	1.74
MH		28.5	72.5	51.2		28.9	67.9	45.9
WQI		48.2	275.7	95.6		62.8	265.7	142.7

Hydro-geochemical data of 42 wells and their distribution in the case study area presented in figure1 were used to determine water resources quality parameters. To measure quality of groundwater resources in terms of irrigation consumption, various standards, and guidelines were used (Table4). These calculations are based on the desirable level standard (Table4). According to the presented standard in table4, because the level of average sulfate was more than 250 mg/l, the amount of magnesium was selected as 30 mg/l. Agricultural waters are highly variable in terms of concentration and soluble salts. Increased soluble ions in groundwater affect physically and chemically plants and soil and reduce soil productivity. Salinity disturbs absorption of water and food activities from the soil. Salinity is one of the important parameters in determining suitability of groundwater for irrigation (Wilcox, 1955) with indicators such as salinity hazard, sodium absorption ratio, the percentage of sodium, residual sodium carbonate, etc. Sodium is one of the ions that significantly affect quality of water used for agriculture which is used for classifying irrigation water for sodium solution because this ion by reacting in soil reduces its permeability. That's why the values of electrical conductivity and sodium play a critical role in suitability of the irrigation water. High electrical conductivity and salt in water form saline soil. In this regard, the Wilcox diagram was used to determine type of irrigation water. EC, SAR, and salinity hazard values are used in this diagram. As a result, three important parameters are used in irrigation, in a graph. Therefore, there is no need to draw maps of all parameters, and the required data can be obtained just by drawing Wilcox zonation and sodium percentage maps of the irrigation water. In this study, maps of the waters with high amounts of sodium and low amounts of calcium were used in which ion exchange causes sodium saturation, which eventually led to disintegration of clay minerals, and affect plant growth (Todd & Meys, 2005). Sodium hazard is expressed generally as sodium adsorption ratio (SAR) that is the ratio of sodium to calcium and magnesium. High levels of it can lead to formation of an alkaline soil (Table2). High concentrations of carbonate and bicarbonate ions in irrigation water lead to deposition of calcium and magnesium from the soil solution and increased absorbed sodium in clay surfaces that increases sodium hazard. For describing this, an experimental parameter can be calculated as a residual sodium carbonate (Table2). Soil permeability affects long-term use of irrigation water according to the contents of sodium, calcium, magnesium, and bicarbonate of soil. Permeability index (PI) represents suitability of groundwater for irrigation (Doneen,1964) (Table2). Usually calcium and magnesium play balanced role in most of waters. Chemical balance of magnesium in water will have a negative impact on agricultural areas. Paliwall (1972) developed an index called magnesium ratio that measures the effects of magnesium (Magnesium hazard) in irrigation water. Kelly (1940) by measuring amounts of sodium ions and dividing it by sum of calcium and magnesium ions defined an index named Kelly. Given that the sodium element is very important for all uses of water resources, therefore, its amount and percentage has been widely used to evaluate suitability of irrigation water quality (Wilcox, 1955). High sodium amount in irrigation waters causes that sodium in the water be replaced with ions such as calcium and magnesium in the soil. It makes poor, internal drainage of the soil. This relationship is defined as the soluble sodium percentage (SSP). In table 2, table3, and table4, agricultural parameters and their classification are provided with used standard and relationships. Quality indices: Different methods have been devised and presented in different parts of the world to determine the quality parameters using the statistical methods. Horton (1965) was one of the first persons who proposed the water quality index calculated by the weighted arithmetic method (Equation-1).

$WQI_A = \sum_{i=1}^{n} wiqi$ (1)

Brown et al (1970) upgraded Horton's technique to an increased index and calculated quality index using the geometric and cumulative weighted method (Equation-2).

$WQI_M = \prod_{i=1}^{n} qi^{wi}$ (2)

Another method used for calculation of the quality index is the method proposed by the World Health Organization (1993). In this study, according to statistics of the available parameters and the importance of this case study in terms of irrigation water, the weighted arithmetic method was used (WHO, 2008). In this method, at least three parameters are required and based on the importance of each parameter; a weight is assigned to it. Given that this study aimed to determine quality of groundwater resources for agricultural purposes, irrigation water parameters were very important. On the other hand, because of different standards of water use in agriculture, the most weight of the standard was given to these parameters (Table4). The important parameters in agriculture, such as the EC, TDS, SAR, and so on were weighted by five and respectively calcium, magnesium, and potassium had the minimum weight (1). In table4, parameters, the used standard, standard values, weight, and the relative calculated weight are provided. Quality index values were between zero and infinity. Increase in index values leads to reduced quality. The quality index calculation process is as follows:

In the first stage, to determine water quality index in agriculture each of the parameters were weighted according to their importance. In table4, parameters, standards and used equations, the weight given to each of the parameters and the relative weight of each parameter are provided. In this method, sum of the relative weights of parameters must be equal to one. Otherwise, there has been an error in calculations (Nikoonahad, 2009).

Table 4.Parameters and standards used for irrigation and relative weights calculated for each parameter (Standard and Industrial Research of Iran (2009), ISIRI (WHO; World Health Organization, 2008)

Relative weight(Wi)	Weight (wi)	(Standard value) Sd	Standards and relationships	P
0.0684	5	3000	Davis& DeWeist,1966	*TDS*
0.0684	5	2250	USDA classfication	EC
0.0684	4	6.5-8.5(7.5)	WHO,ISIRI	pH
0.0273	2	300	WHO,ISIRI	Ca
0.0273	2	30*	WHOISIRI	Mg
0.041	3	200	WHO,ISIRI	Na
0.0273	1	12	WHO,ISIRI	K
0.041	3	250	WHO, 2008	SO4
0.041	3	250	WHO, 2008	Cl
0.0273	2	150	WHO,IRISI	HCO3
0.0684	4	100	Sawyer& Mc Carty,1967	TH
0.0684	4	200	IRISI	Alkalinity
0.0684	5	26	Todd& Meys,2005,Richards,1954, (Na/$\sqrt[2]{(Ca+Mg)}$	SAR
0.0684	5	40	Wilcox,1955, ((Na+K)/(Ca+Mg+Na+K))	%Na
0.0684	5	2.5	Richards,1954, (HCO3+CO3)-(Ca+Mg)	RSC
0.0684	5	1	Kelly et al, 1940, (Na/(Ca+Mg))	KI
0.0684	5	50	Doneen, 1964, (Mg/(Ca+Mg))	MH
0.0684	5		Wilcox,1955, SSP=[(Na^{+1}+K^{+1})x100]/(Ca^{+2}+Mg^{+2}+ Na^{+1}+K^{+1})	SSP
0.0684	5		Doneen, 1964, PI=[(Na^{+1}+√$HCO3^{-}$)/ (Ca^{+2}+Mg^{+2}+Na^{+1}+K^{+1})]x100	PI
∑Wi=1	∑Wi=73			
*According to the standards, because level of average sulfate was more than 250 mg/l, the amount of magnesium was selected as 30 mg/l(table 2)				

In the next stage, according to the given weights, quality index of groundwater resources in agriculture were calculated as follows:

$\mathbf{Wi} = \mathbf{wi} / \sum_{i=1}^{n} \mathbf{wi}$(Equation-3)

$\mathbf{qi} = \left(\frac{Ci}{Sd}\right) \mathbf{100}$(Equation-4)

$\mathbf{SIi} = \mathbf{Wi} * \mathbf{qi}$(Equation-5)

$\mathbf{WQI} = \sum \mathbf{SIi}$(Equation-6)

Where; (Wi) is relative weight, wi, is weight of each parameter, n is the parameter number, qi is qualitative rate scale (%), Ci is concentration of the parameter, Sd is the standard of parameter (for irrigation), and WQI is sum of the quality indices SIi. table5 shows values and classification of water quality indices.

Table 5.Classification of water quality based on the value of water quality indices (WHO, 1993)

Water Quality Index (WQI)	class	Water quality index (WQI)
less than50	I	Excellent
50-100	II	good
100-200	III	poor
200-300	IV	Very poor
more than 300	V	Unsuitable (for drinking and etc.)

Results

Statistical analysis: According to table2, the ionic frequency aqueous based on data average for two periods of 2003-2004 and 2013-2014 was in the form of Na + K> Ca> Mg, SO4> HCO3> Cl and Na + K> Ca> Mg, Cl> SO4> HCO3, and had not changed in terms of cations, but in terms of anions, sulfate became to chloride. This ionic frequency represents conversion of sodic, calcic sulfate and bicarbonate waters into sodium chloride and sulfate sodium and calcic's waters. It means encroachment of saline water from the outlet to the middle and feeding parts, indiscriminate harvesting, drop in water table and subsequent increase of ion exchange and dissolution of salt and gypsum deposits in Quaternary sediments of the Ghazvin Plain. It means that hydro-climate factors affected (reduced rainfall, increased evaporation), reduction of water table (excessive harvesting) and chemical reactions between geological formations (clay, gypsum, halide) with water and ion-exchange. By increasing amounts of sodium (halide, albite (plagioclase) of ion exchange), chloride (brine geological and water), calcium (lime and gypsum, ion exchange), magnesium (dolomitic, reverse ion exchange), sulfate (gypsum), bicarbonate (weathering of limestone rocks) and potassium (weathering of clay and illite minerals), values of TDS, EC and other parameters (hardness, alkalinity) were increased. With the increase of ions and substances in groundwater, irrigation water parameters were also changed and it led to changes in water quality.

Water Quality Index

Water quality in terms of agriculture: To achieve maximum productivity in terms of agricultural production good water quality is required. Drainage is an important factor in the growth of plants in accordance with water quality. Proper drainage does not stop plant growth even with the use of water with high salinity. For this reason, use of proper drainage is essential to maintain salt balance within acceptable limits. The case study area is one of the most important agricultural and industrial centers in the country which is followed by population density. That's why synthetic and natural factors have a huge impact on the quality of groundwater for agricultural purposes. Artificial factors including entrance of urban and rural sewages, industrial and agricultural wastewater would reduce the quality. Hydro-climate factors are natural and geological factors. Among hydro-climate factors, rainfall is the most important parameter and has an important role in feeding the aquifer and surface flows. Because of approximately 23 percent reduction in rainfall in the two periods, penetration rate was also dropped sharply. Because of reduced precipitation, improper harvest of the aquifer was increased and water table was dropped sharply. In this condition, geological factor reduces quality of surface water and specially groundwater due to various chemical reactions (existence of limestone and dolomite formations, volcanic (andesite, basalt) and internal (granite) activities, salt and gypsum layers, pan of clay, silt and the clays which are weathering products). For this reason, suitability of water for irrigation, is the assessment that determines the level of some parameters such as; SAR, EC, TDS, RSC, % Na, etc.

In table2, table3, and table4 descriptive statistics, classification and standard parameters used in the irrigation water are provided. In most relationships sodium ion plays a major role in various classifications. Because of the importance of sodium concentration in irrigation water, in the case of being high, this ion reacts with the soil and reduces permeability and it will lead to develop an alkaline and hard soil. In this regard, according to the ionic frequency, water produced every two water years on average data (Table2) in terms of cation has not changed and sodium + potassium are more than calcium and magnesium, and the dominant anion changes of SO4> HCO3> Cl to the Cl> SO4> HCO3 that role of waters such as sodium chloride, calcium sulfate and finally bicarbonates could react with soil and left their devastating effects. Given the direct relationship with the sodium absorption by soil salinity, Agricultural Institute of America Salinity Laboratory (Todd & Meys, 2005) defined sodium absorption ratio (SAR) (Table4). In this connection, SAR, in fact, is use of the EC changes in accordance with sodium content or alkaline hazard. So waters used in irrigation can be classified into groups, classes and show in form of charts Wilcox based on the amount of salt (C), the risk of sodium (S) (alkali) and sodium adsorption ratio (SAR), compared to the rate of change of EC. Wilcox change percentage is presented in table6 for two water years and ten years average. In this study, using the classification table2, the spatial and temporal changes map of irrigation purposes is drawn (Fig.3). As seen in table6 and figure3, in tree ranges reached from water years 2003-04 to 2013-14 respectively from %21.4 to %23.8 (slightly salty, suitable) increase and within the limits of passion and usable in agriculture from 66.6 to %47.6 has dropped. Too salty and unsuitable range from %11.8 to %28.4 has increased. As seen in map of figure3, during the past ten years, range of nutrition (North West) to discharge (South-South East) in line with the groundwater, quality in terms of agriculture has become relatively worse. It's most important reasons can be reduction to 23 percent of rainfall, interpretations harvesting of the aquifer (a drop in average annual 1.37 meters) and dissolving the salt and gypsum formations in the discharge of saline solution up the middle parts plain. These changes are clearly visible in figure3 and in output range; the quality of water is very salty and unsuitable for agriculture.

Table 6.Number and percentage of samples from Ghazvin Plain of Wilcox diagram

Year of sampling	Classification	Number of samples (%)	Ranges
2003-04	**C2S1, C2S2 C3S1, C3S2, C3S3 C4S1,C4S2,C4S3**	**7(16.66), 2(4.76) 11(26.2), 5(35.71),2(4.76) 1(2.3),2(4.76),2(4.76)**	**Slightly salty, suitable Salty, usable Very salty, unsuitable**
2013-14	**C2S1, C3S1,C3S2 C4S1,C4S2,C4S4**	**10 (23.8) 19(45.23),1(2.38) 1(2.3),10(23.8),1(2.3)**	**Slightly salty, suitable Salty, usable Very salty, unsuitable**

Sodium percentage of irrigation water is one of the most important agricultural parameters and its high level is an Inhibiting factor and when sodium increases in irrigation water, it is absorbed by clay particles and causes the distribution of calcium and magnesium ions. This ion exchange will include results such as reduced permeability and poor soil drainage. In table2, table3 and table4 standard classification and the relationship of sodium percentage and its map are presented in figure4. As we can see, situation of groundwater resources in a relatively worse and the suspected poor range encompass a large part and good range passable has dropped. Long-term use of irrigation water usually affects the permeability of the soil and the soil content such as calcium, sodium, magnesium and bicarbonate will be affected. Doneen (1964) created a criteria for the evaluation of water used in irrigation, which he named permeability profile and in table2 are it is presented and classified. In the event of further concentration of bicarbonate and carbonate than calcium and magnesium, the conditions are created for sedimentation (calcium and magnesium) carbonates. RSC amount is in fact characteristic of these effects and the remaining of sodium carbonate is used to detect the status of irrigation water (Table2) (Richards, 1954).

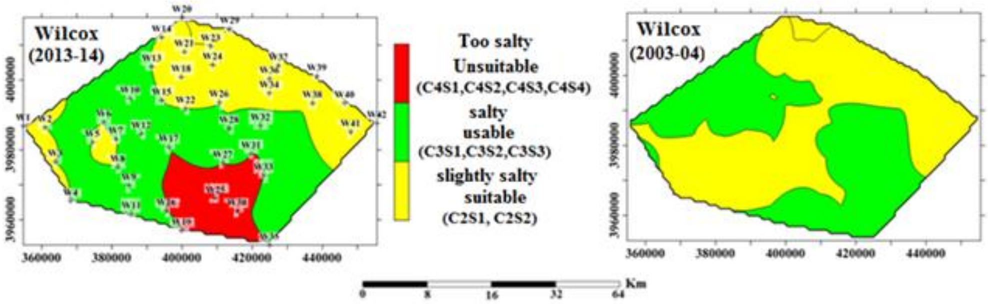

Figure 3. Ghazvin plain's groundwater zoning map of agricultural by Wilcox's classification

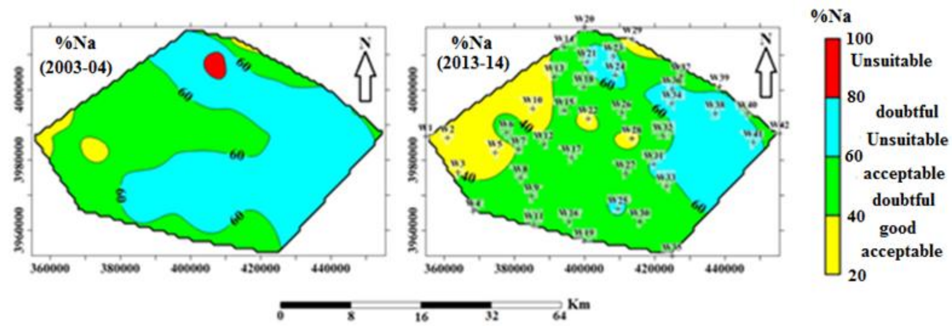

Figure 4. Map of %Na in study area for the two water years (2003-04 and 2013-14)

Analysis of ions and substances in groundwater along with determine agricultural parameters can be effective help to determine groundwater quality parameters in terms of irrigation water. For this purpose, using groundwater analysis, the most important parameters in agriculture and drawing its maps, groundwater quality index is calculated in terms of irrigation and by comparing them with each other, groundwater quality could be identified. Thus, the factors affecting these parameters can be ascertained and could be confirmation the selected method for determine the quality index. Qualitative indicators selected wells Ghazvin Plain by the World Health Organization over two water years 2003-04 and 2013-14 are calculated and the results are presented in table6. Water quality index based on irrigation water standards presented in table4, was calculated. Quality index for every 42 wells separate elections is calculated and the spatial and temporal changes map based on the values depicted in figure-5 is drawn. As seen in table6 and figure5, in these two water years drastically changed was not very high but groundwater resources quality have gone towards the worse. In water years 2003-04 the good ranges are all gone and have become the area poor and very poor.

Table 7 .Classification of water quality groundwater for years, 2003-04, and 2013-14 Ghazvin (WHO, 1993)

WQI	Class	Quality	Well No: (%) 2003-04	Well No: (%) 2013-14
>50	I	Excellent	(0)…	(0)…
50-100	II	Good	1,5,10,22,28,29,37,42(19)	1,29(4.76)
100-200	III	Poor	2,3,4,6,7,8,9,11,12,13,14,15,16,17,18,19,20,21,23, 24,25,26,27,29,30,32,33,34,35,36,38,39,40,41(78.5)	2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19, 20,21,22,26,28,30,31,32,33,34,35,36,37,39,40, 41,42 (83.33)
200-300	IV	Very poor	31(2.3)	38,27,25,24,23(11.9)
<300	V	Unsuitable	-- (0)	-- (0)

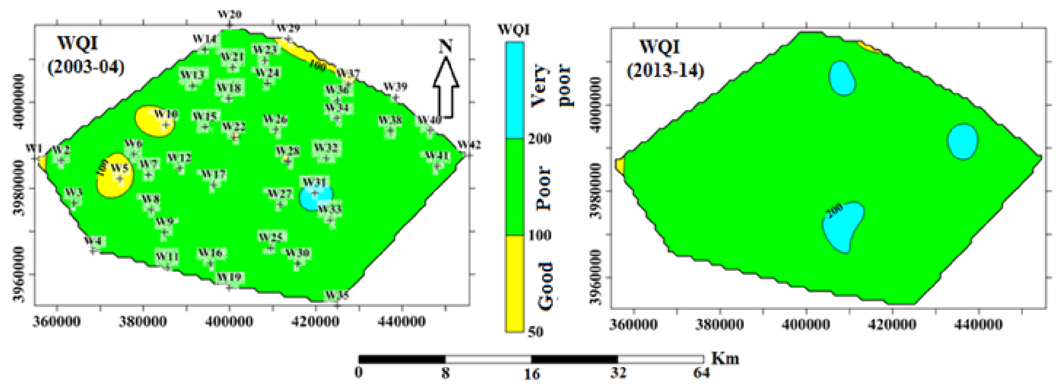

Figure 5 .Map changes when quality index (WQI) Ghazvin Plain groundwater in agriculture

To evaluate and compare the parameters of irrigation water quality index, more than three classified mapped Wilcox and the percentage of sodium are used. Because Wilcox covered three parameter maps classified as EC, SAR and sodium hazard that comes with levels of sodium covers a large part of agricultural parameters. In this comparison decreased precipitation, irregular withdrawals from the aquifer and water level drawdown as variable parameters given special attention. But geological factor is expressed as fixed function, can be effective. Accordingly in water years 2003-04 almost all of the study area in Wilcox zoning map is applicable to agriculture Most sodium in the map of the acceptable range includes good water for use in irrigation somewhat suspicious covered and no problem. The majority of the study area in map is in the poor category of quality index and small area is covered nice and very poorly. In water years 2013-14 as could be seen in the Wilcox zoning map, output range of plain, water from high salinity profile and inappropriate has advanced to the middle parts of the plain. Then it is in the middle salted water, usable and in part of slightly salty and proper nutrition. According to factors said Holiday dissolution of sediments and gypsum and water level drawdown and reduction of hydraulic gradient causes that salt solution and geological brines advance into the plain and poor areas increase. Map of sodium percentage in suspected inappropriate range has increased and the appropriate category has been added too and reduces other categories. As a result, irrigation water quality has fallen sharply this year. According to the specifications of these two maps, quality index map is also affected and small ranges good are disappeared and have added to the range of very poor and others are in poor areas. Overall comparing the maps shows the water quality status in water years 2013-14 to 2003-04 has become relatively weaker and worse. If it continues to be so in the coming years, Ghazvin Plain aquifer for irrigation water will not be suitable and due to the high standard of drinking water in terms of drinking and irrigation water will be worse. So we need in terms of water resources management authorities that treat more serious and realistic in order to optimize and rationalize offering water to consumer. At the end we could say that three maps relatively good overlap with each other and selective method is usable to determine the quality index with regard to the parameters and the results obtained with high confidence.

Conclusion

Given that table6, figure5, and figure6 were prepared as comparative, created qualitative differences in the index values in the study area for two water years, indicates several factors are involved in causing these changes. These factors can be summarized in three parts:

Hydro-climate factor: according to statistics of 12years and two water years 2003-04 and 2013-14, the average rainfall has been respectively 311.85, 360.5, and 280 mm. [6]. In the two water years studied, rainfall can be seen in about 23% lower. Reducing the amount of precipitation and surface runoff also reduces the infiltrated water. This problem affects the aquifer feeding directly.

The human factor: Given that this area is one of the most important agricultural and industrial centers of the country, population growth and followed by industrial growth and the acreage growth increase water demand directly. It leads to an improper understanding that results a lot of pressure to the aquifer. The water table has dropped by indiscriminate harvesting so that in the study area during the last ten years, the annual average has dropped 1.37 meters. It also creates another problem, it causes a sharp drop in the water table, reducing the hydraulic gradient and reducing the size of the tank, and not replacing void volume causes subsidence within the aquifer. On the other hand, urban and rural sewages along with industrial and agricultural sewages absorbed mostly directly through absorbing wells are dumped into the ground. This is one of the most important pollution factors and quality reduction that causes reduction of the quality index.

Geological factors: geological formations are one of the most important factors in water quality changes (surface and underground). There are different formations in the study area which by chemical reactions between water and sediments bring a lot of different ions into the groundwater. The calcareous sediments, dolomite and marl that exist in the north and northwest of the study area, are dumped large amounts of calcium and magnesium and bicarbonate into the water. On the other hand Holliday deposits, gypsum and clay and dissolving them, bring large quantities of sulfate, sodium, calcium into the groundwater. As a result of weathering of rocks also a large quantities of different ions are imported. Complex chemical reactions have caused increasing hardness, alkalinity, TDS and EC significantly. These parameters increase directly affect the increase in agricultural parameters. Due to the presented factors and in the future due to population growth and increase the urban areas the demand for drinking water will increase. Due to population growth, economic growth that are a collection of industrial and agricultural growth, the amount of water used in agricultural and industrial sectors will increase too. The combination of these factors and to water consumption balance and available water volume, administrators need a firm decision about how to use water resources (surface and underground) impose applicable laws so that protect resources.

References

1. Abessi, O., Saeedi, M., Sharifi, F. Meraji, H. [2009] Development of groundwater quality index, Environ Monit Assess, DOI 10.1007/s10661-009-0837-5, Springer Science + Business Media B.V.
2. Brown, R.M., McLelland, N.I., Deininger, R.A. and O'Conner, M.F., 1972. A water quality index- crashing the psychological barrier, indicators of environmental quality.
3. Dashtibarmaki, M., Rezaei, M.,Nasrsaberi, A.[2014] The assessment of groundwater quality index (GQI) in the Lenjanat aquifer using the GIS, Journal of Engineering Geology, Volume VIII, Number 2.
4. Doneen, L. D. [1964] Water quality for Agriculture, Department of Irrigation, University of California, Davis, 48 pp.
5. Horton, R. K. [1965] An index number system for rating water quality, Journal of Water Pollution Control Federation, 37(3), pp. 300-306
6. Institute of Standards and Industrial Research of Iran [2009] Physico-chemical characteristics of water (Standard Number: 1053), Fifth Edition, pp. 1-18
7. Iran Meteorological Organization (IMO) [2015] Meteorological data parameters
8. Judavi, A., Zare, M. [2009] Introduced GQI index to assess the quality of groundwater for drinking water purposes, the twenty-seventh Meeting of Earth Sciences, Tehran-Iran.
9. Kelly, W.P. [1940] Permissible composition and concentration of irrigated waters, In: Proceedings of the ASCF66. P: 607
10. Khanduzy, G., PariZanganeh, A., Zamani, A., Dadyan, S. [2005] to investigating groundwater quality and hydro-geochemical health of Ramian city of Golestan province, Journal of Research in Community Health, 1 (3): 52-41.
11. Ministry of Energy, [1988] Water quality standards, and design standards water country, Issue 4999, pp. 1-18.
12. Nikoonahad, A., Moazed, H., Kazembeygi, F. [2009] Water quality indices to choose the best indicator of Karun, Iran Water Research Journal, Issue 4, pp: 69-73.
13. Paliwall, K.V. [1972] Irrigation with saline water [z]. Monogram No. 2(new series). IARI, New Delhi, p 198.
14. Regional Water Authority of Ghazvin, [2015] Statistics measuring the water level observation wells, chemical analysis and other information contained in the report shot
15. Rezaei, M., Davatgar, N., Tajdaran, K., Abolpour,B. [2010] The spatial distribution of some water quality indices in Gilan province using geo-statistics, Journal of Soil and Water, Volume 24, Number 5.
16. Richards, L. A. [1954] Diagnosis and improvement of saline and alkali soils, U.S. Department of Agriculture, Hand Book 60, p.160.
17. Salehi, H., Zaynivand, H. [2014] Check the quality of underground water for drinking and agriculture, and select the most appropriate spatial interpolation method (Case study: West of the city of Marivan, Kordestan province), eco-hydrology Journal, Volume 1., Number 3. pp. 166-152.
18. Shweta Tyagi, B. S., Prashant Singh, RajendraDobhal, Water quality assessment in terms of water quality index, American Journal of Water Resources, [2013] Vol. 1, No 3, 34-38, DOI: 10.12691/ajwr- 1-3-3, http://pubsSciepub.com/ajwr/1/3/3.
19. Sawyer, g. N. and McCarty, D. L. [1967] Chemistry of sanitary engineers, 2nd edn, McGraw Hill, New York, 518 pp.
20. Todd, D.K., and Mays L.W. [2005] Groundwater Hydrology, John Wiley& Sons, New York, 535p.
21. Yousefzadeh, A., Shamskhoramabadi, G., Godini, H.R., Husseinzadeh, A., Safari, H. [2012] Check the quality of river water Khorramabad Khorramabad River Water Quality Index (NSFWQI) and Zoning with Geographic information system (GIS), Journal of Lorestan University of Medical research, Results, Volume XV, Issue 5, Pub. 58.
22. Wilcox, L. V. [1955] Classification and use of irrigation waters, USDA, circular 969, Washington DC, USA.
23. WHO, [2008] Guidelines for Drinking-Water Quality, Second addendum, Vol. 1, Recommendations, -3rd ed., ISBN 9789241547604, pp. 1-515
24. World Health Organization (WHO) (1993) International Standards for drinking Water Quality, 4th edition. ISBN: 9789241548151