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The effect of salt basins on the trend of groundwater quality changes in the surrounding basins (case study: Tabriz plain, northwest of Iran)

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ABSTRACT

Urmia Lake is one of the most important inland water bodies in Iran and Tabriz plain which is located in the northwest of Iran. In the last decade, the average water level of this lake has been reduced, and since the Urmia Lake and surrounding groundwater of this lake are related to each other, surveying the changes in the quality and quantity of these water resources is important. The qualitative parameters (pH, sodium adsorption ratio (SAR), electrical conductivity, Na^+, total dissolved solids, Ca^{2+}, K^+, Mg^{2+}, Cl^-, CO_3^{2-}, HCO_3^-, %Na, and SO_4^{2-}) from about 130 wells of Tabriz plain groundwater were investigated from 2010 to 2015. Data were analyzed using geographic information systems. Modified Mann–Kendall test and the values of trend slope using the Theil–Sen estimator were estimated, and for these tests, the R software was used. Based on the results, water samples have an alkaline face and were Ca^{2+}–Mg^{2+}–Na^+ and Cl^-–HCO_3^-–SO_4^{2-} types and characterized as very hard and brackish water throughout the study period. Based on the results of water analysis, most of the qualitative parameters were over the World Health Organization standard limit. The water of Urmia Lake has decreased and the amount of salinity increased, so changes trending in SAR, Na^+, %Na^+, and Cl^- in the Tabriz plain groundwater indicate that changes in the quality of Urmia Lake have a significant impact on the quality of Tabriz plain groundwater.

Keywords: Groundwater; GIS; UrmiaLake; Mann–Kendall

1. Introduction

Iran is in a dry and semi-arid region and also is in a more unfavorable situation in the average climate of the world. Therefore, groundwater resources in this region are considered as a major source for water use in various economic as well as social and agricultural sectors and as drinking water [1,2].

Groundwater as a part of the 'hydrological' cycle due to their low sensitivity to pollution, compared with surface water and its large storage capacity, is a reliable source of water for human consumption. Since groundwater is less contaminated by waste and organisms, it is preferred for public water supply compared with other types of water. But groundwater is under constant threat of saline water incursion, which seems to have become a worldwide concern [3–5].

Tabriz plain is located in East Azerbaijan Province in the northwest of Iran. The plain is part of the Urmia Lake drainage basin and lies between 45°30'–46°15'E and 37°56'–38°17'0N, which covered about 700 km^2 [3].

Tabriz is a populated region of Iran that large portion of drinking water, domestic, industrial, and agricultural water is supplied from groundwater resources. Overexploitation of groundwater resources in recent years have caused an extensive groundwater level decline in the Tabriz plain aquifer [6].

Protecting aquatic ecosystems and managing water resources in these areas is an important reason for anthropology and climate changes [7].

Different researches showed that dissolution of gypsum, anhydrite, and silicate minerals occurs frequently across the Tabriz plain, whereas the groundwater is supersaturated

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according to calcite and dolomite. Some of the effective ways in the hydrogeochemistry in the study area are including weathering and dissolution of different rocks and minerals, ion exchange, and anthropogenic activities especially agricultural activities [6]. Water chemistry is related to different rocks and their interaction with water as well as impact on human activities which tend to alter groundwater quality. Therefore, the geological characteristics of the area can affect the trending of groundwater quality changes.

In recent years, changes in the quality and quantity of lakes cause changes in surrounding waters and encourage scientists to develop advanced methods for understanding the ecosystems of the lake [8,9].

Urmia Lake with a total surface area ranging between 4,750 and 6,100 km^2 is one of the largest saltwater lakes on earth. The concentration of salt in this lake is high and is one of the most important parts of the waters inside Iran, which plays an important role in the environment and the country's northwest economy [10]. In the past decade, the average water level of this lake has decreased significantly, which has endangered its ecosystem. Since the Urmia Lake water and its surrounding groundwater are related, the groundwater level continues to decrease at current rates, so studding of changes in the quality and quantity of groundwater in planning and managing water resources is important for maintaining aquifer in Tabriz plain, as well as monitoring and protecting groundwater quality [6,11–13]. Therefore, analysis of groundwater qualitative changes in water management is one of the most important threats that affect on decision making in health and the geology of each region.

Most methodologies have been used for assessing variations of groundwater geochemistry. One of this methodologies is geographic information system (GIS). GIS is a computer system for managing spatial data. The geographical term indicates that the position of the data is known or can be known in terms of geographical coordinates (latitude and longitude) and the capability of collecting, logging, processing, transforming, illustrating, typing, searching, analyzing, modeling, and outputting data. An important aspect of GIS is that it simplifies the information used and makes the real world easier [14,15].

Various tests, including parametric and nonparametric tests, have been proposed to determine the trends in meteorological and hydrological time series. Mann–Kendall (MK) tests are among known nonparametric tests used to determine the hydrological variables [11,16].

The aim of this study was to evaluate the quality of groundwater in Tabriz plain and compare water quality with standard limit and the impact of quantitative and qualitative changes of Urmia Lake on the trend of this quality.

2. Materials and methods

2.1. Study area and sampling points

The Tabriz area is one of the most industrialized areas in the northwest of Iran. Tabriz plain is located in East Azerbaijan province in the northwest of Iran and at the east of Urmia lake. This plain is defined as cold and dry area [5].

East Azerbaijan Province consists of seven mountainous areas. The mountain range of Arasbaran is the northernmost of these units. The mountain ranges of Misho and Moro, which originate from the west of the province (Marand), lead to the highlands of Aounebne Ali and Shabli and South limit of Tabriz plain are surrounded with Sahand Mountain. In Tabriz plain, the Aji-chai River is flowing toward Urmia Lake. The drinking wells of the study area were considered as sampling points and 130 wells in the area of study were selected as sampling points. The geographic location of the case study and sampling points is shown in Fig. 1.

2.2. Data set

In order to evaluate the processes affecting the groundwater quality in the study area, such as quantitative and qualitative changes of Urmia Lake, the results of analysis of physicochemical parameters of groundwaters of Tabriz plain were investigated from 2010 to 2015.

Data for analysis were taken from East Azerbaijan Regional Water Authority. It is noted that all tests were carried out according to the standard method. Qualitative parameters that were analyzed from 130 wells included Ca^{2+}, Mg^{2+}, K^+, Na^+, Cl^-, CO_3^{2-}, HCO_3^-, SO_4^{-2}, TH, pH, electrical conductivity (EC), total dissolved solids (TDS), sodium adsorption ratio (SAR), and %Na.

2.3. Statistical analysis

The present study investigates the changes in the quality of groundwater in the Tabriz plain using geostatistical methods from 2010 to 2015 using ArcGIS 10.1, and modified MK test is used for examining the qualitative trend, and before trend analysis, all significant autocorrelation coefficients of quality of groundwater parameters were specified [17,18].

In order to sort the data, Excel software was used and for all statistical analyses, software R was used.

2.3.1. Mann–Kendall test

MK test (MK-1), the nonparametric test, is one of the commonest methods employed to determine the linearity or nonlinearity of time series trends. This test was first proposed by

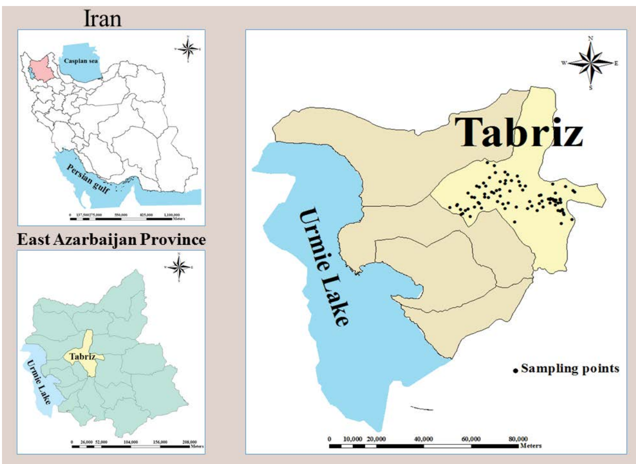

Fig. 1. Study area groundwater sample location map.

Mann and was then developed by Kendall. The purpose of the MK test is to statistically evaluate whether there is a variable trend with time. An upward (downward) trend means that the variable consistently increases (decreases) through time. The main advantage of the MK test is that data need not conform to any particular distribution and missing data are allowed [19,20].

The value of MK test for n data can be calculated from the following relations:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \text{sgn}\left(x_j - x_i\right) \quad (1)$$

x_i is ranked from $i = 1, 2 \ldots n–1$ and x_j is ranked from $j = i + 1, 2 \ldots n$. Each of the data point x_i is taken as a reference point which is compared with the rest of the data point's x_j, so that:

$$\text{Sgn}\left(x_j - x_i\right) = \begin{cases} 1 & if \left(x_j - x_i\right) > 0 \\ 0 & if \left(x_j - x_i\right) = 0 \\ -1 & if \left(x_j - x_i\right) < 0 \end{cases} \quad (2)$$

In this equation, x_i and x_j are the annual values in years i and j ($j > i$), respectively. It has been documented that when the number of observations is more than 10 ($n > 10$), the statistic 'S' is approximately normally distributed with the mean, and $E(S)$ becomes 0. So the variance statistic is given as:

$$\text{Var}\left(S\right) = \frac{n\left(n-1\right)\left(2n+5\right) - \sum_{t=1}^{m} t_1\left(t_1 - 1\right)\left(2t_1 + 5\right)}{18} \quad (3)$$

Where n is the number of observations and t_i are the ties of the sample time series. The test statistic Z is as follows:

$$Z = \begin{cases} \frac{S-1}{\sqrt{\text{Var}\left(S\right)}} & if\ S > 0 \\ 0 & if\ S = 0 \\ \frac{S+1}{\sqrt{\text{Var}\left(S\right)}} & if\ S < 0 \end{cases} \quad (4)$$

Where Z follows a normal distribution, a positive Z and a negative Z depict an upward and downward trend for the period, respectively.

2.3.2. Modified MK test

The modified MK test (MK-2) was proposed by Hamed and Rao, by considering the significance of all autocorrelation coefficients in time series. For this purpose, modified variance [Var(S)] is used for calculation of Z statistics of common MK test [11,21].

$$\text{Var}\left(S\right) = \text{Var}\left(S\right)\left(\frac{n}{n^*}\right) \quad (5)$$

$$\left(\frac{n}{n^*}\right) = 1 + \frac{2}{n\left(n-1\right)\left(n-2\right)} \times \sum_{k=1}^{n-1} 1\left(n-k\right)\left(n-k-1\right)\left(n-k-2\right) rk \quad (6)$$

$$rk = \frac{\times \sum_{k=1}^{n-1} \left(x_i - x'\right)\left(x_i + k - x'\right)}{\frac{1}{n} \sum_{i=1}^{n} \left(x_i - x'\right)^2} \quad (7)$$

That $\left(\frac{n}{n^*}\right)$ represents the modified coefficient of autocorrelated data, rk represents the autocorrelation coefficient of kth, and x' represents the mean of time series.

The significance of autocorrelation coefficient of kth at 95% confidence level can be calculated by the following equation:

$$\left(\frac{-1 - 1.96\sqrt{n-k-1}}{n-k}\right) \leq rk\left(95\%\right) \leq \left(\frac{-1 + 1.96\sqrt{n-k-1}}{n-k}\right) \quad (8)$$

If the obtained rk obeys the above condition, the data will be independent at 95% confidence level. Otherwise, the data are not independent and the effect of autocorrelation coefficient with different lags should be eliminated to determine the time series trend.

If the value of Z is less or greater than the value of Z value of standard normal distribution at 95% confidence level, it means that there is a trend in time series data.

2.3.3. Trend slope

The slope of the trend line was estimated by the research conducted by Theil and Sen. Thiel-Sen is a strong regression technique that is insensitive to outliers and provides the median slope; formal slopes calculated formal possible pairs of values [17,18,22,23].

$$\beta = \text{Median}\left(\frac{X_t - X_s}{t - s}\right) \quad (9)$$

$$\forall s < t$$

where $1 < s < t < n$, β represents the estimator of trend line, and X_t represents the observed t^{th} data. The positive value of β indicates an increasing trend and a negative value indicates a decreasing trend [24,25].

2.3.4. Correlation analysis

Correlation analysis was performed using the Pearson correlation coefficient, and all data were analyzed using R software.

3. Results and discussion

3.1. Analysis of groundwater qualitative parameters in the Tabriz plain

Table 1 summarizes chemical analysis of the groundwater samples at the study area.

Table 1
Groundwater quality parameters used in the Tabriz from 2010 to 2015

Parameters	Unit	WHO limits	Range	2010	2011	2012	2013	2014	2015
SO_4^{2-}	meq/L	4.17	Minimum	0.18	0.15	0.15	0.10	0.45	0.48
			Average	4.50	4.24	4.09	5.52	4.54	5.82
			Maximum	17.95	19.00	19.00	24.00	19.70	24.50
Cl^-	meq/L	5.6	Minimum	0.23	0.23	0.23	0.25	0.53	0.63
			Average	14.73	15.82	14.92	21.60	15.37	21.90
			Maximum	100.50	100.00	100.00	118.75	100.70	119.25
HCO_3^-	meq/L	3.28	Minimum	1.10	0.98	0.98	1.80	1.28	2.18
			Average	4.16	4.60	4.56	5.30	5.01	5.60
			Maximum	12.63	16.75	16.75	15.98	17.45	16.48
Anions	meq/L	–	Minimum	2.05	1.95	1.95	2.15	2.25	2.53
			Average	23.54	24.84	23.75	32.46	24.20	32.76
			Maximum	118.80	115.85	115.85	136.40	116.55	136.90
pH	No dimension	6.5–8.5	Minimum	7.00	7.05	7.05	6.80	7.35	7.18
			Average	8.03	8.27	8.26	7.52	8.71	7.82
			Maximum	9.10	9.10	9.10	8.35	9.80	8.85
TDS	mg/L	500	Minimum	124.80	119.40	119.40	130.20	119.70	130.58
			Average	1,520.11	1,606.72	1,534.56	2,108.08	1,535.01	2,108.38
			Maximum	7,536.75	7,533.50	7,533.50	8,869.25	7,534.20	8,869.75
TH	mg/L	100	Minimum	0.60	70.00	70.00	76.00	70.30	76.38
			Average	292.65	607.13	587.89	797.99	588.34	798.29
			Maximum	1,718.90	3,515.00	3,515.00	3,985.00	3,515.70	3,985.50
SAR	No dimension	–	Minimum	0.54	0.44	0.33	0.55	0.63	0.93
			Average	22,189.55	4,391.76	4,142.60	5,389.61	4,143.05	5,389.91
			Maximum	72,534.00	26,170.00	26,170.00	28,210.00	26,170.70	28,210.50
EC	μS/cm	750	Minimum	208.00	199.00	199.00	217.00	199.30	217.38
			Average	2,354.45	2,488.12	2,378.89	3,250.08	2,379.34	3,250.38
			Maximum	12,555.00	11,590.00	11,590.00	13,645.00	11,590.70	13,645.50
%Na	No dimension	–	Minimum	14.74	12.92	9.46	15.44	9.76	15.82
			Average	42.84	40.85	39.62	43.06	40.07	43.36
			Maximum	84.44	86.28	86.28	84.01	86.98	84.51
K^+	meq/L	2.6	Minimum	0.01	0.04	0.04	0.03	0.34	0.41
			Average	0.20	0.22	0.21	0.23	0.66	0.53
			Maximum	0.65	0.75	0.75	0.81	1.45	1.31
Na^+	meq/L	8.7	Minimum	0.60	0.53	0.52	0.60	0.82	0.98
			Average	12.35	12.50	11.79	16.28	12.24	16.58
			Maximum	79.88	91.00	91.00	107.00	91.70	107.50
Mg^{2+}	meq/L	2.5	Minimum	0.48	0.44	0.44	0.52	0.74	0.90
			Average	4.97	5.27	5.05	6.28	5.50	6.58
			Maximum	21.70	22.10	22.10	25.50	22.80	26.00
Ca^{2+}	meq/L	3.75	Minimum	0.79	0.90	0.90	1.00	1.20	1.38
			Average	6.01	6.87	6.71	9.68	7.16	9.98
			Maximum	45.50	48.20	48.20	54.20	48.90	54.70
Cations	meq/L	–	Minimum	2.05	1.98	1.98	2.15	2.28	2.53
			Average	23.53	24.85	23.76	32.47	24.21	32.77
			Maximum	118.79	115.81	115.81	136.43	116.51	136.93

Table 2
Pearson correlation matrix among the chemical constituents for the groundwater samples

	Variables	K^+	Na^+	Mg^{2+}	Ca^{2+}	SO_4^{2-}	Cl^-	HCO_3^-	EC	TDS	TH
2010											
	K^+	1.000									
	Na^+	0.527	1.000								
	Mg^{2+}	0.680	0.708	1.000							
	Ca^{2+}	0.470	0.353	0.745	1.000						
	SO_4^{2-}	0.623	0.581	0.695	0.557	1.000					
	Cl^-	0.75	0.913	0.870	0.671	0.582	1.000				
	HCO_3^-	0.528	0.526	0.432	0.182	0.536	0.401	1.000			
	EC	0.563	0.851	0.814	0.606	0.603	0.908	0.453	1.000		
	TDS	0.631	0.919	0.894	0.683	0.696	0.987	0.495	0.915	1.000	
	TH	0.51	0.467	0.829	0.838	0.575	0.712	0.255	0.720	0.727	1.000
2011	K^+	1.000									
	Na^+	0.488	1.000								
	Mg^{2+}	0.667	0.782	1.000							
	Ca^{2+}	0.492	0.445	0.752	1.000						
	SO_4^{2-}	0.573	0.624	0.732	0.567	1.000					
	Cl^-	0.538	0.927	0.889	0.723	0.615	1.000				
	HCO_3^-	0.46	0.32	0.426	0.138	0.364	0.224	1.000			
	EC	0.594	0.933	0.923	0.728	0.715	0.987	0.332	1.000		
	TDS	0.595	0.933	0.924	0.728	0.716	0.987	0.331	0.999	1.000	
	TH	0.597	0.615	0.905	0.961	0.673	0.839	0.268	0.857	0.857	1.000
2012	K^+	1.000									
	Na^+	0.475	1.000								
	Mg^{2+}	0.675	0.784	1.000							
	Ca^{2+}	0.493	0.427	0.748	1.000						
	SO_4^{2-}	0.583	0.621	0.72	0.534	1.000					
	Cl^-	0.53	0.922	0.892	0.717	0.598	1.000				
	HCO_3^-	0.448	0.307	0.419	0.129	0.368	0.207	1.000			
	EC	0.59	0.93	0.928	0.72	0.704	0.986	0.321	1.000		
	TDS	0.591	0.93	0.927	0.719	0.705	0.986	0.32	0.999	1.000	
	TH	0.603	0.606	0.904	0.959	0.648	0.838	0.26	0.855	0.855	1.000
2013	K^+	1.000									
	Na^+	0.452	1.000								
	Mg^{2+}	0.609	0.747	1.000							
	Ca^{2+}	0.434	0.426	0.824	1.000						
	SO_4^{2-}	0.463	0.545	0.695	0.655	1.000					
	Cl^-	0.492	0.905	0.904	0.741	0.58	1.000				
	HCO_3^-	0.548	0.314	0.402	0.153	0.398	0.212	1.000			
	EC	0.546	0.905	0.934	0.765	0.695	0.986	0.332	1.000		
	TDS	0.546	0.905	0.934	0.765	0.695	0.986	0.322	0.999	1.000	
	TH	0.511	0.552	0.917	0.981	0.695	0.827	0.244	0.854	0.854	1.000
2014	K^+	1.000									
	Na^+	0.53	1.000								
	Mg^{2+}	0.69	0.79	1.000							
	Ca^{2+}	0.53	0.47	0.75	1.000						
	SO_4^{2-}	0.62	0.65	0.76	0.59	1.000					
	Cl^-	0.57	0.93	0.89	0.74	0.64	1.000				
	HCO_3^-	0.44	0.33	0.44	0.149	0.36	0.22	1.000			
	EC	0.63	0.93	0.92	0.74	0.74	0.98	0.34	1.000		
	TDS	0.63	0.93	0.92	0.74	0.74	0.98	0.34	0.99	1.000	
	TH	0.63	0.64	0.9	0.96	0.7	0.85	0.28	0.87	0.87	1.000

Table 2 (continued)

	Variables	K^+	Na^+	Mg^{2+}	Ca^{2+}	SO_4^{2-}	Cl^-	HCO_3^-	EC	TDS	TH
2015	K^+	1.000									
	Na^+	0.44	1.000								
	Mg^{2+}	0.59	0.75	1.000							
	Ca^{2+}	0.43	0.43	0.82	1.000						
	SO_4^{2-}	0.46	0.55	0.7	0.66	1.000					
	Cl^-	0.48	0.9	0.9	0.74	0.59	1.000				
	HCO_3^-	0.47	0.3	0.37	0.13	0.36	0.18	1.000			
	EC	0.53	0.9	0.93	0.77	0.7	0.98	0.3	1.000		
	TDS	0.53	0.9	0.93	0.77	0.7	0.98	0.3	0.99	1.000	
	TH	0.5	0.56	0.91	0.98	0.7	0.83	0.222	0.85	0.85	1.000

The results of the analysis of water qualitative parameters indicate that most of the values exceed the standard limit and ascending trend continues for most of the parameters. Increasing the concentration of ions such as (Na^+, Cl^-) indicates the infiltration of saline water in the waters of this area and unusable for various utilization. Also salinity that makes water unusable is considered a major agricultural problem. The concentration of some of the major ions in groundwater is higher than the limits for drinking and domestic purposes.

3.2. Correlation matrix

Understanding the relationship and variations between the physicochemical characteristics and ion concentration of groundwater samples and explaining the data and interaction between them could be done based on the statistical analyses. Table 2 shows the results of Pearson correlation matrix for 10 chemical constituents of the groundwater samples.

According to the results, sodium and TDS, chloride and TDS, TDS and EC, and sodium and chloride indicate high correlations and also Na^+, Mg^{2+}, Cl^- exhibited good positive correlations with EC and TDS, also Mg^{2+} and Ca^{2+} exhibited good positive correlations with TH, which indicates high concentrations of Na^+, Mg^{2+}, and Cl^-, while HCO_3^- and Ca^{2+} showed low and weak correlations.

These results showed that water quality could be influenced by seasonal and evaporation effects so that salts like sodium and chloride could be high at dry season.

Fig. 2 demonstrated Piper tri-linear diagram of groundwater samples' faces. The data obtained from the water analysis were graphically presented using a Piper diagram. The cations and anions are shown by separate ternary plots.

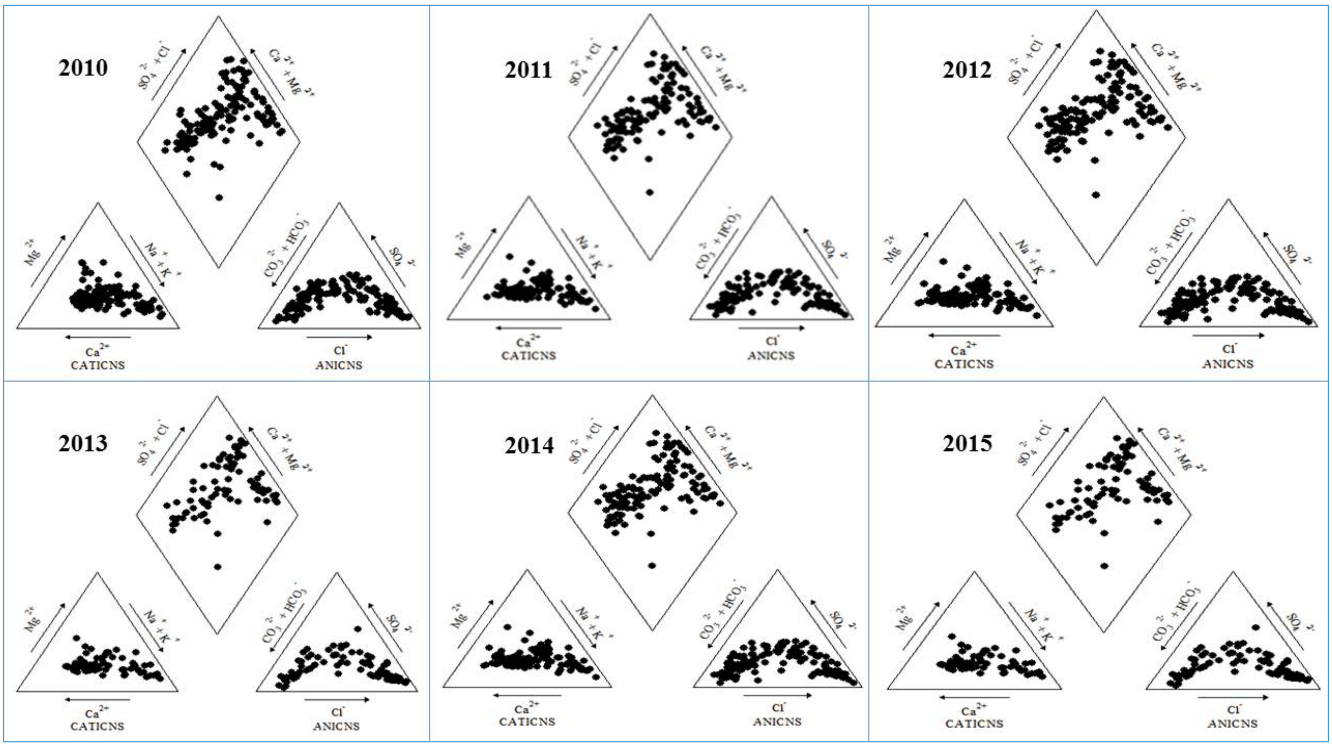

Fig. 2. Piper diagram of groundwater samples in the study area from 2010 to 2015.

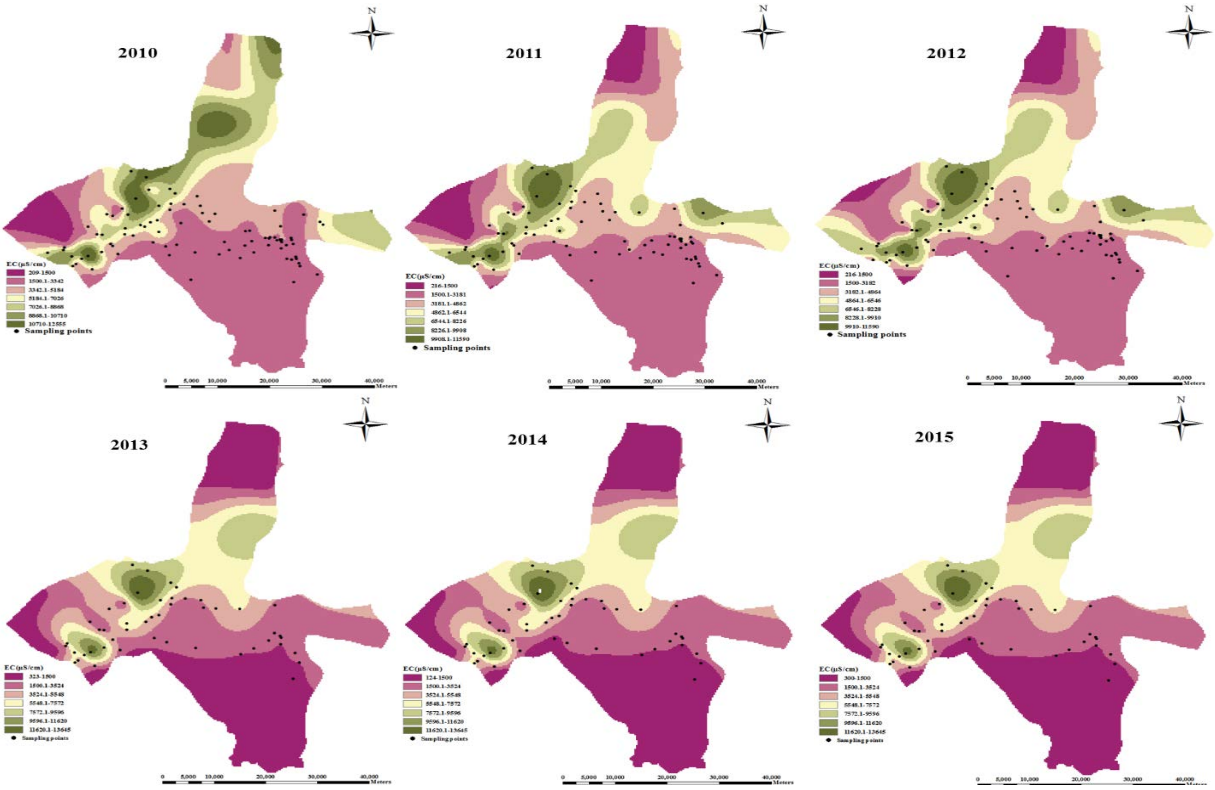

Fig. 3. The amount of EC in the samples studied in Tabriz from 2010 to 2015.

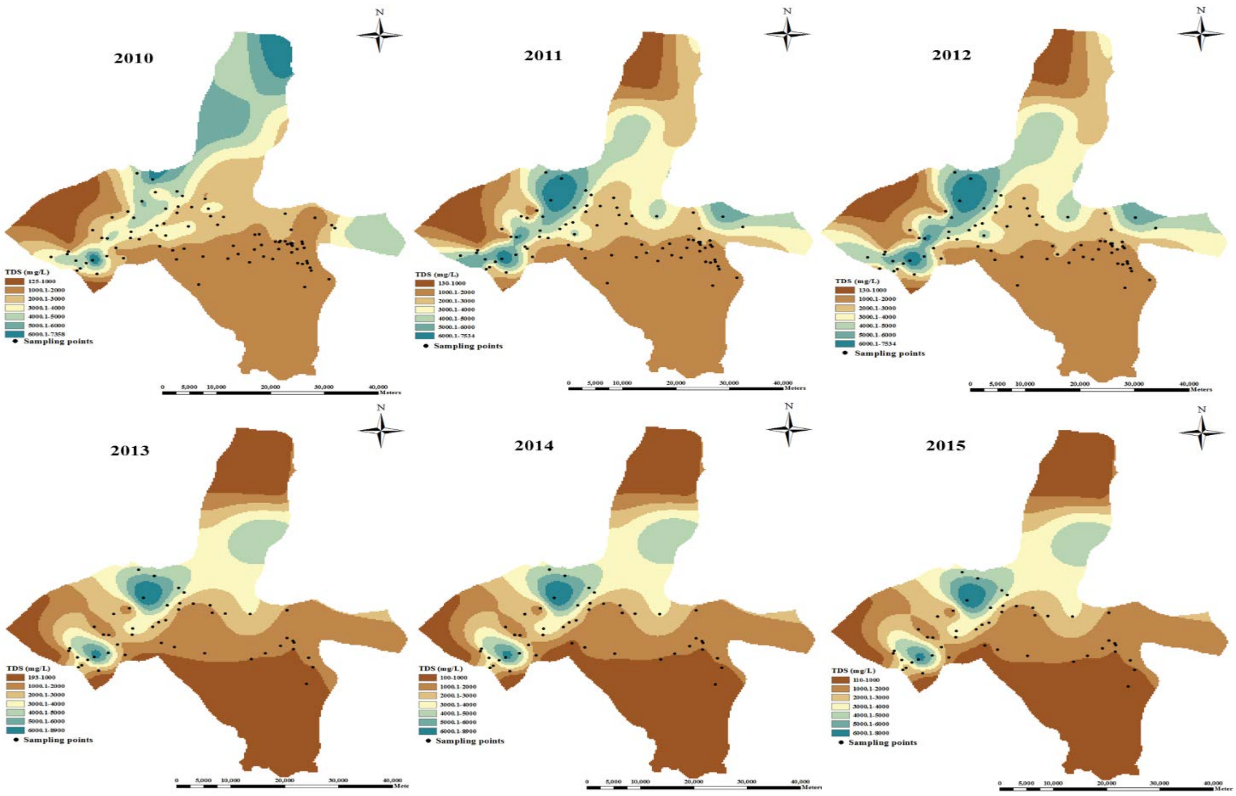

Fig. 4. The amount of TDS in the samples studied in Tabriz from 2010 to 2015.

Table 3
Modified Mann–Kendall Z statistics and Theil-Sen's slope values for groundwater qualitative parameters in the Tabriz plain

	SO_4	Cl	HCO_3	Anions	PH	TDS	TH	SAR	EC	%Na	K	Na	Mg	Ca	Cations
Modified Mann-Kendall (Z)	0.75	1.5	1.5	1.5	–0.75	1.87	0	0	1.5	0	1.006	1.127	1.5	1.5	1.5
Theil-Sen's slope values	0.08	0.81	0.158	1.05	–0.035	124.5	–19.2	–0.95	184.5	0.05	0.004	0. 42	0.16	0.45	1.09

The faces of the samples as a function of the percentage of cations and anions are, respectively, the sum of cations and anions [26].

The groundwater samples of the plains were classified into a variety of water types.

Water type depends on lithological characteristics of aquifers, retention time, and flow pattern of groundwater [27].

In this research based on the results, water samples have an alkaline face and were $Ca^{2+} – Mg^{2+} – Na^{+}$ and $Cl^{–} – HCO_3^{–} – SO_4^{2–}$ type and characterized as very hard and brackish water throughout the study period indicating anthropogenic contamination.

In a study conducted by Dehghanzadeh et al in this basin, which was done for a year, the results indicated that all of the water samples were mostly characterized as very hard and brackish water and were $Ca^{2+} – Mg^{2+} – Na^{+}$ and $HCO_3^{–} – SO_4^{2–} – Cl^{–}$ type [28].

Also in a study conducted by Barzegar et al on characterization of hydrogeological properties of the Tabriz plain, results of Piper diagram showed that the main type of groundwater was Na–Cl, which had attributed to the low velocity of groundwater, longer water residual time, ion exchange, and the geological formations.

3.3. GIS analysis of groundwater qualitative parameters

The EC and TDS levels in the study area from 2010 to 2015 were depicted using the ArcGIS software, as shown in Figs. 3 and 4. In these figures, the brighter range represents fewer values and the darker range is a large value. The results show that the spatial distribution of this value is different.

3.4. Trend analysis of groundwater qualitative parameters

Table 3 depicts the trend values of groundwater qualitative parameters from 2010 to 2015 based on the modified MK test and Theil-Sen slope values of groundwater qualitative parameters.

According to the Modified MK *Z* statistics, about 74% of parameters in the Tabriz plain groundwater had positive trend, and according to the trend slopes of qualitative parameters, about 80% of the trend slopes of the majority of parameters have been positive.

4. Conclusion

Decrease of water level in Urmia Lake and consequently groundwater level in its surrounding basin has led to changes in groundwater qualitative parameters in its basins.

since the level of Urmia Lake water has decreased and the amount of salinity in the lake has increased, changes trending in SAR, Na^{+}, $\%Na^{+}$, and $Cl^{–}$ in the Tabriz plain indicate which geological and hydrological properties can play a main role in these changes, and it can be concluded that changes in the quality of Urmia Lake have a significant impact on the quality of Tabriz plain groundwater.

Excess salinity reduces the osmotic activity of plants and thus interferes with the absorption of water and nutrients from the soil. The SAR, because of measurement of sodium hazard to crops, is an important parameter for determining suitability of groundwater for irrigation and it should be noted that increasing the amount of SAR will disrupt much of uses.

The results of groundwater data analysis of Tabriz plains indicate that the values of quality parameters are in most cases higher than standards and that measures should be taken to avoid drinking and other problems.

Results from a trend of groundwater qualitative parameters based on the modified MK test indicate that majority of cases have positive trend, which indicates an increase in the chemical parameters of groundwater in this area.

Given that salinization of groundwater following the encroachment of seawater in all coastal aquifers of the world is a widespread environmental problem and considering all the problems raised for this area of Iran, basic measures should be taken to improve the quality of groundwater in this area.

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